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FOREWORD

Presented number of Silesian University of Technology. Scientific Papers. Organization and Management Series. Presented papers contain result of researches conducted by various universities. The number consists of 36 papers.

The papers presented in the number concentrate on many topics connected with organization and management. There are in the number papers about: knowledge management; sustainability; finances; industrial management; AI implementation in management; marketing; managerial competences; consumer engagement; innovativeness; organizational culture; lean management; entrepreneurship; human resources management; safety management; quality of life family companies; intellectual capital and economics.

Radosław Wolniak

HIGHER EDUCATION AS A RITE OF PASSAGE: THE HERMETICIZATION OF ACADEMIC LANGUAGE AND BARRIERS TO ACCESS TO KNOWLEDGE

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Purpose: The aim of this paper is to examine academic language as a mechanism of symbolic power and gatekeeping in higher education, conceptualized as a contemporary rite of passage. The study aims to analyze students' perceptions of academic language in terms of cognitive difficulty, symbolic prestige, and exclusion, and to explore how these perceptions influence preferences for simplifying scholarly discourse.

Design/methodology/approach: The study adopts an interdisciplinary framework integrating ritual theory (van Gennep; Turner), Bourdieu's concept of symbolic power, and Andreski's critique of scientific jargon. Empirical data were collected through a diagnostic survey conducted among 288 students representing eight fields of study at selected Polish universities. The research instrument included Likert-scale items and a quasi-experimental comparison of academic and simplified text excerpts. Data analysis employed descriptive statistics, χ^2 tests, Spearman correlations, one-way ANOVA, linear regression, reliability analysis (Cronbach's alpha), and exploratory factor analysis.

Findings: The findings indicate a tension between the norm of scientific rigor and the demand for accessibility. Although students generally supported simplifying academic language, they also associated linguistic complexity with prestige and authority. Greater exposure to academic texts reduced perceived difficulty, while lecturers' communicative practices increased the likelihood of reading abandonment. Preferences for simplification were driven primarily by perceptions of exclusion and hierarchy rather than by self-assessed linguistic competence, with significant disciplinary differences. Factor analysis confirmed a three-dimensional structure of academic language perception: cognitive difficulty, symbolic prestige/power, and exclusion.

Research limitations/implications: The study is limited by its non-random and nationally bounded sample. Future research should include longitudinal and cross-national designs to examine the dynamics of linguistic socialization and the structural role of academic discourse across institutional contexts.

Practical implications: The results suggest the need for greater reflexivity in academic communication and for professional development initiatives aimed at balancing disciplinary precision with clarity. The validated measurement scales may serve as diagnostic tools for evaluating communication quality in higher education institutions.

Social implications: By demonstrating how academic language may function as a mechanism of exclusion and symbolic domination, the study contributes to debates on educational equity and access to knowledge. The findings may inform institutional policies aimed at widening participation and reducing communicative barriers in higher education.

Originality/value: The paper offers an original contribution by combining ritual theory and the concept of symbolic power with quantitative empirical analysis. It provides a multidimensional measurement model of academic language perception and extends research on educational inequality and communicative practices in higher education.

Keywords: academic language; symbolic power; higher education; accessibility; rite of passage.

Category of the paper: Research paper.

Introduction

The transformations of the contemporary world—particularly when viewed through the lens of the rapid development of information technologies, ongoing globalization, and closely related changes in labor market demands—are clearly reflected in the broader context of higher education. This domain undoubtedly constitutes one of the key areas of social reality in which the phenomenon of educational expansion has become a dominant feature (Kukla, 2009; Jedlińska, 2013; Myszka, 2015).

This expansion takes various forms, ranging from the growing number of young people seeking admission to available fields of study to the rising expectations placed on academic staff to develop their research and publication potential (Jałowiecki, 2021). The observed rise in student enrollment has shifted higher education from an elite model to a mass model (Trow, 1974). As Scott (1995) observes, this transition fundamentally transforms the nature of academic institutions, intensifying tensions between accessibility and distinction. In mass systems, symbolic mechanisms of differentiation — including linguistic ones — may become even more significant as markers of status within increasingly heterogeneous student populations. Researchers also emphasize that massification is a multidimensional process: on the one hand, it contributes to the growth of human and social capital; on the other, it poses challenges related to maintaining educational quality, securing adequate funding, and adapting curricula to the increasingly diverse needs of students (Kwiek, 2010).

Higher education institutions are therefore confronted with the need to redefine their functions and adjust their educational offerings to changing realities. Philip G. Altbach (2016) aptly concludes that two forces, mass higher education and the global knowledge-based economy, have triggered an unprecedented transformation (p. 352).

This article aims to analyze the hermetic nature of academic language in higher education, interpreted as a contemporary rite of passage. Drawing on classical ritual theory (V. Turner) and Stanisław Andreski's critique of scientific language, the authors seek to answer how

specialized, often incomprehensible language functions as a mechanism of selection and symbolic power within the academic environment. The research method is a diagnostic survey conducted among students at selected higher education institutions.

1. Theoretical assumptions

One of the key analytical categories in the study is the concept of the rite of passage. It is assumed that, in accordance with Arnold van Gennep's classical conception, the commencement of university studies can be interpreted through the prism of a rite of passage. In *Les rites de passage*, van Gennep (2006) argues that any transition from one life stage to another is accompanied by specific ceremonies and social practices, comprising three phases: separation, transition, and incorporation (*séparation, marge, agrégation*) (p. 21). The beginning of university studies fits this schema particularly clearly. The phase of separation manifests in the abandonment of the former role of a secondary school student. Liminality, in turn, is associated with the initial period of study—a time of uncertainty, adaptation, and initiation into academic life, during which the student no longer belongs to the school world but has not yet attained the status of a professional. Finally, with the internalization of the rhythm of academic life, the completion of initial examinations, and entry into the institutional structures of the university, incorporation occurs, understood as the symbolic inclusion in the academic community.

Victor Turner further developed van Gennep's concept, emphasizing the significance of the liminal phase. In *The Ritual Process*, he writes that liminality is a state in which individuals find themselves on the threshold between established social forms (Turner, 1969, p. 95). It is precisely this state of “in-betweenness” that characterizes the initial period of university studies: the student exists in a condition of suspension, having lost a former status while not yet having attained a new one. Turner also introduces the notion of *communitas*, which he describes as a spontaneous experience of community and equality that emerges during transitional periods. In the context of higher education, *communitas* manifests itself, for example, in first-year student integration activities, the shared struggle with academic demands, or communal life in student dormitories.

From an anthropological perspective, the commencement of higher education is a rite of passage from the stage of school-based youth to academic and professional adulthood. It has a symbolic dimension (matriculation ceremonies), a social dimension (a change of status and affiliation with the academic community), and a psychological dimension (the process of gaining independence and constructing an adult identity). As van Gennep and Turner's theories demonstrate, entering university is not merely a didactic process but also a culturally embedded initiatory experience that confers new meaning on both individual and collective identity.

A crucial analytical category in this study is symbolic power, conceptualized within the framework proposed by Pierre Bourdieu. According to the French sociologist, symbolic power is a form of domination embedded in categories of thought and perception, operating effectively through its “misrecognition” and acceptance by both the dominant and the dominated. Bourdieu (2007) notes that every established order tends to present its own arbitrariness as natural (p. 63). Elsewhere, he emphasizes that symbolic violence operates primarily through the unconscious recognition of its principles, which state that symbolic violence is a form of violence exercised upon a social agent with their complicity (Bourdieu, 2009, p. 664).

Symbolic power, therefore, operates in a dual manner: first, it reinforces the existing order through naturalization; second, it employs language and systems of symbols to establish and legitimize categories of thought that the majority accepts as objective and accurate. In this way, social structures are reproduced subtly, often going unnoticed by the groups subject to them. This perspective is consistent with Foucault’s (1980) understanding of discourse as a site where knowledge and power are mutually constituted. Academic language does not merely describe reality but actively shapes what can be legitimately said, thought, and recognized as valid knowledge. From a critical discourse perspective (Fairclough, 1992), institutional language practices both reflect and reproduce existing social hierarchies, embedding power relations within apparently neutral communicative forms.

In this context, the role of specialized, hermetic language within the academic environment becomes particularly salient. Bourdieu and Passeron (1995) observe that, for most French people, academic language is a dead language rather than a mother tongue, even for children from educated social classes. As a result, it is far removed from the languages actually used by different social classes. The rejection of rational pedagogy in this context amounts to the assumption that all students are equal in their ability to meet the demands of academic language (p. 8). This observation resonates with Bernstein’s (1971) distinction between elaborated and restricted codes, which demonstrates how educational systems privilege specific linguistic forms associated with dominant social groups. In a similar vein, Street (1984) argues that literacy should be understood not as a neutral technical skill but as an ideological practice embedded in relations of power. Academic language thus constitutes not only a communicative medium but also a socially situated code that regulates access to institutional legitimacy.

This observation demonstrates that academic language is neither a natural nor a universally accessible means of communication—even for individuals from privileged backgrounds—and thus functions as a selective mechanism of access. It serves as a linguistic instrument of exclusion that presupposes possession of appropriate cultural and linguistic capital. Only those who have mastered this code can participate in academic communication on equal terms; in doing so, they gain prestige and recognition, which constitute a form of symbolic capital. Linguistic competence, in this sense, is not limited to knowledge of grammar and vocabulary but also encompasses the “right to speak”. Bourdieu (2009) argues:

[...] [A] rigorous science of language substitutes the question of the social conditions of the possibility of linguistic production and circulation. Discourse always owes its most important characteristics to the linguistic production relations within which it is produced. The sign has no existence (except abstractly, in dictionaries) outside a concrete mode of linguistic production. All particular linguistic transactions depend on the structure of the linguistic field, which is itself a particular expression of the structure of the power relations between the groups possessing the corresponding competences (p. 647).

Consequently, academic language functions as an instrument of symbolic power: it legitimizes the prestige and position of those who have mastered it while excluding those who lack the requisite competencies. In this way, hierarchical structures within the academic field are not only sustained but also naturalized, thereby facilitating the reproduction of social inequalities.

When higher education is analyzed as a rite of passage, academic language assumes a crucial role—not merely as a vehicle of knowledge but as a tool for constructing and maintaining boundaries of access to that knowledge. Andreski (1973) incisively exposes the “smokescreen” of scientific jargon, observing that: “The usage of mumbo-jumbo makes it very difficult for a beginner to find his way; because if he reads or hears famous professors from the most prestigious universities in the world without being able to understand them, then how can he know whether this is due to his lack of intelligence or preparation, or to their vacuity? (p. 21)¹” Rather than fostering openness, such language reinforces the symbolic prestige of academic communities and operates as a mechanism of selection, requiring novices to possess adequate cultural and linguistic capital to participate fully in the academic field. In this sense, higher education does not so much provide access to knowledge as initiate individuals into a specific communicative code. Andreski (1973) demonstrates that scientific jargon functions like an incantation: it obscures meaning, maintains hierarchy, and sustains barriers to entry; his critique extends beyond epistemology into the realm of social mechanisms—linguistic hermeticism strengthens the elitist character of higher education, marginalizing those who lack the competencies required for legitimate participation.

2. Description of Methods

The study employed a diagnostic survey. It was conducted among students at selected higher education institutions in Poland (Silesian University of Technology, University of Silesia, University of Opole, University of Economics in Katowice) in October 2025. The questionnaire included items assessing the frequency of linguistic difficulties and the extent to which academic language hinders comprehension of content (Questions 1-2), as well as the consequences of these difficulties for students' attitudes, such as avoiding questions due to

unfamiliarity with “appropriate” academic jargon (Question 3). The operationalizations enabled examination of whether symbolic barriers translate into actual limitations on participation in academic classes and projects (Question 6). Subsequent items focused on perceptions of academic language as a tool for constructing hierarchy and distance relative to teaching staff (Question 7), for enhancing lecturers’ authority (Question 8), and as a form of initiation into the university environment (Question 9). The survey also included questions contrasting the symbolic function of academic language with its perceived practical usefulness (Question 10) and preferences regarding the simplification of academic discourse (Question 11).

A vital component of the research instrument was a block of quasi-experimental questions comparing a text fragment in an academic style with its simplified version (Questions 13a-13c). This element enabled an empirical examination of the process described by Bourdieu as a mechanism of legitimization and the reproduction of inequality through language (Bourdieu, Passeron, 1995). The questionnaire thus allowed not only a statistical description of the frequency of problems associated with hermetic language but also a qualitative capture of its role as an initiatory ritual and an instrument of symbolic power.

A total of 288 students from eight fields of study participated in the survey: Applied Linguistics ($n = 102$; 35.4%), Law ($n = 48$; 16.7%), Romance Studies ($n = 44$; 15.3%), Management ($n = 41$; 14.2%), Chemistry ($n = 18$; 6.3%), Computer Science ($n = 14$; 4.9%), Biotechnology ($n = 11$; 3.8%), and Logistics ($n = 10$; 3.5%). The study examined perceptions of academic language (difficulty, prestige/elitist character, and exclusionary function) and preferences for simplifying academic discourse. Responses to Likert-type items were coded numerically on a five-point scale (e.g., 1 = “strongly disagree”, 5 = “strongly agree”; for frequency items: 1 = “never”, 5 = “very often”). Questions 18-20, which compared text fragments A and B, were analyzed as categorical variables.

Data analysis employed complementary statistical methods tailored to the variables and research objectives. In the initial stage, descriptive statistics included frequency and percentage distributions, as well as means, medians, and standard deviations. Relationships between categorical variables were examined using the χ^2 test of independence, with effect size reported as Cramér’s V. Associations between ordinal variables were assessed using Spearman’s rank correlation coefficient (ρ). Differences between groups were analyzed using one-way analysis of variance (ANOVA), with effect size reported as η^2 . Given the relatively large sample size, ordinal variables were treated as approximately interval-level measures, consistent with standard practice in social science research. To model predictive relationships, particularly those related to perceived linguistic difficulty and preferences for simplification, linear regression analysis was applied. The internal consistency of the scales was assessed using Cronbach’s alpha (α). In addition, exploratory factor analysis (EFA) was conducted to identify the principal dimensions underlying perceptions of academic language. All statistical analyses reported in this study can be fully replicated using the free statistical software Jamovi.

3. Results

In the examined sample, a clear preference for greater accessibility of academic language was observed, along with moderately high agreement with statements about its prestige-related and exclusionary functions.

Table 1.
Descriptive statistics of selected items

opinion	M	Me	SD
Simplification reduces scholarly value	3.21	3	1.11
Abandoning reading due to difficulty	3.38	3	1.03
The language displays knowledge rather than conveys it	3.44	4	0.98
The language emphasises status/authority	3.67	4	0.99
Jargon excludes some students	3.52	4	1.00
Language constructs a student–staff hierarchy	3.59	4	0.97
I would prefer the language to be more accessible	4.18	4	0.82

Note. M – mean, Me – median, SD – standard deviation.

Source: own study.

The scrutiny of descriptive statistics indicates that, for most of the examined items, both the medians and means were located above the midpoint of the scale, suggesting an overall tendency toward agreement with the presented statements. At the same time, the standard deviation values reveal a degree of variability in students' responses, particularly regarding issues related to the symbolic function of academic language.

An analysis of self-reported exposure to academic texts (scale 1-4) indicates that the vast majority of respondents encountered such texts either occasionally or several times a week. The most frequently reported form of contact was reading several times per week (44%), followed by sporadic contact (36%), whereas only 13% of participants reported daily engagement with academic texts. A complete lack of contact with this type of material was declared by 7% of respondents.

Regarding the assessment of the comprehensibility of the compared text excerpts, the overwhelming majority of participants identified the simplified version as easier to understand (71%). In comparison, only 12% considered the original version more accessible. The remaining respondents judged both excerpts to be similarly difficult (10%) or reported difficulty in making an unequivocal assessment (7%).

The χ^2 test revealed a statistically significant association between field of study and the selection of the excerpt perceived as easier to understand: $\chi^2(21) = 46.8$; $p = 0.001$; $V = 0.23$, indicating a relationship of small-to-moderate strength. The strongest preference for the simplified version (B) was observed in the technical and natural sciences (chemistry, biotechnology, computer science). In contrast, relatively more frequent indications of “both similar” were recorded in linguistics and Romance studies. Similarly, in the question concerning which excerpt was “more academic” (Question 19), the academic-style fragment predominated; however, differences between fields of study were again evident: $\chi^2(21) = 39.5$; $p = 0.008$; $V = 0.20$. Students in the humanities were more likely to accept that the simplified style could be considered “equally academic” (response “both”).

The relationship between the frequency of contact with academic texts (Question 5; scale 1-4) and abandoning reading due to difficulty (Question 2; scale 1-5) was also examined. A statistically significant negative correlation was found ($\rho = -0.36$; $p < 0.001$), indicating that more frequent engagement with academic texts was associated with fewer reports of abandoning reading. In addition, abandoning reading correlated positively with the assessment that lecturers’ language hinders content comprehension (item “hinders”; scale 1-5): $\rho = 0.41$; $p < 0.001$, and with the frequency of encountering unclear formulations during classes (Question 6): $\rho = 0.33$; $p < 0.001$.

To compare group means across fields of study, a one-way ANOVA was conducted on key Likert-type variables. Preferences for simplifying academic language (item “I would prefer...,” scale 1-5) differed significantly across fields: $F(7, 280) = 4.62$; $p < 0.001$; $\eta^2 = 0.10$. On average, students in law and the natural and technical sciences expressed the strongest support for simplification. In contrast, the lowest—though still relatively high—support was observed among students in linguistics and Romance studies. Perceptions of the prestige-related function of academic language (e.g., “emphasises status”, Question 4) also varied significantly by field of study: $F(7, 280) = 2.71$; $p = 0.010$; $\eta^2 = 0.06$, indicating a small-to-moderate effect size.

To identify predictive factors associated with the perceived difficulty of academic language and preferences for its simplification, two linear regression analyses were conducted. In the first model, the dependent variable was self-reported abandonment of academic texts. The predictors included frequency of contact with academic texts, evaluation of how much lecturers’ language hinders content comprehension, the frequency of unclear formulations encountered in class, and control variables related to the field of study. The model was statistically significant ($R^2 = 0.29$; $F(12, 275) = 9.28$; $p < 0.001$). The strongest predictor of abandoning reading was the perception that lecturers’ language impeded understanding, whereas more frequent engagement with academic texts was associated with a lower propensity to discontinue reading; a significant, albeit weaker, effect was also observed for the frequency of unclear formulations. The second model examined predictors of preferences for simplifying academic language and included beliefs about the exclusionary function of jargon, its role in

constructing hierarchy and reinforcing lecturers' authority, and evaluations of whether language simplification reduces the scholarly value of content. This model identified which of these beliefs most strongly shape students' attitudes toward the postulate of making academic language more accessible.

In accordance with the adopted theoretical assumptions, the questionnaire items were grouped into three scales reflecting distinct dimensions of perceptions of academic language, and reliability was assessed using Cronbach's alpha coefficient. The scale measuring linguistic difficulty and cognitive barriers—including, among other aspects, abandonment of reading academic texts, frequency of unclear formulations, perceived impediments to comprehension, and avoidance of asking questions—demonstrated good internal consistency ($\alpha = 0.81$). The scale measuring the elitist and prestige-related character of academic language, which encompassed beliefs about its role in displaying knowledge, emphasizing status, constructing hierarchy, reinforcing lecturers' authority, and fulfilling an initiatory function, showed outstanding reliability ($\alpha = 0.84$). The scale measuring exclusion and access to resources—covering perceptions of jargon as an exclusionary factor that limits access to prestigious knowledge resources and full participation in academic discourse—achieved acceptable to good internal consistency ($\alpha = 0.78$).

Exploratory factor analysis of the Likert-scale items identified a three-factor structure underlying perceptions of academic language. The data were suitable for this analysis, as indicated by satisfactory values of the Kaiser-Meyer-Olkin (KMO) measure and a significant result for Bartlett's test of sphericity ($p < 0.001$). Using the extraction method with Varimax rotation, three relatively independent dimensions emerged, each with eigenvalues exceeding unity. The first factor, related to the prestige and symbolic power of academic language, comprised items with high factor loadings ranging from approximately 0.69 to 0.76. The second factor, interpreted as cognitive barriers and linguistic difficulty, included items with loadings between approximately 0.65 and 0.71, while the third dimension, associated with exclusion and access to knowledge resources, consisted of items with loadings ranging from approximately 0.69 to 0.74. Altogether, the three factors accounted for approximately 56% of the total variance in responses. The first factor explained about one quarter of the variance, with the remaining two accounting for additional substantial proportions, indicating appropriate dimensional reduction and a well-defined latent structure of the analyzed construct.

4. Discussion

The study aimed to examine how students from different fields of study perceive academic language in terms of cognitive difficulty, symbolic prestige, and its exclusionary function, and how these attitudes relate to preferences for simplifying scholarly discourse.

The results confirm that academic language operates not only as a vehicle of communication but also as a marker of symbolic prestige. Students' ambivalent attitudes—favoring simplification while simultaneously associating complexity with authority and scholarly value—reflect Bourdieu's (1991) concept of symbolic power, whereby domination is most effective when it is misrecognized as legitimate. Hermetic language is thus naturalized as an attribute of "scientificity," reinforcing hierarchical distinctions within the academic field.

In this sense, academic discourse operates as a structured field of meaning production in which power is exercised through the regulation of legitimate speech (Foucault, 1980; Fairclough, 1992).

Consistent with Bourdieu and Passeron (1995), the data demonstrate that academic discourse functions as a selective code requiring prior possession of cultural and linguistic capital. Reading abandonment was predicted primarily by perceptions that lecturers' language hindered comprehension, indicating that barriers are embedded in communicative practices rather than reducible to individual deficits. This finding supports the thesis that academic language contributes to the reproduction of inequality.

The factor analysis empirically substantiated a three-dimensional structure—cognitive difficulty, symbolic prestige/power, and exclusion—corresponding to the theoretical framework. The prestige dimension reflects processes of distinction and accumulation of symbolic capital (Bourdieu, 1984), while the exclusion dimension highlights unequal access to legitimate speech. The cognitive dimension captures the experiential aspect of liminality (Turner, 1969), as students navigate uncertainty during early stages of academic socialization. The negative correlation between exposure to academic texts and reading abandonment further supports the initiatory interpretation of higher education (van Genneep, 2006), suggesting gradual incorporation into the academic community, albeit without eliminating structural asymmetries.

The quasi-experimental comparison of academic and simplified texts revealed a persistent tension: while simplified language enhanced comprehensibility, the original version was more frequently perceived as "more academic." This pattern illustrates Andreski's (1973) critique of scientific jargon as a mechanism that sustains intellectual authority through obscurity. Complexity appears to derive value not from communicative efficiency but from the prestige it confers.

Disciplinary variation adds further depth to the analysis. Stronger support for simplification among students in technical and legal fields contrasts with greater tolerance for stylistic complexity in the humanities, echoing Hyland's (2004) argument that rhetorical expectations are shaped by epistemological traditions.

Taken together, the findings substantiate the central thesis that academic language functions as an initiatory code mediating access to knowledge, prestige, and participation within a structured field of power. From the perspective of education management and communication quality, they underscore the need for greater reflexivity in academic discourse. Simplification need not undermine scholarly rigor; rather, it challenges the assumption that opacity is a necessary condition of authority. The validated measurement scales provide a diagnostic tool for institutional evaluation and open avenues for longitudinal and comparative research on academic communication. Balancing disciplinary precision with inclusivity may help mitigate exclusionary mechanisms while preserving the normative standards of academic knowledge production.

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Footnotes

¹ All direct quotations from Polish have been translated by R.K.M.

Appendix (Translation of the survey questionnaire into English)

Instructions for respondents: Please answer the following questions by selecting the appropriate option. The results will be analysed exclusively for scientific purposes.

How often do you encounter expressions during classes whose meaning is unclear to you?

- ☐ Never
- ☐ Rarely
- ☐ Sometimes
- ☐ Often
- ☐ Very often

To what extent does the language used by lecturers hinder your understanding of the presented content?

- ☐ Does not hinder it at all
- ☐ Rather does not hinder it
- ☐ Hard to say
- ☐ Rather hinders it
- ☐ Definitely hinders it

Do you ever avoid asking questions during classes because you are concerned that you do not know the appropriate “academic” language?

- ☐ Never
- ☐ Rarely
- ☐ Sometimes
- ☐ Often
- ☐ Always

Do you believe that specialised academic jargon performs an exclusionary function with respect to some students?

- ☐ Definitely not
- ☐ Rather not
- ☐ Hard to say
- ☐ Rather yes
- ☐ Definitely yes

To what extent do you agree with the statement that knowledge of academic language influences access to prestigious resources (e.g. grants, student research groups, research collaboration)?

- ☐ Strongly disagree
- ☐ Rather disagree
- ☐ Hard to say
- ☐ Rather agree
- ☐ Strongly agree

Have you encountered a situation in which a lack of familiarity with the “appropriate” vocabulary limited your participation in classes or academic projects?

- ☐ Never
- ☐ Rarely
- ☐ Sometimes
- ☐ Often
- ☐ Very often

To what extent do you agree with the statement that academic language constructs a hierarchy between students and academic staff?

- ☐ Strongly disagree
- ☐ Rather disagree
- ☐ Hard to say
- ☐ Rather agree
- ☐ Strongly agree

Do you think that complex scholarly language increases lecturers' authority?

- ☐ Definitely not
- ☐ Rather not
- ☐ Hard to say
- ☐ Rather yes
- ☐ Definitely yes

Do you believe that mastering academic jargon constitutes a form of “initiation” into the university environment?

- ☐ Definitely not
- ☐ Rather not
- ☐ Hard to say
- ☐ Rather yes
- ☐ Definitely yes

How do you assess the usefulness of hermetic academic language for the development of your own professional competences?

- ☐ Completely useless
- ☐ Rather useless
- ☐ Hard to say
- ☐ Rather useful
- ☐ Very useful

Would you prefer lectures and academic texts to be formulated in a more accessible manner?

- ☐ Definitely not
- ☐ Rather not
- ☐ Hard to say
- ☐ Rather yes
- ☐ Definitely yes

What strategies do you most often use to cope with incomprehensible academic language?

- ☐ Reading additional literature
- ☐ Consultations with lecturers
- ☐ Discussions in student groups
- ☐ Use of online sources (e.g. forums, dictionaries)
- ☐ Other (please specify):

Instruction: Read the following pairs of text excerpts and answer the questions.

Excerpt A (academic style):

“The process of internalising social norms in the course of institutional academic socialisation conditions an individual’s ability to function within the educational field, which is determined by relations of symbolic power”.

Excerpt B (simplified style):

“During our studies, we learn principles and rules that allow us to function in the academic environment, where relations of influence and prestige are also important”.

13a. Which excerpt was easier for you to understand?

- ☐ Excerpt A
- ☐ Excerpt B
- ☐ Both to a similar extent
- ☐ Hard to say

13b. Which excerpt do you assess as more ‘academic’?

- ☐ Excerpt A
- ☐ Excerpt B
- ☐ Both to a similar extent
- ☐ Hard to say

13c. Which excerpt would encourage you more to continue reading?

- ☐ Excerpt A
- ☐ Excerpt B
- ☐ Neither excerpt
- ☐ Hard to say

DISCIPLINE-SPECIFIC AI ADOPTION IN HIGHER EDUCATION: INSIGHTS FOR ADVANCING QUALITY EDUCATION AND SUSTAINABILITY (SDG 4)

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Purpose: This study examines the usage patterns of artificial intelligence (AI) tools among 859 university students in Poland, representing three major academic fields. The research aims to identify discipline-specific differences in AI adoption, usage motivations, perceived benefits, and challenges, contributing to evidence-based strategies for advancing Sustainable Development Goal 4 (Quality Education).

Design/methodology/approach: An exploratory quantitative approach was employed using a cross-sectional online survey conducted from February to May 2025. Data from 859 students across humanities and social sciences, natural sciences and technology, and arts and communication were analysed using descriptive statistics and nonparametric methods (Kruskal-Wallis and DSCF post-hoc tests).

Findings: Significant inter-group differences were identified in AI adoption patterns. Humanities students primarily use AI for knowledge expansion (54%) and translation (48%). Natural sciences students emphasise problem-solving (51%) and knowledge acquisition (62%). Arts students focus on translation (63%) and creative content generation (46%). Despite widespread adoption, students across all disciplines express concerns about data privacy, ethics, and employment impacts.

Research limitations/implications: Convenience sampling and unequal group sizes limit generalizability. The cross-sectional design captures a single point during rapid technological change. Future longitudinal and comparative studies are recommended.

Practical implications: Universities should develop discipline-specific AI integration strategies, targeted professional development for faculty, and comprehensive AI literacy curricula. Preparing graduates for the evolving business landscape requires aligning AI literacy, critical thinking, and ethical competencies with industry expectations.

Social implications: The findings underscore the need for inclusive and equitable AI integration in higher education to prevent new forms of digital inequality, contributing to sustainable economic growth, digital transformation, and responsible workforce development.

Originality/value: This study provides empirical evidence on discipline-specific AI adoption patterns in the underexplored Central and Eastern European context, documenting usage during the critical transition from experimental to systematic AI integration in higher education.

Keywords: artificial intelligence, higher education, AI literacy, cross-disciplinary differences, sustainable education.

Category of the paper: Research paper.

1. Introduction

The emergence of generative artificial intelligence (GenAI) has catalysed a profound transformation in higher education, often described as a paradigm shift comparable to the advent of the internet (Polyportis, 2024). Since the launch of ChatGPT in November 2022, universities worldwide have moved from experimental AI use toward more systematic integration strategies. While 2024 has been described as a critical design phase, 2025 is expected to become the “year of discovery” for meaningful AI implementation (Inside Higher Ed, 2024). These developments are reshaping how students acquire knowledge, create content, and develop academic skills while presenting both opportunities and challenges for educational institutions (Alreshidi et al., 2025).

This transformation aligns with Sustainable Development Goal 4 (Quality Education), which aims to ensure inclusive and equitable education and promote lifelong learning (United Nations, 2030). AI technologies may act as educational equalisers by supporting language accessibility, personalised learning, and broader access to resources (Pachava et al., 2025). However, disciplinary differences in the adoption and integration of AI may also create new inequalities, as academic fields vary in their engagement with and acceptance of these technologies. Understanding such variations is essential for designing inclusive AI integration strategies that advance SDG 4 targets (Zapata et al., 2024).

Empirical evidence indicates significant disciplinary differences in students’ engagement with generative AI. Technology-oriented fields typically demonstrate higher adoption rates than the arts, humanities, and social sciences. These differences extend beyond frequency of use: technical disciplines often integrate AI into complex problem-solving tasks, while humanities and social sciences more commonly use it for communication or content analysis (Kim et al., 2025). Although students across disciplines frequently use AI for routine tasks, their engagement with cognitively demanding activities varies considerably, suggesting that task characteristics and disciplinary epistemologies influence AI adoption patterns (Qu et al., 2024).

AI-powered tools are increasingly embedded in modern educational environments, enabling personalised learning, real-time feedback, and improved access to global knowledge resources (Zhou et al., 2024). Generative tools such as ChatGPT, Google Gemini, and Microsoft Copilot facilitate academic writing, problem-solving, and project development (Von Garrel, Mayer,

2023; Almassad et al., 2024). At the same time, translation technologies and writing assistants help overcome linguistic barriers for multilingual student populations (Bensalem et al., 2024). These developments reflect the growing importance of digital and AI literacy in higher education (Celik et al., 2024).

Despite rapid adoption, institutions face significant implementation challenges. A 2024 survey of chief technology officers found that only 9% believe higher education institutions are adequately prepared for the continued expansion of AI (Inside Higher Ed, 2024). Research also suggests that students may view AI less positively when applied to summative assessment or wellbeing support, while expressing greater acceptance for career support, formative learning, and administrative services (Rodway, Schepman, 2023). These findings highlight the importance of implementation strategies that prioritise student agency, disciplinary relevance, and ethical considerations.

Acceptance of AI also varies across academic disciplines. Students in natural sciences and technology report more frequent use of AI platforms and greater acceptance of their integration into academic workflows (Balabdaoui et al., 2024). In contrast, humanities students often express greater concern about ethics, data privacy, and the impact of AI on creativity and analytical thinking (Qu et al., 2024). Arts and communication students constitute a distinct group, frequently using AI for translation and content generation while also expressing high levels of concern about ethics and intellectual property (Amini, 2025).

Although global research provides valuable insights into AI adoption, regional perspectives remain underexplored, particularly in Central and Eastern Europe. Poland's higher education sector, combining traditional universities with innovative private institutions, offers a useful context for examining how AI adoption interacts with diverse disciplinary cultures and educational traditions. Local institutional environments and disciplinary cultures strongly influence how students perceive and engage with AI technologies (Qu et al., 2024).

This study addresses gaps in knowledge about discipline-specific AI adoption by analysing how students in the humanities and social sciences, the natural sciences and technology, and the arts and communication use AI tools in their academic work. Conducted between February and May 2025, during a period when universities were transitioning from experimental to more systematic AI integration, the study captures student experiences during a critical phase of educational transformation.

The research examines AI usage among 859 students from Polish universities and addresses three research questions: (1) What are the primary purposes of AI use across disciplines? (2) How frequently do students from different fields use various AI tools? (3) What benefits and challenges do students associate with AI in higher education?

The study contributes to the literature in several ways. First, it provides empirical evidence from Central and Eastern Europe, complementing existing studies from other regions (Diloy et al., 2023; Von Garrel, Mayer, 2023). Second, it identifies disciplinary differences in AI adoption, offering insights for developing targeted support strategies and more equitable

approaches to AI integration. Third, it highlights ethical and pedagogical challenges associated with AI adoption across fields, providing guidance for policymakers and educational leaders seeking responsible implementation. Finally, the findings contribute to discussions on achieving SDG 4 by examining how patterns of disciplinary AI adoption may support or hinder efforts to ensure inclusive and equitable quality education.

The remainder of this article is structured as follows: the Theoretical Background section reviews current research on AI applications in education, ethical challenges, and global adoption trends. The Methodology section outlines the survey-based research approach. The Results section presents findings on AI usage frequency, user motivations, perceived benefits and challenges, and statistically significant differences across disciplinary groups. In the Discussion section, these findings are contextualised within the broader academic landscape. Finally, the Conclusion highlights the main findings, research limitations, practical recommendations, and potential directions for future studies.

2. Theoretical Background

2.1. The Evolution of Artificial Intelligence in Higher Education

Artificial intelligence (AI) has evolved from experimental applications to integral components of contemporary higher education systems, fundamentally transforming how students acquire knowledge and engage with academic content across disciplines (World Economic Forum, 2024). The rapid acceleration in AI adoption, particularly following the launch of ChatGPT in November 2022, has created what researchers characterise as a paradigm shift in educational practices (Zhou et al., 2024). This transformation represents more than technological adoption; it constitutes a fundamental reimaging of teaching methodologies, learning processes, and academic skill development in the digital age (Walter, 2024).

AI-powered tools enable a shift from traditional, instructor-centred teaching methods to more interactive, personalised learning experiences that adapt to individual student needs and learning preferences. Modern students are increasingly utilising AI-based technologies to complete complex projects, create sophisticated presentations, and engage in advanced analytical tasks, effectively replacing conventional note-taking and research methods with more efficient and automated solutions (Haleem et al., 2021). These changes align with broader trends toward digitalisation in education, making knowledge acquisition more accessible, streamlined, and globally connected.

The integration of AI into educational systems has opened new pathways for skill development and knowledge acquisition, offering tailored learning approaches that respond to individual student needs, learning styles, and academic goals (Mariappan, Krishnan, 2023).

Contemporary students, characterised by high levels of digital competence, can effectively leverage AI tools to enhance their academic performance and develop essential 21st-century skills (Karagül et al., 2021). Their growing familiarity with generative AI (GenAI) technologies enables them to utilise these tools strategically and purposefully in their learning processes, resulting in more efficient and effective educational outcomes (Kelly et al., 2023).

2.2. Theoretical Frameworks for Understanding AI in Education

Personalised Learning Theory and AI Integration

The theoretical foundation for AI in education rests significantly on personalised learning theory, which emphasises the adaptation of educational experiences to individual learner characteristics, needs, and preferences (Zhiyenbayeva et al., 2022; Rodríguez et al., 2024). AI's capacity to analyse vast amounts of learning data and adapt to individual learning styles enables students to progress at their own pace in ways that align with their cognitive preferences and academic strengths (Mariappan, Krishnan, 2023). This personalisation increases engagement and learning effectiveness, allowing students to overcome academic challenges more efficiently while building confidence in their abilities. AI-powered learning platforms exemplify this theoretical approach by simplifying complex topics and presenting them in accessible formats tailored to individual comprehension levels. These systems ensure that students grasp fundamental concepts before progressing to more advanced material, creating scaffolded learning experiences that support academic success across diverse student populations (Celik et al., 2024).

Social Learning Theory and AI-Mediated Interactions

The application of social learning theory to AI-enhanced education reveals how AI technologies can facilitate collaborative learning experiences and peer interactions. Recent research demonstrates that AI tools can support social learning processes by enabling students to engage in collaborative content creation, peer review activities, and group problem-solving exercises mediated by intelligent systems (Zhou, Schofield, 2024). This theoretical perspective suggests that AI's educational value extends beyond individual learning enhancement to include facilitating meaningful social learning experiences.

Constructivist Learning Theory and AI Tools

Constructivist learning theory offers another crucial framework for understanding the role of AI in education. AI tools support constructivist principles by enabling students to actively construct knowledge through interaction with intelligent systems, exploration of AI-generated content, and creative application of AI capabilities to solve authentic problems (Grubaugh et al., 2023; Sima et al., 2024). This approach positions AI as a cognitive tool that supports students' active construction of understanding rather than passive consumption of information.

2.3. AI Tools in Higher Education

Generative AI and Content Creation Tools

AI tools offer an extensive range of functionalities that support diverse aspects of the learning process, with generative AI representing the most transformative category (Dang, Liu, 2022). Chatbots such as ChatGPT, Google Gemini, and Microsoft Copilot provide real-time academic support by answering complex questions, generating original content, and assisting in the creation of presentations, research proposals, and algorithmic solutions (Fauzi et al., 2023; Labadze et al., 2023). These tools effectively simulate academic consultation processes, providing students with immediate access to sophisticated analytical and creative capabilities.

Language Support and Communication Tools

Translation and language support technologies, including Google Translate, DeepL, and advanced language processing tools, help students overcome linguistic barriers while facilitating access to academic resources in multiple languages (Galante, 2020; Varela Salinas, Burbat, 2023). These tools are particularly valuable for international students and multilingual academic environments. Text analysis and transformation tools, such as QuillBot, Consensus, and advanced paraphrasing systems, assist students in synthesising information, rephrasing content, and preparing comprehensive literature reviews. Writing assistants like Grammarly and ProWritingAid enhance the quality of academic writing by identifying grammatical errors, suggesting stylistic improvements, and providing feedback on clarity and precision (Koltovskaia, 2020).

Immersive and Interactive Learning Technologies

Advanced AI technologies, designed to simulate human interactions, further enrich educational experiences by creating immersive learning environments. Virtual avatars and intelligent tutoring systems serve as sophisticated tools for online education, creating engaging environments that enhance student motivation and improve academic performance (Herbert, Dołżycka, 2022). These innovations significantly transform the academic landscape by making education more accessible, interactive, and effective for diverse learner populations.

2.4. Discipline-Specific AI Adoption Patterns

STEM Fields

Research consistently demonstrates that students in natural sciences, technology, engineering, and mathematics (STEM) fields represent the most frequent and sophisticated users of AI tools in higher education contexts (Von Garrel, Mayer, 2023). These students primarily leverage AI technology to comprehend and solve complex problems, analyse data, make decisions, develop programming skills, and tackle advanced academic writing tasks (Sergejev et al., 2024; Tyaningsih et al., 2024). STEM students commonly utilise tools such as ChatGPT for coding assistance, Canva for scientific visualisation, and specialised AI platforms for data analysis and mathematical modelling (Fadli, Iskarim, 2024). However, despite their

frequent usage, a substantial majority of STEM students recognise critical issues related to the reliability, accuracy, and potential biases inherent in AI systems, demonstrating a sophisticated understanding of AI limitations (Balabdaoui et al., 2024). Recent research indicates that natural science students approach AI tools deliberately and strategically, often integrating multiple AI applications into comprehensive problem-solving workflows (Balabdaoui et al., 2024). Studies reveal a strong interest among STEM students in the expanded integration of AI within educational processes, with many expressing expectations that universities should provide AI-powered tools based on credible, peer-reviewed academic sources (Balabdaoui et al., 2024).

Humanities and Social Sciences

Recent studies highlight the growing adoption of artificial intelligence tools in social sciences and humanities, though with distinct patterns compared to STEM fields. These technologies enable personalisation of learning processes while supporting content generation, critical analysis, and research synthesis activities (Kyrpa et al., 2024; Lobanova et al., 2024). In communication-related disciplines, tools such as ChatGPT are widely utilised for writing assistance, research support, and content development (Prokhorchuk, 2023). Students in humanities and social sciences recognise AI's value in both academic and professional contexts, particularly for tasks involving language processing, content analysis, and research organisation. Among the most frequently utilised AI tools are adaptive learning platforms, intelligent tutoring systems, and data visualisation solutions that support progress tracking and learning analytics (Lobanova et al., 2024). However, concerns about data privacy, academic integrity, and the authenticity of AI-generated content have emerged as significant considerations (Arly et al., 2023). Despite numerous benefits, persistent challenges include ethical considerations, reliability concerns, and insufficient preparation of educators for effective AI integration in humanities teaching (Lobanova et al., 2024).

Arts and Creative Disciplines

Art students represent the least studied group regarding the use of AI tools in learning, design, creative processes, and project development, creating a significant gap in the current research literature. Limited available studies suggest that art students generally accept AI technologies, viewing them as support tools for artistic activities rather than replacements for human creativity (Garwol, 2024). However, these students express substantial concerns about intellectual property rights, copyright protection, and the potential impact of AI on artistic originality and authenticity. Research conducted among creative professionals indicates that artificial intelligence can effectively serve as a “partner in the creative process”, assisting artists in developing interactive installations, graphic design projects, and multimedia presentations (Cherevatiuk, 2024). AI tools have shown particular promise in enhancing formal analysis skills among students in art history and visual studies courses, providing new approaches to understanding artistic techniques and cultural contexts (Carpino, Hudson, 2024).

2.5. Contemporary Challenges and Ethical Considerations

The rapid expansion of AI in higher education has revealed concerning disparities in access, comfort, and proficiency across different student populations and academic disciplines. Recent research indicates that while educators generally show higher comfort levels with AI technologies compared to students, significant gaps exist in their adherence to institutional AI ethics policies and understanding of appropriate usage guidelines (Copyleaks, 2024). These disparities raise critical questions about educational equity and the potential for AI adoption to exacerbate existing inequalities rather than addressing them. The integration of AI in higher education requires careful consideration of ethical frameworks that address privacy, academic integrity, bias, and the preservation of human agency in learning processes. Recent systematic reviews emphasise the importance of developing comprehensive ethical guidelines that balance AI's educational benefits with the protection of student rights and the preservation of educational values (Batista et al., 2024). Educational institutions must navigate a complex ethical terrain involving data privacy, algorithmic bias, academic dishonesty, and the appropriate balance between AI assistance and independent learning.

2.6. Implications for Sustainable Development Goal 4

The relationship between AI adoption in higher education and Sustainable Development Goal 4 (Quality Education) represents a critical area for contemporary research and policy development. AI technologies have demonstrated significant potential to enhance educational accessibility, personalisation, and effectiveness, particularly for underserved populations and students with diverse learning needs (AI for Good Foundation, 2024). However, the discipline-specific nature of AI adoption creates new challenges for achieving equitable quality education. Recent research proposes comprehensive frameworks for AI integration that prioritise educational equity, cultural sensitivity, and sustainable development principles (Pena et al., 2025). These frameworks emphasise the importance of understanding disciplinary differences while ensuring that AI implementation supports inclusive educational practices that benefit all students regardless of their academic field or background.

3. Methods

This study employs an exploratory quantitative approach to analyse how university students use artificial intelligence (AI) tools, their motivations, and their perceptions of these technologies in an academic context. A cross-sectional survey method was employed, enabling the examination of trends and attitudes among students from various fields of study during the critical period of AI adoption in 2024.

3.1. Research Setting and Participants

The study was conducted at leading private universities in Poland, with campuses located in major cities across the country. The research setting provides valuable insights into AI adoption patterns within Central and Eastern European higher education contexts, where educational systems are undergoing rapid digital transformation. A total of 859 undergraduate and postgraduate students participated in the research, representing a substantial sample size that enables reliable statistical analysis across disciplinary groups.

Due to research constraints and the need for timely data collection during a period of rapid AI evolution, a convenience sampling method was employed, allowing for efficient data collection across multiple institutions. However, this method did not provide comparable sample sizes in each group and limited the generalizability of the findings to the entire student population in Poland. Despite this limitation, the substantial sample size provided valuable insights into the diverse ways AI tools are utilized in the academic environment.

The final sample consisted of 564 students from the humanities and social sciences (65.7%), 200 students from the natural sciences and technology (23.3%), and 95 students from the arts and communication (11.1%). Age analysis revealed that 79.1% of respondents were 25 years old or younger, while the remaining participants belonged to older age groups. This demographic structure enables the assessment of differences in AI tool usage across various student groups while reflecting the contemporary Polish higher education demographic profile.

3.2. Data Collection Process

An anonymous online survey, conducted from February to May 2025, gathered quantitative data on student AI tool usage across disciplines. This data collection period marks a critical moment in AI adoption, coinciding with the transition from experimental to systematic AI integration in higher education institutions. The questionnaire addressed usage frequency, AI technologies used, perceived benefits, and application concerns while ensuring participant anonymity and ethical compliance.

The 35-question survey was organised into five theoretically grounded sections: (1) Demographic characteristics and academic background; (2) AI tool usage methods and contexts; (3) AI usage frequency across different categories; (4) Perceived benefits and learning outcomes; (5) AI technology challenges and ethical concerns. The questionnaire employed multiple measurement approaches: 5-point Likert scales (1 = strongly disagree to 5 = strongly agree) for attitudinal measures, frequency scales for usage patterns, multiple-choice questions for categorical data, and open-ended questions for qualitative insights.

3.3. AI Tool Application Areas Covered in the Study

The study examined student usage across six comprehensive AI tool categories, selected based on a systematic literature review and consultation with educational technology experts: (1) Generative AI chatbots (e.g., ChatGPT, Microsoft Copilot, Google Gemini) for content generation and academic consultation; (2) Text editing and translation applications (e.g., DeepL, Grammarly, Google Translate) for language support and writing enhancement; (3) Virtual assistants (e.g., Google Assistant, Siri, Alexa, Cortana) for task management and information retrieval; (4) AI-enhanced educational platforms (e.g., Duolingo, Coursera, Khan Academy) for personalized learning experiences; (5) Academic integrity tools (e.g., Copyscape, Turnitin) for plagiarism detection and originality verification; (6) Research and citation support tools (e.g., QuillBot, Citation Machine) for paraphrasing and bibliographic management.

3.4. Data Analysis

Data analysis employed a multi-stage statistical approach combining descriptive statistics and inferential testing. The primary analysis utilised the non-parametric Kruskal-Wallis one-way ANOVA, followed by Dunnett's C (DSCF) post-hoc pairwise comparisons, to determine statistically significant differences in student AI usage patterns across disciplines. The Kruskal-Wallis test was selected due to the ordinal nature of the Likert scale data, confirmed absence of normality (Shapiro-Wilk tests), and the presence of unequal variances and group sizes across disciplinary categories. Effect sizes (eta-squared) were calculated to assess the practical significance of observed differences. All analyses were conducted using SPSS version 29.0, with an alpha level set at 0.05 for statistical significance testing.

4. Results

The utilisation of commonly available AI tools among students of various academic disciplines reveals distinct patterns, associated with specific needs and problems they face. Humanities and social sciences students use AI predominantly for expanding knowledge (54%), text translation or proofreading (48%), and developing the concepts of work or projects (43%), showcasing a balanced reliance on AI for both research and communication tasks (Figure 1). Conversely, natural sciences and technology students prioritise AI for expanding knowledge (62%) and problem-solving, decision-making, and making recommendations (51%). However, text translation or proofreading (53%) remains among the most popular reasons for AI utilisation (Figure 2). These findings seem to reflect their engagement with complex, data-driven processes and the use of multiple, multilingual sources. Lastly, students in arts and communication rely most heavily on AI for text translation or proofreading (63%), expanding

knowledge (57%), and text analysis, processing, and generation (46%) (Figure 3). This indicates a strong focus on communication and content creation within their field.

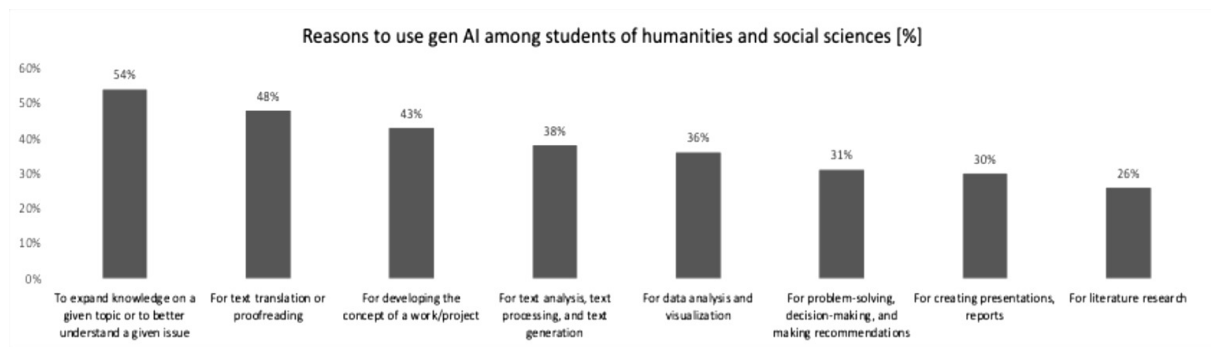


Figure 1. The utilisation of AI among students of humanities and social sciences [%, multiple-option choice, n = 564].

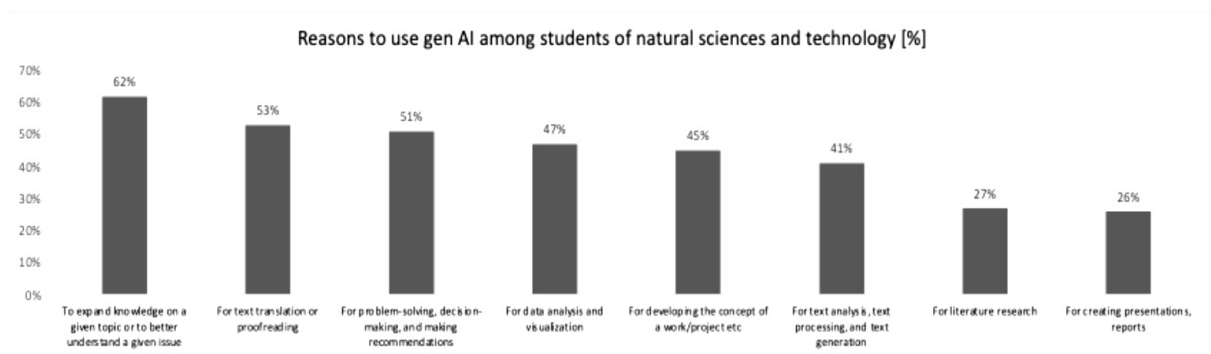


Figure 2. The utilisation of AI among students of natural sciences and technology [%, multiple-option choice, n = 200].

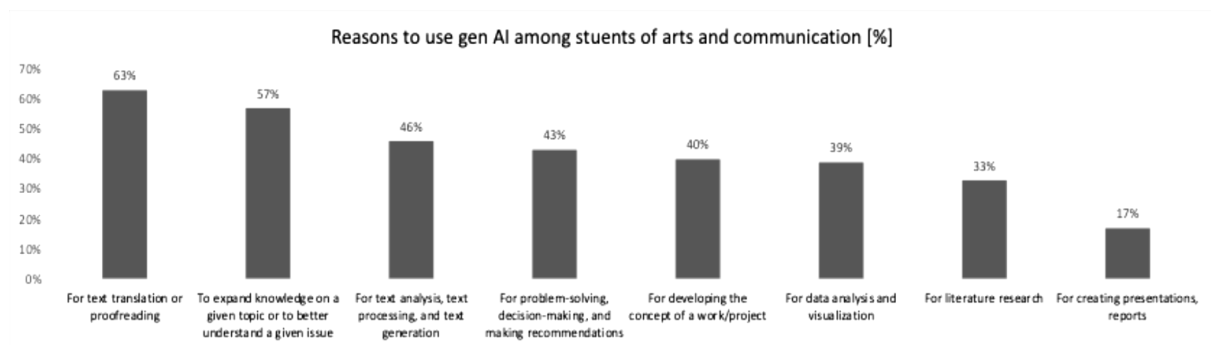


Figure 3. The utilisation of AI among students of arts and communication [%, multiple-option choice, n = 95].

Table 1.

The frequency of using various AI tools among students in different fields of study

Type of AI tool	Field of study	Mean	SD
AI chatbots	Humanities and social sciences	3.06	1.148
	Natural sciences and technology	3.54	1.124
	Arts and communication	3.27	1.096
Virtual assistants	Humanities and social sciences	2.80	1.458
	Natural sciences and technology	2.59	1.450
	Arts and communication	2.47	1.435

Cont. table 1.

Language translation and correction tools	Humanities and social sciences	2.53	1.378
	Natural sciences and technology	2.71	1.423
	Arts and communication	2.85	1.414
Learning platforms	Humanities and social sciences	2.36	1.225
	Natural sciences and technology	2.62	1.435
	Arts and communication	2.65	1.435
Antiplagiarism tools	Humanities and social sciences	1.50	0.833
	Natural sciences and technology	1.44	0.849
	Arts and communication	1.83	1.182
Automated citation generators	Humanities and social sciences	1.50	0.913
	Natural sciences and technology	1.54	0.971
	Arts and communication	1.61	1.170

The frequency of using various AI tools among students in different fields of study differs greatly (Table 1). AI chatbots like ChatGPT enjoy the greatest use frequency among students of all reported fields of study. In fact, 54% of natural science and technology students, 44% of art and communication students, and 36% of humanities and social science students use AI chatbots at least a few times a week. Language translation and correction tools are also frequently used. 39% of art and communication students use such tools at least a few times a week. 32% of natural science and technology students and 30% of humanities and social science students use language translation and correction tools with matching frequency. Virtual assistants seem to be used quite as often as language translation tools. Learning platforms are used less frequently, with 33% of art and communication students, 25% of natural science and technology students, and 20% of humanities and social science students using them at least a few times a week. Antiplagiarism tools and automated citation generators are among the least popular tools reported to be used.

Nonparametric one-way ANOVA using the Kruskal-Wallis test, together with DSCF (Dunnett's C) pairwise comparison, was used to investigate whether there are statistically significant differences between students' AI usage patterns stemming from their respective fields of study. The results suggest a few noteworthy cases where students of different study fields differ significantly in their frequency of using various AI tools. Students in natural sciences and technology use AI chatbots significantly more often than students in humanities and social sciences (3.54 vs. 3.06, $p < 0.001$), perhaps reflecting the former's need to solve complex problems related to their field. Similarly, natural science and technology students use learning platforms more often than humanities and social science students (2.62 vs. 2.36, $p < 0.021$). This difference may stem from the nature of natural and technical studies, which require precision and keeping pace with rapid advancements. Interestingly, there is also a significant difference in the use of AI-powered antiplagiarism tools. Arts and communication students (1.83) use these tools significantly more often than humanities and social science students (1.50, $p < 0.038$) and natural science and technology students (1.44, $p < 0.009$). This may reflect greater sensitivity among arts and communication students regarding the ethical use of others' work.

Table 2.*How AI helps students with learning [%, multiple-option choice]*

Benefit of AI use	Humanities and Social Sciences	Art and Communication	Science and Technology
Increases efficiency in acquiring information	69.7%	63.2%	74.5%
Helps develop skills through adaptive learning	40.2%	36.8%	53%
Facilitates personalization of the learning path	39.9%	40%	40.5%
Increases speed of acquiring information	0%	0%	0%

Students surveyed seem to value AI in their learning process for similar reasons. Regardless of their field of study, students most appreciate the increased efficiency in acquiring information thanks to AI tools (between 63.2% and 74.5%) (Table 2). It is interesting to note, however, that while efficiency is highly valued, other potential benefits of AI tools, such as personalized and adaptive learning experiences, were not as frequently mentioned.

Table 3.*Potential challenges associated with using AI [%, multiple-option choice]*

Challenges of AI use	Humanities and Social Sciences	Art and Communication	Science and Technology
Lack of understanding of AI	35.1%	41.1%	33%
Fear of job loss	33.7%	49.5%	35%
Ethical challenges	35.1%	44.2%	30.5%
Privacy concerns	47.2%	54.7%	45%

Surveyed students most often cited privacy concerns as a challenge associated with using AI. Other challenges, such as a lack of understanding of AI, fear of job loss, and ethical issues, were reported at similar rates. However, art and communication students expressed the most concern about the potential challenges of using AI tools (Table 3).

5. Discussion

The results of this study confirm the transformative impact of artificial intelligence (AI) tools across higher education disciplines, providing empirical evidence of what researchers have characterised as a paradigm shift in educational practices (Zhou et al., 2024). The findings reveal that AI adoption has moved beyond experimental usage to become integral to academic workflows, with over 95% of surveyed students actively utilising AI tools in their educational activities. The timing of this research—conducted during the critical transition period from February to May 2025—captures AI usage patterns during what experts have identified as the

shift from experimental to systematic integration phases in higher education (Inside Higher Ed, 2024).

The study's most significant contribution lies in revealing how discipline-specific factors shape AI adoption patterns. The findings demonstrate that disciplinary differences extend far beyond simple tool preferences to reflect deeper philosophical approaches to knowledge creation and academic practice, confirming recent theoretical frameworks that emphasise the cultural-historical dimensions of technology adoption in educational contexts (Qu et al., 2024).

Students in humanities and social sciences demonstrate a communication-oriented approach to AI usage, primarily employing tools for knowledge expansion (54%), text translation and proofreading (48%), and conceptual project development (43%). This pattern reflects the interpretive and communicative nature of humanities disciplines, where AI serves as a supplementary tool for enhancing textual analysis, cross-cultural communication, and content synthesis rather than replacing core analytical processes (Lobanova et al., 2024). The emphasis on translation and language support tools reflects the increasingly multilingual and globally connected nature of humanities scholarship.

Students in natural sciences and technology fields demonstrate the most sophisticated integration of AI tools into their academic workflows, with 62% using AI for knowledge expansion and 51% for problem-solving and decision-making. This pattern reflects the analytical and computational nature of STEM disciplines, where AI tools align naturally with existing methodological approaches and research practices (Sergejev et al., 2024). The statistically significant higher usage of generative chatbots (3.54 vs. 3.06, $p < 0.001$) and educational platforms (2.62 vs. 2.36, $p < 0.021$) among STEM students compared to humanities students confirms previous research indicating that technical fields naturally emerge as leaders in technological innovation adoption (Balabdaoui et al., 2024).

The findings reveal that arts and communication students occupy a unique position in AI adoption, demonstrating both the highest usage rates for translation tools (63%) and the strongest concerns about ethical implications. This paradoxical pattern reflects the complex relationship between AI and creative practice, where students simultaneously embrace AI's creative potential while grappling with fundamental questions about authorship, originality, and intellectual property (Garwol, 2024). The significantly higher usage of anti-plagiarism tools among arts students (1.83 vs. 1.50 for humanities, $p < 0.038$) suggests heightened sensitivity to issues of originality and academic integrity.

5.1. Theoretical Implications

The disciplinary differences observed in this study can be understood through cultural-historical activity theory, which emphasises how technological tools are mediated by cultural practices, community norms, and historical traditions. Each academic discipline represents a distinct activity system, characterised by specific tools, rules, and community practices that shape how AI technologies are perceived, adopted, and integrated into academic work.

STEM disciplines, with their emphasis on quantitative analysis and systematic problem-solving, naturally align with AI capabilities for data processing and algorithmic thinking. Humanities disciplines, focusing on interpretation, critical analysis, and cultural understanding, utilise AI differently, emphasising language processing and content synthesis capabilities while maintaining human agency in interpretive processes.

The findings support constructivist learning theory by demonstrating that students actively construct their understanding of AI tools based on their disciplinary contexts and educational needs. Rather than passively adopting AI capabilities, students engage in purposeful selection and integration of AI capabilities that align with their field-specific learning objectives and methodological approaches.

The study reveals universal concerns about data privacy, ethical implications, and academic integrity across all disciplinary groups, confirming recent research indicating that students are increasingly aware of the complex ethical dimensions of AI usage in educational contexts. The finding that arts students express the strongest ethical concerns aligns with research indicating that creative disciplines are particularly sensitive to issues of intellectual property, authorship, and originality.

The study's findings occur within a broader context where only 9% of higher education leaders believe their institutions are adequately prepared for AI's continued expansion (Inside Higher Ed, 2024). This preparedness gap suggests that students are navigating AI adoption with limited institutional guidance, which may lead to inconsistent practices and missed opportunities for pedagogically sound integration.

5.2. Implications for Sustainable Development Goal 4

The study's findings have significant implications for achieving Sustainable Development Goal 4 (Quality Education), revealing both the potential for AI to enhance educational accessibility and quality while also creating new challenges for educational equity. The discipline-specific nature of AI adoption suggests that institutions must develop nuanced approaches to AI integration that ensure all students, regardless of academic field, can benefit from AI's educational potential.

The study's findings support the development of comprehensive frameworks for AI integration that prioritise educational equity, cultural sensitivity, and sustainable development principles. Such frameworks must acknowledge disciplinary differences while ensuring that AI implementation supports inclusive educational practices that benefit all students. Key components of inclusive AI integration include: (1) discipline-specific AI literacy programs that address both technical skills and ethical considerations; (2) comprehensive support systems that help students navigate AI tools effectively while maintaining academic integrity; and (3) institutional policies that promote responsible AI usage while preserving the core educational values of different academic disciplines.

5.3. Practical Implications for Stakeholders

For Educational Institutions

Institutions should develop discipline-specific AI integration strategies that acknowledge the unique needs, challenges, and opportunities within different academic fields. This includes creating targeted professional development programs for faculty, developing comprehensive AI literacy curricula for students, and establishing clear ethical guidelines for the use of AI in academic contexts. Institutions should invest in infrastructure and support systems that enable all students, regardless of disciplinary background, to benefit from AI's educational potential while maintaining appropriate oversight and guidance.

For Faculty and Educators

Faculty should develop an understanding of how AI tools can enhance rather than replace core disciplinary practices and learning objectives. This includes exploring pedagogical approaches that integrate AI tools meaningfully into course design while maintaining focus on critical thinking, creativity, and disciplinary expertise. The findings highlight the importance of explicit discussions about AI usage in academic contexts, including ethical considerations, appropriate usage guidelines, and the relationship between AI assistance and independent learning.

For Students

Students should develop AI literacy skills that include both technical competency and ethical awareness. This includes understanding the capabilities and limitations of different AI tools, developing critical evaluation skills for AI-generated content, and maintaining awareness of academic integrity requirements in AI-enhanced learning environments. The findings suggest that students across all disciplines can benefit from AI tools, but practical usage requires purposeful integration aligned with disciplinary learning objectives and methodological approaches.

For Policymakers

Policymakers should support the development of comprehensive frameworks for AI integration in higher education that prioritise educational equity, academic integrity, and sustainable development goals. This includes funding research on the educational impact of AI, supporting professional development for educators, and developing guidelines for the responsible use of AI in educational contexts. The findings suggest the need for policies that address the digital divide and ensure that all students, regardless of disciplinary background or socioeconomic status, can access and benefit from AI-enhanced educational opportunities.

6. Summary

This study provides valuable empirical evidence of the complex, discipline-specific nature of AI adoption in higher education, revealing both the transformative potential and significant challenges associated with integrating AI across various academic fields. The findings demonstrate that AI adoption reflects more profound differences between disciplines, requiring nuanced approaches to integration that acknowledge and support disciplinary diversity while promoting educational equity and academic integrity. The research contributes to an understanding of how AI technologies are reshaping higher education while highlighting the importance of maintaining human agency, critical thinking, and disciplinary expertise in AI-enhanced learning environments.

6.1. Limitations

Several limitations should be acknowledged when interpreting these findings. The convenience sampling methodology may have overrepresented students with greater interest in or experience with AI technologies, potentially biasing the results toward higher usage rates and more positive attitudes. The unequal sample sizes across disciplinary categories, particularly the smaller sample sizes in the arts and communication, may limit the statistical power to detect differences in this group. Additionally, the cross-sectional design captures AI usage patterns at a single point in time during a period of rapid technological change, potentially missing important temporal dynamics in adoption patterns.

6.2. Future Research

Future research should address several critical questions emerging from this study. Longitudinal studies are necessary to track the evolution of AI usage patterns as students progress through their academic programs and as AI technologies continue to advance. Research examining the long-term impact of AI usage on learning outcomes, critical thinking skills, and academic performance across different disciplines would provide valuable insights for educational policy and practice. Comparative studies across different national and institutional contexts would help identify universal patterns versus culturally specific factors in AI adoption. Additionally, qualitative research exploring the lived experiences of students using AI tools across different disciplinary contexts would provide deeper insights into the motivations, challenges, and outcomes of AI adoption.

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THE LINGUISTICS STUDENT FACED WITH THE CHALLENGES OF SPECIALISED DISCOURSE ANALYSIS

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Purpose: The aim of this article is to identify the challenges faced by students of applied linguistics when analysing specialised discourse and developing the specialist competences necessary to function effectively in today's labour market.

Design/methodology/approach: The article is based on an analysis of the specific nature of specialised discourse (at the lexical, morphosyntactic, textual and phonetic levels, as well as in terms of specialised, sociolinguistic and intercultural competences) and on a qualitative analysis of specialised Italian language textbooks used by students of applied linguistics (content analysis).

Findings: The analysis of the characteristics of specialised discourse points to a long list of challenges for linguistics students in the areas studied, while the analysis of selected textbooks reveals their great potential in teaching specialised competences, as well as the uneven development of language competences, including the lack of a translation component. It has been confirmed that effective work with specialised discourse requires an integrated approach that takes into account both linguistic and subject-specific aspects.

Research limitations/implications: The study was conducted on a limited sample of specialist Italian language textbooks, which limits the possibility of generalising the results. It would be worthwhile to extend the study to include a comparative analysis of textbooks for other languages and at other levels of proficiency.

Practical implications: The findings may influence the modification specialised language curricula, particularly through greater use of authentic materials, pragmatic competence training and the development of discourse analysis tools in teaching practice.

Social implications: Improving the quality of specialist language teaching translates into better preparation of graduates for work in multilingual and multicultural environments, which can increase their professional mobility and effectiveness in intercultural communication.

Originality/value: This article attempts to systematically address the real challenges faced by students of applied linguistics when analysing specialised discourse. A novel feature is the combination of a didactic perspective with metalinguistic reflection, which may be useful for both academic teachers and authors of teaching materials.

Keywords: specialised discourse, applied linguistics, discourse analysis, specialised language; mobility; multiculturalism.

Category of the paper: research paper.

1. Introduction

In the face of dynamic changes in the contemporary labour market, applied linguistics is no longer perceived solely as the study of language – it is gaining a practical dimension, focused on preparing students for the realities of international and intercultural professional communication. Knowledge of a foreign language, although still important, is not sufficient in the context of contemporary requirements. Intercultural, pragmatic and interpersonal skills are also becoming crucial, as they enable effective functioning in diverse professional environments.

In the era of globalisation, effective communication is based on flexible movement between different linguistic and cultural codes and on understanding the specifics of specialist professional contexts. A particular challenge is the mastering of specialist discourse, which requires not only advanced knowledge of professional terminology, but also the ability to recognise complex syntactic structures, genre conventions and cultural conditions specific to a given professional field. Therefore, the education of future linguists should be interdisciplinary and based on working with authentic texts and real communication situations.

The aim of this article is to present the main challenges faced by students of applied linguistics in the context of specialised discourse analysis, as well as to identify the areas of competence that need to be developed in order to prepare them to function effectively in the realities of today's global labour market.

In order to better define the specific nature of these challenges, it is necessary to examine the issue of specialised discourse, its definitions and properties that determine how language functions in professional contexts. In the following section of this article, three popular textbooks on Italian specialised language will be analysed in order to assess the extent to which they take into account the development of the key elements of specialised discourse and the competences necessary for its correct use.

2. Literature analysis – the Specificity of Specialised Discourse

Discourse can be defined broadly as language in use or as a communicative act, text, or utterance enacted in a specific communicative context (Dijk, 2001). Contemporary research further emphasises discourse as a social practice that reflects and shapes power, identities, and professional norms within communities of practice (Fairclough, 2020).

Specialised discourse, on the other hand, is a specific way of using language within a particular professional or scientific community, serving the function of exchanging knowledge, coordinating activities among experts, and supporting professional practices

(Grucza, 2006). It is characterised not only by the precise use of terminology and adaptation to the context of professional communication, but also by its dynamism — it evolves with the development of the field and changing communication needs (Gotti, 2008).

Specialised discourse encompasses a variety of forms of communication, from written texts such as scientific articles or reports, through oral interactions such as conferences and meetings, to multimodal presentations using charts, diagrams, or other visual aids (Balboni, 2000). In addition to the transmission of information, it plays negotiating, persuasive, and regulative roles, influencing decisions, standard-setting, and shaping knowledge structures within specific domains (Porcelli, 1990; Fairclough, 2020). This multidimensionality means that specialised discourse requires its participants not only to be linguistically proficient, but also to have the social, cultural, and contextual competences that enable them to navigate through a specific professional environment effectively.

Having defined specialised discourse and discussed its general characteristics, it is worth taking a closer look at its features at various linguistic levels — from lexical, through morphosyntactic, to textual and phonetic. This analysis will provide a more detailed understanding of how specialist language functions in practice and what challenges its users face, especially students of applied linguistics.

2.1. Characteristics of Specialised Discourse at the Lexical Level

The key characteristics of specialised discourse at the lexical level include monoreferentiality, transparency, lack of emotional connotations, conciseness and conservatism. Monoreferentiality means that within a given field a term has one precisely defined meaning, while transparency refers to a direct relationship between form and meaning, with metaphors rarely used. Specialised language is also characterised by the lack of emotional connotations and a tendency towards conciseness, whereby concepts are expressed in the shortest possible form, often through acronyms, abbreviations or compound lexemes; additionally, it shows a degree of conservatism, reflected in the predominance of established terms whose meanings remain stable (Gotti, 2008). Developing specialised vocabulary presents particular challenges because learners must acquire not only precise lexical items but also the ability to use them in occupation-specific communicative activities (Dudzik, Dzięcioł-Pędich, 2022).

In addition to unambiguity and precision, an important feature of specialised vocabulary is a high frequency of borrowings and calques and term-formation creativity. New concepts, rooted in Latin and Greek, are created by adding various prefixes, suffixes or by combining existing words. The complexity and diversity of word-formation processes characteristic of specialist language make its mastery a time-consuming and labour-intensive process. Students must gradually learn the meanings of individual morphological elements, such as prefixes and suffixes, and understand the rules for combining them (cf. Balboni, 2000, pp. 51-58; Borczyk, 2023; Gotti, 2008; Porcelli, 1990, pp. 10-11).

From the learner's perspective, these characteristics make the acquisition of specialised vocabulary particularly demanding. Students must not only memorise precise terminology but also recognise word-formation patterns and interpret numerous borrowings, acronyms and compound forms. As a result, developing lexical competence in specialised discourse requires systematic practice and gradual familiarisation with the morphological structure of terms.

Specialised discourse differs from general language not only in its terminology. Many important challenges that linguistics students face can also be found at the morphosyntactic level.

2.2. Characteristics of Specialised Discourse at the Syntactic Level

A primary feature of specialised discourse at the syntactic level is its tendency towards conciseness. This often manifests in the omission of articles, prepositions, and other minor linguistic elements—a phenomenon known as elision. In Italian, for example, such omissions are common in scientific, technical, and IT texts, instructional manuals, and public notices. Elision is motivated by the need for brevity and the efficient transmission of information, where articles and prepositions are considered secondary to the clarity of the message. In business communication, a reduced linguistic form is also frequently used, with unnecessary adjectives omitted and punctuation simplified. In legal and administrative texts, however, elision often arises from stylistic conventionalism rather than a need for brevity. For learners of specialised language, mastering elision requires understanding both the contexts in which it occurs and its communicative function (cf. Balboni, 2000; Hyland, 2022).

Nominalisation is another significant syntactic feature, which transforms verbs or other grammatical categories into nouns. This process allows complex actions or processes to be expressed concisely and formally, contributing to the impersonal and objective tone typical of professional discourse. In legal, scientific, and administrative texts, nominalisation is used to condense information and formalise statements, but excessive nominalisation can reduce text accessibility, particularly for students unfamiliar with the field or topic (cf. Borczyk, 2024).

Depersonalisation, closely related to nominalisation, involves the frequent avoidance of personal forms in favour of impersonal constructions. This strategy emphasises the action or state itself rather than the agent performing it, enhancing objectivity and communicative distance. Traditional syntactic patterns, such as subject–predicate–complement, are often modified, which can introduce ambiguity or require careful interpretation. In formal documents like civil contracts or administrative texts, depersonalisation is reinforced by anonymising participants, e.g., referring to “buyer” and “seller” instead of specific individuals, highlighting the formal and impersonal character of the discourse (cf. Sinatra, 2008).

Another syntactic aspect worth noting in specialist discourse is passivisation, which is a special form of depersonalisation. As the name suggests, it involves the frequent use of the passive voice, which serves to shift the emphasis from the performer of the action to the process

itself and the result of the action. This phenomenon most often appears in administrative and legal texts, as well as in technical descriptions and operating procedures. The purpose of passivisation, like depersonalisation, is to increase the objectivity of the statement and focus the recipient's attention on the subject of the message rather than its sender. It is worth noting that for learners of specialist language, such formal simplifications do not always translate into ease of comprehension, as they require users to have much more developed language skills. Therefore, the teaching process should be appropriately adapted – both in terms of methodology and the selection of materials – in order to effectively support the acquisition of these complex structures.

At the morphosyntactic level, specialised discourse shows clear tendencies in verb tense and grammatical mood usage, which vary depending on the communicative purpose and the nature of the field. Present tense is common in factual descriptions, passive voice or past perfect in process and research descriptions, while instructional materials often employ infinitive or imperative forms. Future tense predominates in economic forecasting texts, whereas conditional and subjunctive moods appear in speculative, philosophical, or hypothetical contexts. Modal verbs are frequently used in scientific discourse to express assumptions or hypotheses (Hyland, 2022).

Sentence structure is another key syntactic element. The choice between simple and complex sentences is determined by style and field specificity. Scientific texts describing research processes favour complex subordinate sentences for clarity and precision. Legal and argumentative texts also rely heavily on subordinate constructions, while technical and technological texts often use coordinate compound sentences. Simple sentences are characteristic of manuals and instructional documents but are usually dense with terminology, abbreviations, and specialised vocabulary (cf. Balboni, 2000; Ballarin, 2009; Porcelli, 1990).

In summary, at the syntactic level, specialised discourse poses challenges for students in mastering complex grammatical and structural features such as elision, nominalisation, depersonalisation, and passivisation. These phenomena require not only knowledge of grammatical rules but also the ability to interpret texts where such forms enhance objectivity, conciseness, and formal tone. Additionally, the diversity of verb tenses, moods, and sentence structures across different professional fields demands sustained practice and careful guidance to ensure comprehension and correct usage.

2.3. Characteristics of Specialised Discourse at the Textual Level

At the textual level, specialised discourse is distinguished by its specific organisation of content, standardised structure and functionality subordinated to specific communication goals. Within micro-languages, various types of texts are characteristic, such as scientific articles, reports, research papers, technical documentation, user manuals, regulations, specifications, contracts, official letters, formal correspondence, as well as recruitment documents, including CVs, covering letters, and references (Hyland, 2022).

The structure of such texts is usually based on scientific conventions, which are highly formalised, predictable and often supported by editorial templates. In legal and administrative texts, standardisation manifests itself, among other things, in the logical arrangement of paragraphs, the presence of headings and subheadings, and the use of numerous footnotes and bibliographies. This facilitates navigation through the content and promotes unambiguous communication, which is particularly important in professional environments that require a high level of precision (cf. Gotti, 2008; Porcelli, 1990).

Visual elements such as graphs, tables, diagrams, infographics, and charts play an important role in organising information and enhancing clarity. In technical and promotional texts, these elements can dominate over verbal content, which is reduced to the essential minimum, reflecting the principles of economy of language and effective persuasion (cf. Balboni, 2000; Gotti, 2008; Porcelli, 1990).

In the area of electronic communication, including email correspondence, there is a departure from rigid standards – stylistic simplifications, the absence of classic forms of politeness, and inconsistent use of spelling rules are common. This is a manifestation of changes in the culture of written communication, resulting from the need for speed and effectiveness, as well as the influence of technology on language (Balboni, 2000; Hyland, 2022).

In promotional and advertising texts, such as brochures or industry leaflets, visual elements take on a dominant role. Verbal communication is reduced to the bare minimum, and images become the main vehicle for content (cf. Balboni, 2000, pp. 51-58; Gotti, 2008; Porcelli, 1990). This type of message is subject to the principles of economy of language and effective persuasion.

Understanding textual characteristics in specialised discourse requires students to master the organisation and conventions of various text types, interpret and reproduce standardised structures, and integrate visual and verbal elements effectively. They must also adapt to stylistic variations across media and professional contexts, recognising differences in formality, purpose, and audience expectations, which presents a significant challenge.

2.4. Characteristics of Specialised Discourse at the Phonetic Level

At the phonetic and phonological level, specialised discourse poses several challenges for learners, even though it is less frequently analysed in language education. Phonetic difficulties include the pronunciation of complex, multisyllabic terms of Latin, Greek, or other classical origin, such as *elettroencefalografia*, *interdisciplinarità*, or *ipercolesterolemia* in Italian (Balboni, 2000; Gotti, 2008). Mastery of such terms requires precise control of stress, syllable division, and intonation patterns typical of the language.

Other challenges involve the use of intonation, rhythm, and speech rate. In formal specialist contexts—such as ed intonation predominates, and speech should be neither too fast nor irregular to avoid comprehension difficulties or phonetic distortions (Crystal, 2003).

These aspects mean that phonetic competence must be developed alongside lexical, syntactic, and pragmatic skills. Moreover, learners must cultivate broader communication abilities, including specialist, sociolinguistic, and intercultural competences. In professional contexts, the challenge lies not only in how one speaks, but also in what is communicated, to whom, and under what circumstances, highlighting the complexity of mastering specialised discourse in multilingual and multicultural environments (Levis, 2020).

2.5. Specialist Competence

Specialised discourse is deeply embedded in subject-specific knowledge, which creates a number of challenges for learners. Students must not only master the language but also acquire a thorough understanding of the subject matter in order to interpret texts accurately. Developing specialist competence involves learning to use terminology precisely, understanding processes and concepts specific to a professional domain, and recognising genre conventions typical of professional texts (Hyland, 2022).

The literature (Swales, 1990) highlights that genre awareness—the ability to identify the structure and function of texts according to their communicative purpose and audience—is critical. Students face the challenge of distinguishing between different text types, such as technical reports and legal contracts, which have diverse formal, stylistic, and pragmatic requirements. Without sufficient specialist knowledge, learners risk misinterpreting meaning, misusing terminology, or selecting inappropriate linguistic forms.

In educational practice, these challenges imply that teaching specialist language must go beyond vocabulary memorisation. Students need guidance to understand the discursive context of a field and to apply their knowledge effectively. Additionally, sociolinguistic competence presents another layer of difficulty: learners must adapt their language to varied professional relationships, levels of formality, and institutional norms, which requires both linguistic flexibility and cultural awareness (Hyland, 2022).

2.6. Sociolinguistic Competence

Sociolinguistic competence refers to the ability to use language in a manner appropriate to the social and situational conditions in which communication takes place. In models of communicative competence (Canale, Swain, 1980; Bachman, 1990), it is considered a key component alongside grammatical and pragmatic competence, as it involves understanding factors such as the status of interlocutors, the degree of formality, professional relationships, and institutional contexts. Recent research continues to emphasise that sociolinguistic competence enables language users to adapt linguistic choices to cultural expectations, social norms, and communicative situations, which is essential for effective interaction in educational and professional settings (Santipolo, 2020; Balboni, 2022). For students, developing this competence often presents a challenge, as it requires not only linguistic knowledge but also awareness of social conventions and professional norms.

In the context of specialised discourse, sociolinguistic competence involves the ability to adapt communication to different audiences—for example, a superior, business partner, client, or member of a project team. Learners must therefore learn to select an appropriate language register, use suitable polite forms, adjust the tone of communication, and structure arguments in a manner consistent with professional expectations. A particular difficulty arises from the need to recognise how the same communicative intention may require different linguistic forms depending on the context—for instance, when formulating a request in a formal email compared with informal workplace communication.

Insufficient sociolinguistic competence may lead to communicative problems such as excessive directness, unintended impoliteness, or stylistic awkwardness. These challenges highlight the importance of incorporating activities that develop stylistic and pragmatic awareness into specialist language education, including the analysis of authentic communication situations and practice in adapting language to diverse professional contexts.

2.7. Intercultural Competence

The modern professional environment increasingly operates in multicultural contexts, which creates a need for the development of intercultural competence. This concept refers to the ability to communicate effectively and appropriately with representatives of other cultures while maintaining openness and awareness of cultural differences (Byram, 1997). For students, developing such competence often poses a challenge, as it requires not only linguistic knowledge but also the ability to recognise cultural assumptions, interpret messages in different cultural contexts, and adapt communication strategies accordingly (Deardorff, 2020; Jackson, 2020).

In the context of specialist discourse, intercultural competence involves adapting the tone and form of communication to the recipient's cultural and professional expectations. Students must learn to recognise differences in communication styles, such as varying degrees of directness in argumentation, the use of politeness strategies, or conventions of professional correspondence.

Earlier research by Hall (1976) and Hofstede (2001) highlights deeper cultural differences related to perceptions of time, hierarchy and patterns of communication. These factors may also influence the interpretation and production of specialist texts, including business correspondence or professional instructions, which can create additional difficulties for learners.

Developing intercultural competence in language education therefore requires not only providing knowledge about other cultures but also fostering students' ability to reflect on cultural differences and adjust their communication to diverse professional contexts (Deardorff, 2020).

In summary, the development of specialist, sociolinguistic and intercultural competences should be an integral part of language education focused on professional realities. Teaching materials, particularly specialist language textbooks, play an important role in this process, as they are intended not only to introduce terminology but also to prepare students to function effectively in multicultural professional environments.

3. Methods

The aim of this study is to analyse three popular textbooks on specialized Italian used in the education of applied linguistics students. The study aims to assess the extent to which these textbooks support the development of the above-mentioned competences and prepare students for effective communication in a professional environment, as well as to identify potential gaps or teaching difficulties. This analysis was conducted to collect the data necessary for answering the following research questions:

- **Lexical competences**
 1. What is the scope and degree of difficulty of specialist terminology in textbooks?
 2. What types of lexical exercises are used?
 3. Do textbooks present word formation processes and the use of loanwords, abbreviations, acronyms, neologisms and calques?
 4. Do they contain glossaries and definitions of terms to support the acquisition of specialised vocabulary?
- **Morphosyntactic competences**
 1. What is the level of syntactic complexity and grammatical difficulty of the texts?
 2. Do the textbooks analyse phenomena typical of specialised language, i.e. elision, nominalisation, depersonalisation, passivisation?
 3. Do the grammar exercises allow for the practical application of morphosyntactic structures?
- **Textual competences**
 1. Do the textbooks present a variety of text types characteristic of particular specialist fields?
 2. Do the materials contain exercises that support the recognition and reproduction of typical text structures?
 3. To what extent do they develop students' genre awareness?
- **Phonetic competences**
 1. What is the level of phonetic difficulty of the analysed texts?
 2. Do the textbooks contain phonetic transcriptions, listening tasks or audio/video recordings?

3. How do the exercises develop correct pronunciation, intonation and accent?

- **Specialised competence**

1. To what extent do textbooks provide substantive contexts for specialised terminology?
2. Do they introduce students to authentic professional situations?
3. To what extent do they use authentic professional materials in teaching specialised language?

- **Sociolinguistic competence**

1. How do textbooks support the adaptation of language to different social roles and communication contexts?
2. Do the materials take into account formality, tone, polite forms and register differences?
3. How do the exercises develop communication skills in different social situations?

- **Intercultural competence**

1. How do textbooks treat issues of intercultural communication?
2. To what extent do they take into account the role of cultural context in communication?
3. Do textbooks address culturally sensitive topics and how are they presented?

The research questions outlined above constitute the analytical framework for the present study.

4. Results

The results of the analysis are presented separately for each textbook and organised according to the competence areas defined in the analytical framework.

4.1. Textbook 1

Title: *Italiano Medico. Servizi sanitari. Terminologia medica. Casi clinici. Livello B1-B2*

Author: Daniela Forapiani

Publisher: Rome, Edilingua, 2012

Target group:

This textbook is intended for foreign students (including *Erasmus* programme participants) enrolled at Italian universities, as well as for non-native professionals working in Italian hospitals. It is designed for learners at B1-B2 levels and was developed in collaboration with the University of Parma. It can be used both for self-study and during university courses or specialized medical language training.

Structure of the textbook:

The textbook consists of ten thematic units. The first two chapters focus on topics and terminology related to the structure of the human body and professional medical equipment. The following three chapters deal with the Italian healthcare system, hospital organisation, and blood donation. The last five chapters are devoted to particular systems of the human body (digestive, cardiovascular, respiratory, urinary, and musculoskeletal).

Additional materials include audio recordings available on CD or via QR codes, an appendix with materials for copying and cutting out, an alphabetical glossary, a webography, transcripts of recordings, and an answer key.

4.1.1. Lexical Competence

With regard to RQ1 (scope and difficulty of specialist terminology), the textbook provides a broad range of medical vocabulary focusing on anatomy, medical equipment, healthcare systems, and the terminology of particular body systems. The terminology is introduced gradually and adapted to the B1-B2 level, although it includes numerous specialised medical terms.

Addressing RQ2 (types of lexical exercises), the textbook offers a wide variety of vocabulary activities. These include identifying terms in a visual dictionary, labelling illustrations and photographs, completing definitions with missing keywords, memory games for vocabulary retention, crossword puzzles reinforcing spelling, synonym matching, categorisation tasks, word games, and term definition exercises.

In relation to RQ3 (word formation processes and specialised lexical phenomena), the textbook presents selected word-formation processes by highlighting the meaning and function of common medical prefixes and suffixes. Learners are also encouraged to work with abbreviations and acronyms typical of medical discourse.

Regarding RQ4 (presence of glossaries and definitions), the textbook includes an alphabetical glossary at the end, which references the pages where each term appears in context. Space is also provided for students to write translations in their native language, which supports vocabulary acquisition.

4.1.2. Morphosyntactic Competence

With regard to RQ1 (level of syntactic complexity), the analysed texts demonstrate a relatively high degree of syntactic complexity typical of medical communication. The language reflects authentic medical discourse and includes complex sentence structures.

In relation to RQ2 (analysis of specialised morphosyntactic phenomena), the texts contain frequent examples of ellipsis, nominalisation, depersonalisation, passivisation, and implicit forms. However, these phenomena are generally not explicitly analysed or explained, which may limit learners' awareness of these features.

Addressing RQ3 (grammar exercises enabling practical application), the textbook includes grammar sections (*spunti grammaticali*) dealing with selected topics such as articles or irregular plural forms. These exercises are embedded within the units and are often combined with

communicative activities, language games, and role-plays, which facilitate the practical application of grammatical structures.

4.1.3. Textual Competence

In response to RQ1 (variety of text types), the textbook presents a range of materials including illustrations, photographs, dialogues, case studies, and models of doctor–patient interaction.

With regard to RQ2 (exercises supporting recognition and reproduction of text structures), the units are organised into clearly defined sections that include vocabulary introduction, main texts, exercises, and multimedia materials. Numerous tasks require students to analyse and reproduce specific communicative formats.

Addressing RQ3 (development of genre awareness), the textbook introduces learners to authentic types of medical texts such as laboratory test results, ECG printouts, and patient records, thereby supporting students' familiarity with professional documentation.

4.1.4. Phonetic Competence

With regard to RQ1 (phonetic difficulty of the texts), the phonetic difficulty may be considered relatively high due to the presence of numerous complex and multisyllabic medical terms.

Addressing RQ2 (phonetic support materials), the textbook includes audio and video recordings accompanied by transcripts, although phonetic transcriptions are not provided.

4.1.5. Development of Specialised Competence

Addressing RQ1 (substantive contexts for specialised terminology), each unit introduces vocabulary within realistic medical scenarios, such as the functioning of the healthcare system or hospital procedures.

With regard to RQ2 (introduction to professional situations), the textbook includes numerous case studies and role-play activities simulating doctor–patient interactions or other professional situations.

In response to RQ3 (use of authentic materials), the textbook incorporates authentic documents and materials reflecting the real context of the Italian healthcare system.

4.1.6. Development of Sociolinguistic Competence

Addressing RQ1 (adaptation of language to social roles), the exercises frequently require students to adopt different communicative roles, such as doctor, patient, receptionist, or helpline operator.

Regarding RQ2 (formality and register), the textbook introduces elements of formality and polite expressions primarily through dialogues presented in listening activities.

In relation to RQ3 (communication in social situations), role-plays and simulated interactions enable learners to practice communication strategies appropriate for different professional contexts.

4.1.7. Development of Intercultural Competence

With regard to RQ1 (intercultural communication), the textbook is strongly embedded in the Italian healthcare context and familiarises students with cultural norms related to medical communication in Italy.

Addressing RQ2 (role of cultural context), sections such as *Lo sapevi che...?* and prompts encouraging online exploration promote cultural reflection and contextual understanding.

In relation to RQ3 (culturally sensitive topics), such topics are generally limited. One example is a dialogue involving an immigrant contacting a helpline to obtain information about procedures for acquiring a health insurance card.

4.2. Textbook 2

Italiano per giuristi – updated edition. Level B1-C2

Author: Daniela Forapiani

Publisher: Alma Edizioni, Florence, 2021

Target group:

The textbook is intended for students (including Erasmus programme participants), translators, researchers, and international professionals who require specialised knowledge of Italian for legal or academic purposes. It is designed for learners with B1-B2 level language proficiency and a general understanding of legal systems. The textbook may also be used for self-study.

Structure of the textbook:

The textbook consists of fifteen thematic units focusing on key areas of law, including the Italian legal system, hierarchy and interpretation of legal sources, constitutional law, civil law, commercial law, comparison between Roman-Germanic and Anglo-Saxon legal traditions, as well as civil and criminal procedure.

Additional materials include an alphabetical glossary with definitions and references to textbook units, an answer key, and an appendix containing a webography with links to legal websites.

4.2.1. Lexical Competence

With regard to RQ1 (scope and difficulty of specialist terminology), the textbook presents a very extensive range of legal terminology covering fields such as civil law, administrative law, criminal law, and European law. The degree of lexical difficulty is high, as many terms occur exclusively in legal discourse and have no direct equivalents in general language.

Addressing RQ2 (types of lexical exercises), the textbook offers numerous vocabulary tasks, including paraphrasing legal provisions, summarising content, matching definitions, identifying synonyms and antonyms, completing diagrams and mind maps, filling in keywords in legal texts, answering detailed comprehension questions, and solving crossword puzzles that reinforce spelling.

In relation to RQ3 (word formation processes and specialised lexical phenomena), the textbook highlights selected word formation mechanisms by presenting the function of common prefixes and suffixes and encouraging learners to create derivative forms and complete lexical families. Work with abbreviations and acronyms is also included, and certain loanwords used in legal discourse, such as *common law*, are discussed.

Regarding RQ4 (presence of glossaries and definitions), the textbook includes an alphabetical glossary with definitions and references to the units in which the terms appear. The glossary also provides space for learners to note translations in their native language.

4.2.2. Morphosyntactic Competence

With regard to RQ1 (level of syntactic complexity), the analysed texts demonstrate a very high level of syntactic complexity characteristic of legal discourse. Long sentences, elaborate subordinate structures, and complex complements frequently occur in the materials.

In response to RQ2 (analysis of specialised morphosyntactic phenomena), the textbook explicitly addresses linguistic features typical of specialised legal language, including ellipsis, nominalisation, depersonalisation, passivisation, and implicit forms. These phenomena are discussed and illustrated through examples taken from authentic legal texts.

Addressing RQ3 (grammar exercises enabling practical application), the textbook contains numerous grammar activities designed to practise complex sentence structures, such as inserting relative pronouns, analysing participial constructions, completing clauses with appropriate conjunctions, and studying the role of pronouns and particles in legal texts.

4.2.3. Textual Competence

Addressing RQ1 (variety of text types), the textbook presents a wide range of legal genres, including laws, codes, excerpts from judicial decisions, contracts, official documents, court summonses, and procedural documents.

With regard to RQ2 (recognition and reproduction of text structures), authentic formatting of legal documents is preserved, including articles, paragraphs, headings, and numbering. This allows learners to become familiar with the structural conventions of legal texts.

In relation to RQ3 (development of genre awareness), the textbook promotes students' understanding of the stylistic and functional characteristics of legal genres by providing models and templates of official documents.

4.2.4. Phonetic Competence

With regard to RQ1 (phonetic difficulty), the phonetic complexity of the texts is relatively high due to the presence of numerous complex and multisyllabic legal terms.

Addressing RQ2 (phonetic support materials), the textbook does not include audio recordings, listening exercises, or phonetic transcriptions.

In response to RQ3 (development of pronunciation and prosody), pronunciation and intonation are not explicitly addressed, as the textbook focuses primarily on written legal discourse.

4.2.5. Development of Specialised Competence

Addressing RQ1 (substantive contexts for specialised terminology), the textbook provides extensive explanations of legal institutions, legal systems, and basic legal procedures.

With regard to RQ2 (introduction to professional situations), the textbook includes tasks simulating professional activities such as drafting legal documents, analysing regulations, interpreting legal provisions, or reviewing contracts.

In response to RQ3 (use of authentic materials), the materials include excerpts from authentic legal documents, judicial decisions, and legal articles, which reflect the real language used in professional legal contexts.

4.2.6. Development of Sociolinguistic Competence

Addressing RQ1 (adaptation of language to social roles), the textbook indirectly introduces role-based communication through tasks involving formal legal correspondence or official documentation.

Regarding RQ2 (formality and register), the materials emphasise the use of highly formal and specialised legal register typical of professional legal communication.

In relation to RQ3 (communication in social situations), exercises occasionally involve stylistic transformations and the use of formal expressions; however, explicit comparisons between legal language and other language varieties are limited.

4.2.7. Development of Intercultural Competence

With regard to RQ1 (intercultural communication), references to intercultural aspects appear occasionally, mainly in the context of comparisons between the Italian legal system and other European legal traditions.

Addressing RQ2 (role of cultural context), the textbook assumes a certain level of familiarity with Italian institutions and therefore offers limited explicit discussion of cultural context.

In relation to RQ3 (culturally sensitive topics), intercultural reflection remains marginal and cultural pragmatics of legal communication are not explicitly addressed.

4.3. Textbook 3

Italiano in azienda

Authors: Giovanna Pelizza, Marco Mezzadri

Publisher: Guerra Edizioni, Perugia, 2012

Target group:

The textbook is intended for foreign students and professionals who use Italian in the workplace, particularly in business and commercial contexts. It is designed for learners with at least an intermediate level of language proficiency (A2-B2).

Structure of the textbook:

The textbook consists of twelve thematic units covering key areas of commercial communication, including job search, employment, business travel, advertising, trade fairs, transport, commercial correspondence, and financial transactions.

Additional materials include an audio CD, an appendix with visual materials supporting interactive tasks, transcripts of recordings, an alphabetical glossary with references to textbook units, and an answer key.

4.3.1. Lexical Competence

With regard to RQ1 (scope and difficulty of specialist terminology), the textbook offers a broad range of business-related vocabulary associated with employment, marketing, trade fairs, transport, commercial correspondence, and financial transactions.

Addressing RQ2 (types of lexical exercises), the materials include numerous vocabulary activities such as labelling illustrations, completing definitions and texts with missing terms, creating acronyms, matching synonyms and antonyms, categorising vocabulary, constructing mind maps, and participating in role-play activities simulating telephone conversations.

In relation to RQ3 (word formation processes and specialised lexical phenomena), the textbook does not explicitly analyse word formation mechanisms such as prefixes, suffixes, or compound formation. However, it introduces learners to abbreviations and loanwords frequently used in international business communication.

Regarding RQ4 (presence of glossaries and definitions), an alphabetical glossary is provided at the end of the textbook, with references to the pages where the terms occur in context and space for writing translations.

4.3.2. Morphosyntactic Competence

With regard to RQ1 (level of syntactic complexity), the materials reflect realistic communication in business contexts and include texts of varying complexity, such as business correspondence, contracts, and procedural descriptions.

In response to RQ2 (analysis of specialised morphosyntactic phenomena), examples of ellipsis, nominalisation, depersonalisation, passivisation, and implicit forms appear in authentic documents; however, these phenomena are not explicitly analysed.

Addressing RQ3 (grammar exercises enabling practical application), each unit contains grammar activities focusing on structures such as verb forms, participles, pronouns, adjective gradation, and the imperative mood. These structures are subsequently practised in communicative contexts.

4.3.3. Textual Competence

Addressing RQ1 (variety of text types), the textbook includes a wide range of materials such as dialogues, case studies, product presentations, reports, brochures, and authentic documents.

With regard to RQ2 (recognition and reproduction of text structures), the units contain numerous exercises requiring learners to analyse and reproduce the structure and layout of business texts and documents.

In response to RQ3 (development of genre awareness), the textbook introduces authentic communicative formats such as job advertisements, CVs, cover letters, brochures, business letters, bookings, and complaints.

4.3.4. Phonetic Competence

With regard to RQ1 (phonetic difficulty), the phonetic complexity of the texts can be considered moderate, although certain multisyllabic terms may pose pronunciation challenges.

Addressing RQ2 (phonetic support materials), the textbook includes audio recordings accompanied by transcripts, which support listening comprehension and dialogue practice.

In relation to RQ3 (development of pronunciation and prosody), various activities encourage the development of appropriate pronunciation, tone, and register, particularly through role-plays and simulated telephone conversations.

4.3.5. Development of Specialised Competence

Addressing RQ1 (substantive contexts), the units focus on realistic business situations such as job applications, commercial negotiations, business travel, and product presentations.

With regard to RQ2 (professional situations), role-play activities simulate typical workplace interactions.

In response to RQ3 (use of authentic materials), learners are exposed to numerous authentic documents and communicative situations reflecting real business practice.

4.3.6. Development of Sociolinguistic Competence

Addressing RQ1 (adaptation of language to social roles), the textbook includes numerous tasks requiring learners to adjust their language depending on the communicative role, such as employer, employee, client, or sales representative.

Regarding RQ2 (formality and register), exercises emphasise appropriate tone, polite expressions, and register differences in both spoken and written communication.

In relation to RQ3 (communication in social situations), simulated dialogues and telephone interactions provide opportunities to practise professional communication strategies.

4.3.7. Development of Intercultural Competence

With regard to RQ1 (intercultural communication), the textbook is strongly embedded in the Italian business environment.

Addressing RQ2 (role of cultural context), the section *La cultura degli affari* introduces elements of business culture and non-verbal communication.

In relation to RQ3 (culturally sensitive topics), intercultural comparisons appear occasionally, particularly when discussing greetings or polite expressions, and learners are encouraged to compare Italian communication norms with those of their own cultures.

The results of the above analysis form the basis for the conclusions and didactic implications presented in the following section.

5. Discussion

The aim of this study was to examine the extent to which selected Italian specialist language textbooks support the development of linguistic and communicative competences necessary in professional contexts. The analysis focused on seven competence areas: lexical, morphosyntactic, textual, phonetic, specialist, sociolinguistic, and intercultural. The study

included textbooks from the fields of medicine, law, and business, allowing for consideration of diverse specialist discourses and identification of both their pedagogical potential and limitations.

The analysis revealed that all three textbooks provide a rich repository of specialist vocabulary introduced in communicative contexts and supported by exercises such as paraphrasing, synonym matching, summarizing, and contextual tasks. This result is consistent with research emphasizing the central role of terminology in specialist language teaching and the importance of contextualized vocabulary learning for developing professional communicative competence (Hyland, 2022). *Italiano Medico* and *Italiano in azienda* introduce terminology gradually, facilitating vocabulary acquisition at an intermediate level, whereas *Italiano per giuristi* presents a higher level of lexical difficulty, reflecting the complexity of legal discourse. Similar observations regarding the high lexical density and conceptual complexity of legal discourse have been made in studies on legal language and professional communication (Gotti, 2019). Word formation and grammatical processes are analyzed only partially, which poses challenges for applied linguistics students who must integrate vocabulary knowledge with the ability to use it in professional contexts (Hyland, 2022).

At the morphosyntactic level, the materials reflect structural features of specialist discourse, including nominalization, depersonalization, passive voice, and ellipsis. Only the law textbook explicitly addresses these phenomena and provides exercises for analyzing complex structures, which is particularly important for students preparing for careers as translators or interpreters. These findings correspond with studies showing that specialist discourse often relies on dense nominal structures and impersonal grammatical forms that contribute to objectivity and precision in professional communication (Gotti, 2019; Hyland, 2022). In the other textbooks, these features remain largely implicit, requiring students to independently identify and interpret grammatical rules in different professional contexts.

Regarding textual competence, all textbooks present diverse authentic or quasi-authentic genres, such as medical documentation, legal acts, court decisions, business correspondence, or technical reports. Exercises focusing on recognizing and reproducing text structures promote genre awareness, which is essential for functioning within professional discourse communities. For applied linguistics students, this means mastering both the structure of texts and their pragmatic and cultural functions.

Phonetic competence is developed primarily in the medical and business textbooks through audio materials and listening exercises, whereas the law textbook focuses on written texts. The lack of phonetic exercises in the legal context presents a significant challenge for students, who must develop both oral and written competences in the specialist language.

The development of specialist competence is supported through case studies, role simulations, and authentic documents that enable students to integrate linguistic knowledge with domain-specific expertise. Sociolinguistic competence is fostered mainly through simulations of professional interactions, role-play, and dialogic exercises, which are

particularly important for students learning to adapt language to different audiences and situations. Intercultural competence is developed unevenly and requires the inclusion of cross-cultural comparisons to prepare students for work in multicultural professional environments.

The analysis demonstrates that learning specialist discourse presents applied linguistics students with complex challenges. They must master terminology, syntactic structures, genre conventions, phonetic rules, and sociolinguistic and cultural norms, all within various professional domains. This process requires an interdisciplinary approach and engagement with authentic materials that reflect real communicative practices in specific fields. Similar conclusions have been drawn in contemporary research on language for specific purposes, which emphasizes that effective professional communication requires the integration of linguistic competence, disciplinary knowledge, and discourse awareness (Hyland, 2022).

6. Summary

The conclusions drawn lead to several practical recommendations for specialist language teachers:

- Supplementing textbook materials with phonetic exercises, prosodic tasks, and analyses of morphosyntactic structures, especially when working with legal and business texts.
- Introducing elements of intercultural reflection – through comparisons of systems (e.g. legal, health, business) and communication norms – to support adaptive and pragmatic competences, which are essential in preparing students for real-world professional interactions.
- Integration of materials from different textbooks and fields – combining different styles, registers, and text structures allows for the development of linguistic *metacompetence* and teaches students how to work with heterogeneous material.
- Enriching classes with a translation component – although the texts require students to understand, interpret, and transfer meaning between languages, the textbooks do not offer translation tasks or strategies. Therefore, written and oral translation, terminology transfer exercises, translation strategies, and analysis of translation errors should be an integral part of the course.
- Using active learning methods – such as debates, case studies, interpreting and translation, professional simulations, and role-playing. These types of activities not only support knowledge acquisition but also promote the development of communication skills in professional environments.

In summary, effective teaching of specialist language requires going beyond the textbook and adopting a flexible, reflective teaching approach. The role of the teacher should not be limited to presenting content – they should act as a mediator and guide, focusing on supporting students in developing their translation, pragmatic, and intercultural competences, which are essential in dynamic and multilingual professional environments.

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STRUCTURE OF THE ESG BOND MARKET IN THE UNITED KINGDOM IN YEARS 2020-2025

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Purpose: The aim of the study is to identify and interpret the determinants of the development of the sustainable finance instruments market in the United Kingdom in the years 2020-2025, taking into account the role of institutional factors. The analysis focuses on three dimensions: the types of issued instruments, the structure of issuers and the geographical structure of the markets on which the instruments are listed.

Design/methodology/approach: A quantitative analysis of data concerning the issuance of ESG instruments was employed, encompassing their classification, the structure of issuers and the concentration of stock exchange listings. The analysis was embedded in an institutional perspective. Hypotheses concerning the dominance of green bonds, the concentration of issuance among specific types of issuers and the concentration of trading on leading market platforms were subjected to verification.

Findings: The results show a clear concentration of the market in the green bond segment, the dominance of certain categories of institutional issuers and a strong concentration of listings on the largest trading platforms. The market structure is institutionalized and the standardization process encourages the concentration of capital in specific segments and financial centers.

Research limitations/implications: The study focuses on a single national market (the United Kingdom) and a specific time horizon (2020-2025). This approach requires caution when formulating conclusions of a universal nature that extend beyond the country under study. At the same time, the results indicate the need for further research and a more in-depth analysis of the institutional mechanisms influencing the architecture of sustainable finance markets.

Practical implications: The identification of market concentration and segmentation patterns enables support for the decision-making of regulators, financial institutions and issuers regarding instrument design, the choice of issuance and listing platforms, and the assessment of market competitiveness.

Keywords: ESG bonds; green bonds; institutional factors; market concentration; market structure; United Kingdom; sustainable finance.

Category of the paper: Research paper.

1. Introduction

Financing the climate, social, and governance (ESG) transition is increasingly shifting from the level of political declarations to concrete market mechanisms, in which debt instruments linked to environmental and social objectives play a particularly significant role. In this context, the sustainable finance instruments market is not merely another segment of financial innovation, but rather a space where relationships between public regulation, investor expectations, and corporate financing strategies are shaped (Huo et al., 2025; Chen et al., 2025; Rodrigues et al., 2025; Boermans, 2023). Over the past decade, the sustainable finance market has been developing rapidly, becoming a key channel for mobilizing capital for energy and climate transitions. Of particular importance in this process is the market for bonds linked to environmental and social objectives, which enable direct linkage of acquired financing to the implementation of specific investment projects. These instruments serve as an intermediary between long-term climate policy strategies and the decisions of institutional investors seeking assets aligned with ESG criteria (Tolliver et al., 2020; Chen & Zhao, 2021).

The structure of this market reflects not only the demand for capital but also the institutionalization of sustainable finance standards. Previous studies have primarily focused on the growth dynamics of the sustainable finance instruments market, financing costs, or the profitability of individual instruments, while its internal architecture remains underexplored. Meanwhile, elements such as the relationships between instrument types, issuers, and investors allow us to capture how institutional factors (regulatory, normative, and market-based) shape capital allocation patterns and reinforce specific operational models in the sustainable financial instruments market. For this reason, researchers are increasingly focusing not only on the scale of the ESG instruments market but also on its institutional structure. Analyzing market architecture allows us to understand the mechanisms of capital concentration, the role of dominant issuer categories, and the importance of market infrastructure in the allocation of sustainable development financing. From this perspective, the ESG instruments market can be viewed as an institutional system in which regulations, reporting standards, issuer strategies, and investor preferences co-shape long-term market patterns (Petry, 2020; Sapozhnikov et al., 2024; Baldi, Pandimiglio, 2022).

A particularly interesting sustainable finance market is the United Kingdom, which combines a developed financial sector with active policies supporting sustainable finance and a highly internationalized market infrastructure (Carlin et al., 2024; Bracking, 2024). Therefore, the aim of the study is to identify and interpret the determinants of the development of the sustainable finance instruments market in the United Kingdom in the years 2020-2025, taking into account the role of institutional factors. The analysis focuses on three dimensions: the types of instruments issued, the structure of issuers, and the spatial distribution of listings. The adopted perspective allows for the identification of mechanisms of institutional concentration, segmentation, and temporal stabilization.

The conducted analysis indicates a clear concentration of the market in the most standardized segments, the dominance of green bonds in the issuance structure, and the significant role of the largest institutional entities and leading trading platforms. The results suggest that market development is strongly institutionalized and focuses on specific forms of financing and market infrastructure.

The contribution of the manuscript is both empirical and structural. First, the study provides a systematic analysis of the architecture of the ESG bond market in the United Kingdom across instruments, issuers, and exchange listings. Second, it captures the degree of institutional market concentration and the role of dominant trading platforms. Third, it allows for the interpretation of these phenomena from an institutional perspective. The study also has an applied dimension, supporting the decision-making processes of regulators, financial institutions, and issuers in shaping sustainable finance policies, designing instruments, and selecting issuance and listing platforms.

However, the limitations of the present study should be noted. The study focuses on a single national market (the United Kingdom) and a specific time horizon (2020-2025). This approach requires caution when formulating conclusions of a universal nature that extend beyond the country and the studied time frame. Due to the relatively short time horizon of the analysed period (2020-2025), the study focuses on structural comparisons of issuance numbers and values rather than on econometric modelling of market dynamics.

The remainder of the article is organized as follows. The second section presents a literature review. This is followed by the research methodology and key empirical findings. The final section presents the discussion and conclusions.

2. Literature review

The literature on green finance covers a broad spectrum of topics, ranging from empirical and regulatory analyses to research on innovation and broadly understood sustainable development. In recent years, studies focusing on the functioning of green segments of capital markets and their role in reducing information asymmetries, enhancing market transparency, and supporting economic transformation have gained prominence. Brožek (2023) emphasizes that the development of green finance is closely linked to the level of economic innovation. Research indicates that increased investment in research and development correlates with higher utilization of renewable energy and lower per capita CO₂ emissions. This suggests that capital markets, by financing environmental innovations, can play a key role in energy and technological transformation.

Contemporary studies show that the development of the green financial instruments market is influenced by numerous macroeconomic, market, technological, and social factors (Abhilash et al., 2024; Fatmawatie et al., 2024; Gruishina et al., 2023; Paul, 2018; Puszer, 2019, p. 119; Caggiano, Greco, 2011; Van et al., 2025). At the same time, institutional factors and market infrastructure, including stock exchanges, are highlighted as overarching determinants of market development, shaping its scale, dynamics, credibility, and efficiency (Anh Tu et al., 2020; Umar et al., 2024; Gajewski, 2014). Of particular importance for the development of the green financial instruments market is the quality of regulatory and legal frameworks regarding climate policy. Previous studies indicate that a clearly defined sustainable development policy positively affects the green bond market (Grishunin et al., 2023). This is confirmed by Tolliver et al. (2020), who, using structural equation modeling (SEM), examined the impact of capital market growth factors and national commitments arising from the Paris Agreement (NDCs) on the volume of green bond issuance. Their results indicate that, among the analyzed variables, the most significant, positive, and statistically meaningful effect on the volume of green bond issuance was exerted by nationally determined contributions (NDCs). These findings demonstrate that national climate commitments constitute an important mechanism stimulating the development of the green bond market. Similar results were obtained by Saini & Shri (2024), who showed that political stability, regulatory quality, and efficient public administration are strategic factors for implementing sustainable finance at the national level. They also noted that these factors support the development of ESG reporting.

A second element of institutional infrastructure consists of uniform standards, taxonomies, and verification mechanisms. The literature indicates a positive correlation between the development of the green bond market and institutionalized classification and reporting systems such as the EU Taxonomy, ICMA Guidelines, and the Climate Bonds Standard. Their significance includes, among others, reducing due diligence costs, increasing demand for sustainable instruments, and mitigating greenwashing risk (Baldi, Pandimiglio, 2022; Chen, Zhao, 2021; Corapi, 2023). Conversely, the lack of uniform standards, ESG taxonomies, and impact measurement methods is identified as one of the main barriers limiting market development and increasing operational costs (Sapozhnikov et al., 2024; Ahir, Mahida, 2025; Chauhan, 2025). The importance of regulatory quality, political stability, and efficient public administration is also emphasized (Saini, Shri, 2024). Other studies on green bonds, such as Alsamani (2019), draw attention to the fragmentation of regulatory standards. Studying the green bond market in the United Kingdom, Alsamani highlights that this market is primarily based on voluntary guidelines, such as the Green Bond Principles (GBP) and the Climate Bond Standard (CBS), which limits its transparency and coherence. The author also notes that the lack of mandatory reporting requirements and the absence of a central supervisory institution for green finance increase the risk of greenwashing and hinder market development. In a comparative context, Alsamani analyzes regulatory systems in countries including France,

China, and the Nordic countries, noting that stricter legal frameworks foster faster growth of the green bond market.

More broadly, the literature emphasizes that the United Kingdom faces the need to strengthen the regulatory framework for green finance. The Accelerating Transition report (Carlin et al., 2024) and the essay by Bracking (2024) indicate that the current voluntary approach is insufficient and that the state should introduce more rigorous requirements regarding reporting, asset classification, and market supervision of green instruments. The authors propose, among other measures, the creation of a national green asset taxonomy, harmonization of standards with the European Union, strengthening the role of exchanges as supervisory institutions, and the issuance of new instrument classes, such as adaptation bonds. It is also noted that the United Kingdom - as a global financial center - has the potential to become a leader in green finance, provided that appropriate regulatory reforms are implemented.

Stoliarchuk et al. (2023) emphasize state involvement, which, through incentives, guarantees, and green public finance institutions, helps create initial transaction flows and reduce transaction costs. Similarly, Azam et al. (2022) show that in developing economies, basic market institutions such as property rights protection, contract enforcement, and the rule of law are important, promoting both the adoption of renewable energy and the development of sustainable finance.

Market infrastructure, particularly the functioning of stock exchanges, also plays a key role in the development of sustainable finance instruments (Próchniak et al., 2025). The literature highlights that exchanges act as institutional intermediaries, supporting the standardization of reporting, the visibility of issuers, and investors' access to reliable information (Petry, 2020; Sapozhnikov et al., 2024). Specialized trading platforms establish transparent listing rules, implement disclosure systems, and formalize reporting practices, which form the basis of market liquidity and positively influence investors' trust in sustainable finance instruments. The role of stock exchanges as institutions supporting green finance development is extensively described by Erhart (2018), who presents five pioneering European exchanges that have established specialized segments for green bonds: Oslo Børs, Nasdaq Stockholm, London Stock Exchange, Luxembourg Stock Exchange, and Borsa Italiana. These segments, based on additional listing criteria such as the obligation to disclose the use of proceeds, external verification, and regular reporting, act as quasi-regulators, enhancing issuance credibility and reducing information asymmetry. Erhart (2018) notes that these exchanges not only provide trading platforms but also shape market standards, conduct educational activities, and support the development of green indices and benchmarks.

The significance of exchange segments for reducing information asymmetry has been empirically confirmed by Stoczek (2025), who analyzes the impact of listing green bonds on specialized Green Bond Sections (GBS) on market liquidity. A study covering 482 corporate bonds found that listing on a GBS is associated with a statistically significant reduction in bid-

ask spreads, indicating reduced information asymmetry. This effect is particularly strong for smaller, high-risk, and unrated bonds, suggesting that exchange segments serve as signaling mechanisms, especially valuable for institutional investors. Importantly, Stoczek notes that the mere presence of bonds on a GBS - regardless of disclosure quality - has reputational value, highlighting the role of exchanges as trust-building institutions in the green instruments market.

Different conclusions emerge from Efremenko (2025), who examines the Green Economy Mark (GEM) on the London Stock Exchange, awarded to companies generating at least 50% of revenues from environmentally beneficial activities. The study found that although there is a short-term increase in stock prices on the announcement day, the effect quickly dissipates, and cumulative abnormal returns return to neutral levels. Moreover, GEM does not attract new investors or increase trading activity of existing shareholders. Efremenko argues that the mark does not provide investors with new information, as it is based on publicly available data (e.g., FTSE Green Revenues). Unlike bond segments, GEM does not function to reduce information asymmetry, and its impact on the market is limited.

Despite numerous studies on the determinants of ESG instrument market development, the literature focuses primarily on macroeconomic and regulatory factors, while structural analyses demonstrating how institutional factors translate into the internal architecture of the market (instrument segmentation, issuer concentration, and exchanges) are lacking. A literature review also indicates that the number of studies dedicated to the sustainable finance instruments market in the United Kingdom is limited. The present study fills this gap by providing a structural analysis of the UK market during 2020-2025.

Despite numerous studies on the determinants of green bond market development, the literature focuses primarily on macroeconomic and regulatory factors. At the same time, the literature still lacks structural analyses demonstrating how institutional factors translate into the internal market architecture (instrument segmentation, issuer and exchange concentration), especially with respect to individual national markets. This gap is particularly evident in the UK market, which, despite its global role in finance, remains relatively underexplored. In response to this identified research gap, the following research hypotheses were formulated:

- H1: In the sustainable finance instruments market in the United Kingdom in 2020-2025, there is a persistent concentration of issuance value in the green bond segment.
- H2: The structure of ESG bond issuance value in the United Kingdom is dual in nature - primarily determined by corporate and sovereign issuers, with the public sector generating a relatively small number of issuances but issuances of above-average nominal value.
- H3: The sustainable finance instruments market issued by UK entities in 2020-2025 is characterized by a high and persistent degree of listing concentration on a single platform (London Stock Exchange), both in terms of the number of issuances and their value.

3. Sustainable Bond Market (SBM) on the LSE: an overview

The Sustainable Bond Market (SBM) is a specialized segment of the debt instruments market operating within the London Stock Exchange, concentrating on issuances linked to sustainable development goals and the financing of environmental and social projects. The SBM was developed based on the first dedicated green bond segment, launched by the LSE in 2015 in response to the growing needs of investors and issuers for transparency, standards, and access to capital directed toward low-carbon economic development.

The market offers a range of classification segments, including green, social, and sustainable bonds, transition bonds aimed at supporting the low-carbon transition, and issuer-level classifications, where the core activities of the issuer are aligned with environmental economy principles or their sustainability profiles meet specified criteria. Instruments listed on the SBM must comply with certain standards, such as disclosure of the use of proceeds, publication of sustainable finance frameworks, and engagement of external reviewers, all of which are intended to increase investor confidence and mitigate greenwashing risk.

The SBM functions as a platform for both primary and secondary markets, enabling issuers of various asset classes - from traditional bonds to more complex financial structures - to raise capital from a broad base of institutional investors with long-term investment horizons. Furthermore, the LSE facilitates the publication of key documents, including external opinions, sustainable finance frameworks, and annual reports on the achievement of environmental and social objectives, promoting greater transparency for market participants.

The SBM operates as a global market, attracting issuances from multiple countries and sectors, including large green bonds of international significance. For example, the market has listed bonds that were the first of their kind in specific regions regarding currency, structure, or geographical reach, highlighting the LSE's role as an important center for global sustainable finance. For issuers, the SBM provides access to a deep international capital base and benefits associated with increased visibility in the global capital market. For investors, it offers a source of diversified debt instruments with clearly defined proceeds dedicated to environmental and social objectives, facilitating the implementation of investment strategies aligned with ESG principles (Environmental, Social, Governance).

The development of the SBM also responds to the growing global demand for financing climate-related actions and the transition toward a low-carbon economy, as evidenced by its expansion from simple green bond segments to a multi-dimensional platform including social bonds and transition-linked instruments. In recent years, the market has continued to grow in terms of both the number of issuances and the total capital raised, making the SBM a key component of the global green finance architecture (londonstockexchange.com).

Contemporary literature on ESG finance covers a wide spectrum of topics, from empirical and regulatory analyses to research on innovation and broadly defined sustainable development. In recent years, particular attention has been paid to studies focusing on the functioning of green segments of capital markets and their role in reducing information asymmetries, enhancing market transparency, and supporting economic transformation. The literature emphasizes that capital markets - through green bond issuance, the creation of specialized exchange segments, and the development of reporting standards - play a significant role in mobilizing capital for environmental purposes. At the same time, empirical studies indicate that the effectiveness of these mechanisms depends on the quality of regulation, transparency of disclosures, and the capacity of infrastructural institutions to reduce information asymmetry and greenwashing risk.

4. Research methodology

The study has an empirical as well as descriptive-comparative character. Its objective is to analyze the structure of the ESG bond market in the United Kingdom during the years 2020-2025 based on quantitative data on the issuance of these instruments. The applied research approach focuses on identifying market heterogeneity across institutional and product dimensions, without formulating causal conclusions.

The analysis was directed towards comparing the significance of individual segments of the ESG bond market in terms of:

- instrument type (green bonds, social bonds, sustainability bonds, sustainability-linked bonds, and transition bonds),
- issuer type (corporate, financial institutions, sovereign, agency, municipal),
- listing exchange.

This classification framework directly corresponds to the tables and descriptions presented in the empirical section of the article.

The empirical basis of the study consists of data from the Environmental Finance Data database (efdata.org), covering ESG bond issuances in the United Kingdom from 2020 to 2025. All issuances available in the database for the specified period were included in the analysis, without additional sample selection.

The analysis of the ESG bond market was based on the following measures:

- number of issuances, treated as a measure of issuance activity,
- total issuance value, expressed in USD million, as a measure of financing scale,
- issuance structure by listing exchange, allowing for the assessment of market concentration.

These measures were compiled on an annual basis and across dimensions consistent with the presentation of empirical results.

5. Results

This chapter presents the results of the empirical analysis of the ESG bond market in the United Kingdom during 2020–2025, encompassing both the number of issuances and their total value. The analysis is based on data from the Environmental Finance Data database (efdata.org, 06.02.2024) and was conducted across dimensions of instrument type, issuer type, and listing exchange.

5.1. Number of ESG bond issuances

The analysis of the number of ESG bond issuances by instrument type (Table 1) indicates significant differentiation in market structure over the analyzed period. In 2020, the market was characterized by a relatively low number of issuances and a clear dominance of green bonds and social bonds, alongside a noticeable, though smaller, share of sustainability bonds. Sustainability-linked bonds and transition bonds played a marginal role in that year.

The year 2021 saw a marked increase in the number of issuances across all major market segments. The number of green bond and sustainability bond issuances increased most significantly, leading to a substantial expansion of the ESG instrument structure present in the UK market. At the same time, the number of sustainability-linked bond issuances also grew noticeably, although these instruments remained a relatively small-scale segment.

During 2022–2025, the structure of issuance numbers showed increased volatility. The number of green bond issuances remained at a relatively stable level, whereas the significance of sustainability bonds fluctuated, with notable increases in 2022 and 2024 and a decline in 2023 and 2025. Sustainability-linked bonds remained a niche instrument throughout the analyzed period, while transition bonds appeared only sporadically, confirming their marginal role in the quantitative structure of the ESG bond market.

Table 1.
Number of ESG bond issuances by instrument type

Year	Green bond	Social bond	Sustainability bond	Sustainability-Linked bond	Transition bond
2020	14	11	7	-	1
2021	50	15	24	11	1
2022	32	6	31	7	-
2023	26	6	12	2	-
2024	34	17	29	5	-
2025	35	6	19	3	-

Source: own calculations based on efdata.org.

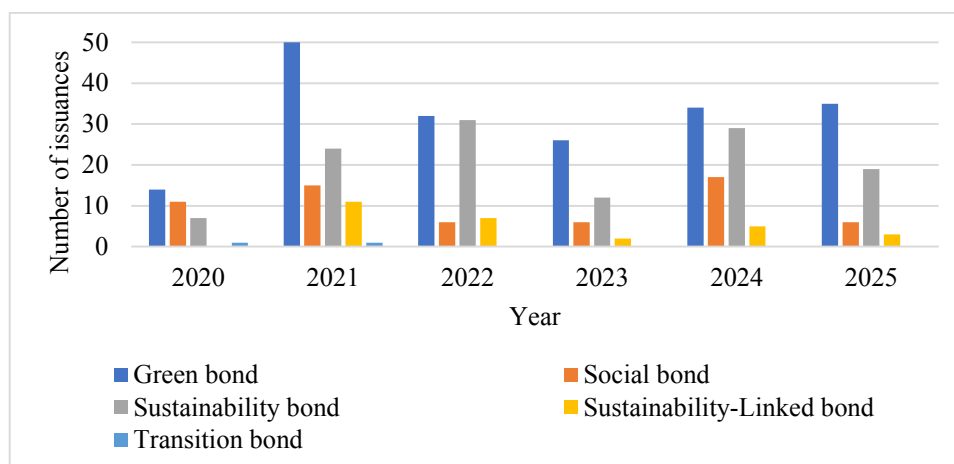


Figure 1. Number of ESG bond issuances by instrument type.

Source: own calculations based on efdata.org.

The structure of ESG bond issuances by issuer type (Table 2) highlights the dominant role of corporate issuers in 2020-2021. From 2022 onwards, the share of financial institutions increased, which in selected years became the largest group of issuers. Sovereign, municipal, and agency issuances occurred only sporadically, confirming the limited role of the public sector in shaping the number of ESG bond issuances.

Table 2.

Number of ESG bond issuances by issuer type

Year	Agency	Corporate	Financial Institution	Municipal	Sovereign
2020	-	28	5	-	-
2021	-	73	24	2	2
2022	1	30	42	-	3
2023	-	31	8	-	7
2024	-	67	13	5	-
2025	-	42	15	1	5

Source: own calculations based on efdata.org.

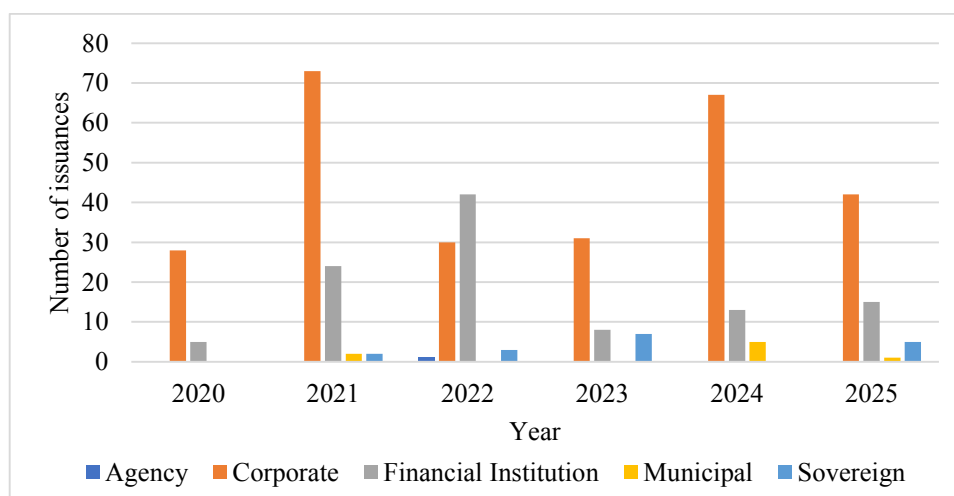


Figure 2. Number of ESG bond issuances by issuer type.

Source: own calculations based on efdata.org.

Although analyzing the number of issuances captures differences in issuance activity across market segments, a more comprehensive assessment of their significance in market structure requires consideration of issuance value, which in the subsequent part of the chapter forms the basis for analyzing the scale of financing by instrument type, issuer type, and listing exchange.

5.2. Value of ESG bond issuances

The analysis of ESG bond issuance values by instrument type (Table 3) indicates a strong concentration of market value in the green bond segment throughout the 2020-2025 period. In all years, green bonds generated the highest total issuance value, with particularly high levels observed in 2021 (USD 38,4 billion), and subsequently in 2023-2025, when issuance values remained above USD 30 billion per year. Following the pronounced peak in 2021, issuance value declined in 2022, before returning to high levels in subsequent years, indicating significant value volatility within this market segment.

The second most significant category in terms of issuance value is sustainability bonds. The issuance value of these instruments reached its highest levels in 2021 (USD 9,8 billion) and 2024 (USD 8,6 billion), with noticeably lower values in the other years.

Social bonds showed relatively lower total issuance value compared to green and sustainability bonds. Nevertheless, issuance values increased in 2024 (USD 7,1 billion) and remained elevated in 2025, indicating the growing importance of this segment in the final phase of the analyzed period.

Sustainability-linked bonds remained instruments of limited value significance. After a relatively high issuance value in 2021 (USD 5,9 billion), a marked decline occurred in 2022-2024, followed by a rebound in 2025. The absence of a clear upward trend confirms the unstable character of this segment.

Transition bonds appeared only sporadically and accounted for a marginal share of total market value.

Table 3.

ESG bond issuance value (in million USD) by instrument type

Year	Green bond	Social bond	Sustainability bond	Sustainability-Linked bond	Transition bond
2020	3727,96	1565,31	2850,57	-	557,30
2021	38446,85	4355,83	9757,49	5868,91	745,80
2022	19803,89	2051,18	4321,52	2293,75	-
2023	33267,01	2362,96	3659,65	1008,27	-
2024	30596,86	7145,99	8612,48	1627,01	-
2025	31338,79	4918,14	6784,79	2286,71	-

Source: own calculations based on efdata.org.

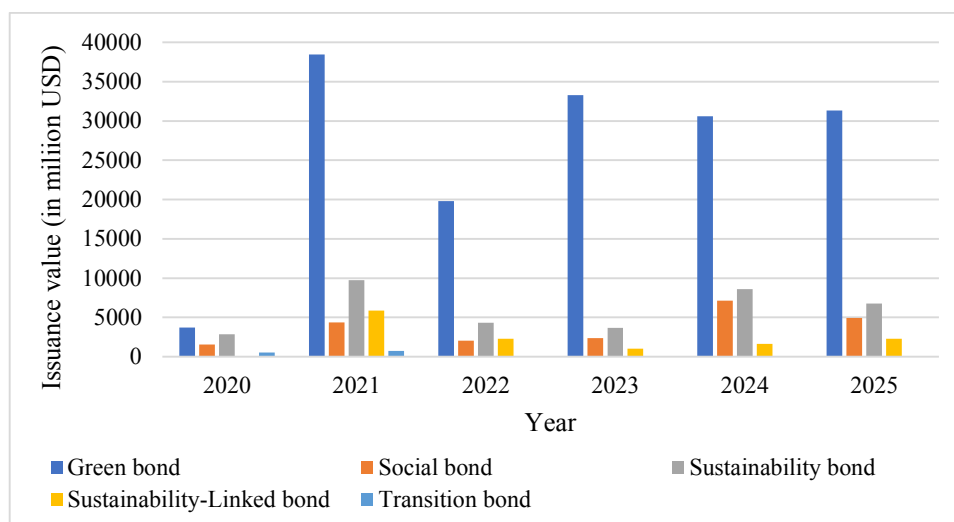


Figure 3. ESG bond issuance value (in million USD) by instrument type.

Source: own calculations based on efdata.org.

Comparison of ESG bond issuance values by issuer type (Table 4) indicates a clear concentration of market value in two groups: corporate and sovereign. In individual years, value dominance alternates between these two categories.

Table 4.

ESG bond issuance values (in milion USD) by issuer type

Year	Agency	Corporate	Financial Institution	Municipal	Sovereign
2020	-	7341,39	1359,74	-	-
2021	-	30883,94	5608,79	757,66	21924,49
2022	298,40	12056,89	4409,00	-	11706,05
2023	-	16119,61	1612,83	-	22565,45
2024	-	25913,88	5473,36	-	16595,09
2025	-	22014,88	8204,40	412,00	14697,15

Source: own calculations based on efdata.org.

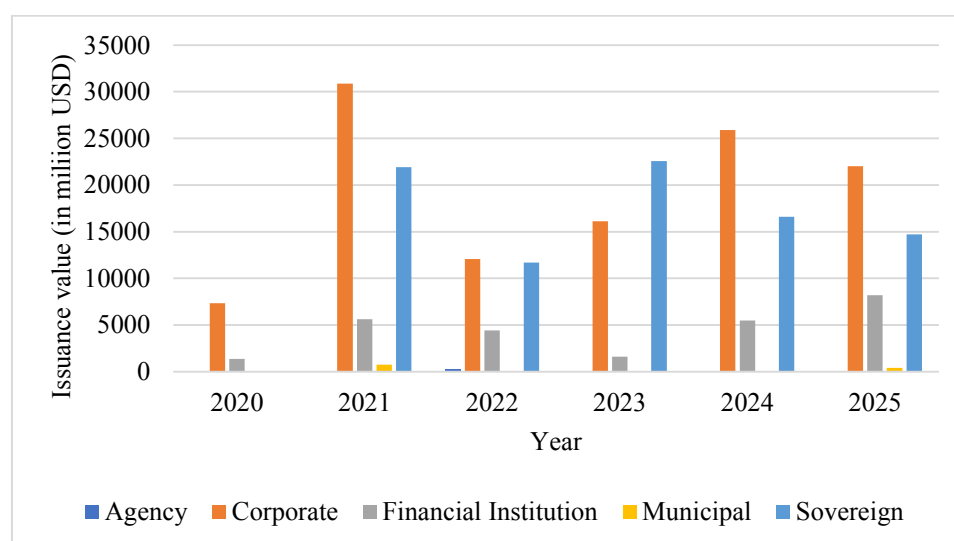


Figure 4. ESG bond issuance values (in milion USD) by issuer type.

Source: own calculations based on efdata.org.

In 2020-2021, the highest issuance values (Table 4) were generated primarily by corporate issuers, reaching over USD 30 billion in 2021. At the same time, sovereign issuances in the same year reached a very high value (USD 21,9 billion), indicating the significant role of individual, large-scale issuances in shaping the aggregate market value.

In 2022, issuance values declined in both the corporate and sovereign segments, while the importance of financial institutions increased, with their issuances totaling USD 4,4 billion. This trend continued in the following years, as financial institutions gradually expanded their issuance scale, reaching over USD 8,2 billion in 2025.

Sovereign issuers played a particularly important role in 2023–2025, generating very high issuance values despite a relatively small number of transactions (e.g., USD 22,6 billion in 2023 and USD 16,6 billion in 2024). The high issuance values in this segment highlight the substantial impact of individual issuances on overall market value.

Agency and municipal issuers accounted for a marginal share of ESG bond issuance value. Their activity was sporadic and did not significantly affect the overall value structure of the market during the analyzed period.

5.3. ESG bond issuances by listing exchange in 2020-2025

The distribution of ESG bond issuances by listing exchange (Table 5) indicates a strong concentration of issuance activity on the London Stock Exchange (LSE) throughout the analyzed period. The LSE remains the dominant listing venue for ESG issuances, accounting for the vast majority of transactions each year. This phenomenon is particularly pronounced in 2024, when the number of issuances listed on the LSE reaches the highest level in the entire study period, significantly surpassing the combined activity of other exchanges.

Other listing platforms serve a supplementary and specialized role. Euronext Dublin and the Luxembourg Stock Exchange show moderate but relatively stable presence, especially in 2021-2022 and 2024. Their significance should be interpreted as a result of favorable regulatory frameworks and the reputation of these markets in sustainable finance instruments.

Other exchanges, including the Johannesburg Stock Exchange, Hong Kong Stock Exchange, Frankfurt Stock Exchange, and SIX Swiss Exchange, appear only sporadically, with listed issuances being isolated cases. This indicates that, from the perspective of UK issuers, these exchanges do not constitute a systemically significant alternative, but rather occasional listing channels for specific issuances.

Table 5.
Number of ESG bond issuances by listing exchange

Year	2020	2021	2022	2023	2024	2025
Listing exchange	Issaunce value					
London Stock Exchange	25	19	10	18	40	27
Euronext Dublin	2	9	7	1	11	2
Luxembourg Stock Exchange	3	5	1	3	2	3
Gibraltar Stock Exchange	-	1	-	-	-	-
Johannesburg Stock Exchange	-	-	2	-	1	-
Hong Kong Stock Exchange	-	-	1	-	2	-
Frankfurt Stock Exchange	-	-	1	-	-	-
Taipei Stock Exchange	-	-	2	1	2	1
Vienna Stock Exchange	-	-	-	1	-	-
Oslo Stock Exchange	-	-	-	-	1	-
SIX Swiss Exchange	-	-	-	-	1	-
Total number of issuances	30	34	24	24	60	33

Source: own calculations based on efdata.org.

The analysis of ESG bond issuance values by listing exchange (Table 6) confirms the conclusions drawn from the analysis of issuance numbers, while also revealing an even higher degree of market concentration in terms of value. The London Stock Exchange consistently generates the highest issuance value each year, with particularly strong growth observed in 2023–2024. This indicates that the LSE's dominance is not solely due to the number of listed issuances, but also to the concentration of the largest-value transactions.

In 2024, the value of issuances listed on the LSE exceeded USD 22 billion, reflecting the accumulation of large green and sustainability bond issuances. This underscores the central role of the LSE as the main platform for ESG capital allocation for UK issuers.

The value of issuances on the Luxembourg Stock Exchange shows high interannual volatility, with 2021 recording an exceptionally high issuance value despite a relatively small number of transactions. This suggests the presence of individual, large-scale issuances that significantly influence aggregate data, but do not alter the structural position of this exchange relative to the LSE.

Euronext Dublin, in turn, shows moderate issuance values throughout the period, which, combined with a relatively higher number of issuances in selected years, indicates a specialization in smaller-average-value issuances, often used by issuers with more diversified profiles.

Other exchanges account for a marginal share of total issuance value, with their market participation being sporadic and not significantly affecting the aggregated structure of the ESG bond market.

Table 6.*ESG bond issuance values by listing exchange (in million USD) in 2020-2025*

Year	2020	2021	2022	2023	2024	2025
Listing exchange	Issuance value (in million USD)					
London Stock Exchange	4037,55	5719,23	6241,29	15649,18	22705,87	12530,33
Euronext Dublin	373,30	999,03	41,19	300,00	305,35	24,87
Luxembourg Stock Exchange	346,51	9223,04	-	1674,51	1312,69	685,65
Gibraltar Stock Exchange	-	2,5	-	-	-	-
Johannesburg Stock Exchange	-	-	46,20	-	47,93	-
Hong Kong Stock Exchange	-	-	41,07	-	575,05	-
Frankfurt Stock Exchange	-	-	159,68	-	-	-
Taipei Stock Exchange	-	-	55,00	47,77	60,00	20,00
Vienna Stock Exchange	-	-	-	75,00	-	-
Oslo Stock Exchange	-	-	-	-	62,50	-
SIX Swiss Exchange	-	-	-	-	249,48	-

Source: own calculations based on efdata.org.

The combined analysis of issuance numbers and values by listing exchange indicates that the UK ESG bond market in 2020-2025 shows a high degree of geographic and institutional concentration. The dominance of the London Stock Exchange is evident both in terms of volume and value, confirming its role as a key infrastructural hub for ESG financing.

At the same time, the presence of specialized European exchanges, such as Euronext Dublin and the Luxembourg Stock Exchange, points to the existence of alternative listing channels, which, however, do not challenge the central position of the LSE. This market structure promotes liquidity concentration and instrument standardization, but it may also limit the diversification of listing venues over the longer term.

The analysis of the percentage shares of the London Stock Exchange (LSE) in both the number and value of ESG bond issuances (Table 7) confirms the strong structural dominance of this platform in the UK market during the period 2020-2025. In most years, the LSE accounted for the clear majority of listed instruments. Its share in the total number of ESG bond issuances ranged from 41,7% in 2022 to over 80% in 2020 and 2025, indicating that the majority of UK ESG bonds are listed on this exchange.

Table 7.*Percentage shares of the London Stock Exchange in the number and value of ESG bond issuances in 2020-2025*

Year	Share of the number of emissions	Share of emission value
2020	83,3%	84,9%
2021	55,9%	35,9%
2022	41,7%	94,8%
2023	75,0%	88,2%
2024	66,7%	89,7%
2025	81,8%	94,5%

Source: own calculations based on efdata.org.

An even stronger concentration can be observed in terms of issuance value. With the exception of 2021, the LSE generated between approximately 85% and 95% of the total issuance value, reaching particularly high levels in 2022 (94,8%) and 2025 (94,5%).

This suggests that the largest-value ESG bond transactions are predominantly concentrated on this platform.

The only notable deviation from this pattern occurred in 2021, when the LSE's share in issuance value declined to 35,9%, despite maintaining a majority share in the number of issuances. This discrepancy indicates that several high-value transactions were listed on alternative exchanges in that year. Nevertheless, the subsequent years confirm the persistent dominance of the LSE as the primary infrastructural hub for ESG bond listings by UK issuers.

Overall, the results clearly demonstrate a high degree of geographic and institutional concentration of ESG bond listings. The very high market shares of the London Stock Exchange indicate a strongly centralized market structure, with the LSE functioning as the central infrastructural hub for ESG bond issuance by UK entities.

These results provide strong empirical support for Hypothesis H3, confirming the persistent concentration of ESG bond listings and issuance value on a single dominant trading platform, namely the London Stock Exchange.

6. Discussion

The empirical results presented in chapter 4 allow for the formulation of conclusions regarding the structure and evolution of the ESG bond market in the United Kingdom during 2020-2025. The analysis reveals that the development of this market was uneven and selective, both in terms of instruments, issuers, and listing exchanges.

First, our analysis confirms the dominant role of green bonds in the UK market structure. Both the number of issues and their value indicate a persistent market concentration in this segment. This result is consistent with the findings of previous studies, which indicate that green bonds remain the most developed and standardized segment of the sustainable finance market (Rodrigues et al., 2025; Sapozhnikov et al., 2024). Other types of ESG bonds play a complementary role, with sustainability bonds showing periodic increases in significance, while sustainability-linked bonds and transition bonds remain marginal segments. Similar conclusions are drawn by Chen et al. (2025), who emphasize that institutional investors' preferences favor instruments with a clearly defined environmental objective, which strengthens the position of green bonds in the market structure.

Second, comparing the number of issuances with their value indicates no clear correlation between issuance activity and the scale of financing. Segments with a high number of issuances do not necessarily account for the largest share of market value, confirming the appropriateness of using both measures in parallel when analyzing market structure.

Third, analysis of the market structure by issuer type indicates the coexistence of two main groups of entities shaping the market's value: corporate issuers and sovereign issues. Corporate issuers account for the largest number of issues, while sovereign issues generate very high transaction values. This result is consistent with the observations of Tolliver et al. (2020), who indicate that government involvement in meeting climate commitments can lead to the issuance of large-value green bonds. At the same time, the observed increase in the importance of financial institutions as issuers confirms the institutionalization of the green finance market (Anh Tu et al., 2020; Azam et al., 2022).

Fourth, the obtained results confirm the strong concentration of ESG bond listings on a single exchange platform – the London Stock Exchange. The literature emphasizes that stock exchanges play a significant role in the development of the green finance market by creating specialized trading segments and standardizing disclosures (Erhart, 2018; Petry, 2020). The LSE's dominance can be interpreted as a manifestation of the centralization of financial infrastructure and the effect of the exchange's reputation as a global hub for financing sustainable development. The obtained results are also consistent with Stoczek's (2025) research, which indicates that specialized green bond segments can reduce information asymmetry and increase market liquidity. Concentrating issues on a single platform may promote the standardization of reporting practices and increase market transparency.

At the same time, it should be noted that the observed market concentration may also have potential consequences for its competitive structure. As Alsamani (2019) points out, the UK green bond market operates largely based on voluntary regulatory standards. This may limit the market's institutional diversification and lead to its concentration around the largest entities and trading platforms.

The results confirm the importance of institutional factors in shaping the structure of the ESG bond market. At the same time, they indicate that the development of this market in the UK is proceeding selectively, concentrating around the most standardized instruments, the largest issuers, and the dominant stock exchange infrastructure.

7. Conclusions

A study of the structure of the ESG bond market in the UK from 2020 to 2025 allows us to draw several key conclusions. First, the market is characterized by the persistent dominance of green bonds in terms of both the number of issues and their value. Second, the issuer structure indicates the complementary role of corporate and sovereign issuers. Third, the market is characterized by a high degree of infrastructural concentration, reflected in the dominance of the London Stock Exchange as the main platform for listing ESG instruments. The results confirm the significant role of institutional factors in shaping the architecture of the sustainable

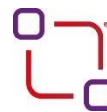
finance market. Finally, the findings indicate that variations in total market value are strongly influenced by the scale of individual issuances rather than by the number of issued ESG instruments.

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FACTORS DETERMINING DIGITALIZATION IN POLISH COMPANIES IN THE CONTEXT OF THE EUROPEAN INDUSTRIAL STRATEGY

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Purpose: The purpose of this study was to identify and analyse the key factors that shape and drive the digitalisation processes of Polish enterprises within the broader framework of the European Industrial Strategy. More specifically, the study aimed to determine the significance of individual entrepreneurial ecosystem components—particularly government policy, institutional support, relational networks, and human-capital capacities—in influencing firms' progress toward digital transformation.

Design/methodology/approach: The starting point for the research discussed in this article was to determine the degree of identification, significance, and comparison of the elements of the ecosystem, with a particular focus on the role of higher education institutions. Higher education institutions are a significant component considered in most economic development policies, as they play a crucial role in transferring knowledge and scientific achievements to businesses and are vital in building national, sectoral, and technological ecosystems. To achieve this goal, data was collected using the CATI method in a nationwide study of enterprises (n = 302).

Findings: The research findings indicated a weak identification of the elements of the entrepreneurial ecosystem within the processes of digitalisation. Furthermore, it revealed that government policy is the best-identified element of the entrepreneurial ecosystem (27%) and is, among the others, the most positively impactful aspect concerning the integration of digital technology in business operations (63.9%).

Practical implications: Government policy influence affects the digitalisation processes and the adaptive actions taken by enterprises, regardless of their size.

Originality/value: Future research on the ecosystem and its structure should consider the role of enterprises in the functioning of this system as a whole.

Keywords: government policy, entrepreneurship, economic development, technological change, digital transformation, innovation leaders, IT Management, innovation, technological change and growth.

Category of the paper: research paper.

1. Introduction

The transformation of industrial policy since the mid-20th century has increasingly emphasised entrepreneurship, innovation, and technology as foundational drivers of economic development. While early post-war policies primarily targeted reconstruction and support for fundamental sectors of the economy, subsequent decades saw the emergence of structured measures supporting micro-, small-, and medium-sized enterprises (MSMEs) in regions such as India in the 1950s and Europe in the 1970s (Audretsch, Beckmann, 2007). This evolution ultimately shifted the focus of national economic strategies toward the cultivation of enterprise dynamism and the facilitation of innovation-based growth (Warwick, 2013; Borbas, 2015).

Against this historical backdrop, the contemporary policy environment—particularly within the European Union—places unprecedented emphasis on digitalisation as a central determinant of competitiveness and resilience. The European Industrial Strategy (2020) identifies digital transformation and ecological sustainability as its two fundamental pillars, outlining a coordinated approach to strengthening industrial ecosystems through regulatory harmonisation, increased innovation capacity, development of digital skills, and improvements in data-processing and technological infrastructure (Autio, 2016; *Prosperity, People and Planet*, 2019). These priorities have direct implications for enterprises across member states, including Poland, where digital competencies, access to enabling technologies, and institutional support mechanisms increasingly shape patterns of organisational development and market competitiveness.

Within this policy context, the digitalisation of Polish companies is not solely a technological issue but rather a multidimensional process influenced by a set of interrelated factors, including government policy, the availability of skilled labour, institutional support networks, the maturity of entrepreneurial ecosystems, and firms' internal capacities for organisational adaptation. The European Industrial Strategy underscores the need to strengthen these determinants by promoting cross-industry collaboration, investing in digital infrastructure, enhancing access to low-emission energy, and supporting the development of advanced technological solutions. Consequently, the factors influencing digitalisation in Polish enterprises must be examined through the lens of both domestic conditions and supranational strategic frameworks.

The concept of the entrepreneurial ecosystem—originating in natural sciences (Clements, Pound, 1898) and later adapted to economics and management (Blew, 1996)—provides an analytical foundation for understanding how these factors interact. Modern entrepreneurial ecosystems encompass institutional and resource configurations that shape productive entrepreneurship and drive economic development (Baumol, 1993; Stam, 2024). Their structure includes core actors such as universities, firms, public institutions, and specialised intermediaries, all of which contribute to the diffusion of knowledge and the development of digital capabilities (Iansiti, Levien, 2004; Oliveira et al., 2019).

However, empirical studies highlight persistent weaknesses in ecosystem coordination, especially in contexts where relationships between institutions, enterprises, and policy frameworks remain fragmented. This challenge is observable in Poland, where—despite substantial progress—companies demonstrate varying levels of digital maturity and uneven engagement with ecosystem actors. Understanding the determinants of digitalisation therefore requires investigating how Polish enterprises interact with governmental initiatives, access technological resources, and participate in knowledge-sharing networks shaped by both national and European policies.

Digitalisation is also a focal point of EU industrial policy due to its structural implications for labour markets, productivity, and long-term competitiveness. While digital technologies may create new economic opportunities, they can also lead to the stagnation of wages, automation of routine activities, and significant shifts in employment structures (Acemoglu, Restrepo, 2018). These dynamics highlight the importance of developing comprehensive support mechanisms that enable companies—especially SMEs—to harness digital tools while adapting effectively to evolving market conditions.

In this context, the present chapter seeks to analyse the factors determining the digitalisation of Polish companies, with particular emphasis on their alignment with the priorities and mechanisms defined within the European Industrial Strategy. Given that higher education institutions serve as critical nodes for knowledge transfer and capacity building, their role within the entrepreneurial ecosystem is of particular interest. By examining the degree to which Polish enterprises identify, value, and utilise ecosystem components, this study contributes to a deeper understanding of how institutional, organisational, and policy-driven factors jointly determine the pace and effectiveness of digital transformation in Poland.

2. The Economic Development Policy in the Digital Age

In the digital age, economic development policy undergoes profound transformation as governments confront new technological, organisational, and societal challenges. Contemporary research on economic policy and entrepreneurial ecosystems reflects a shift from traditional industrial frameworks toward models that recognise the centrality of digital technologies, knowledge flows, and innovation networks in shaping economic performance. This scholarship highlights how mechanisms of spatial business concentration, competitiveness, and development dynamics increasingly depend on institutions that support digital-enabled entrepreneurship—such as incubators, accelerators, clusters, hubs, and both traditional and digital entrepreneurship ecosystems (Ahokangas et al., 2018; Sussan, Acs, 2017). These institutions play a vital role in enabling firms to access knowledge, adopt new technologies, and integrate into digitally networked markets.

The digital age also expands the scope of development policy beyond individual enterprise support to encompass systemic strategies facilitating innovation diffusion and knowledge transfer. Universities, in particular, emerge as pivotal actors within these reconfigured policy landscapes. Their functions extend from educating graduates equipped with digital and entrepreneurial competencies (European Commission, 2005; Bedó et al., 2020; Czaja, Kafel, 2022), to collaborating with industry and public stakeholders on applied research and technology deployment (Watson, 2010; Buła, Schroeder, 2020). As centres of innovation and knowledge creation, universities significantly influence growth dynamics at both national and regional levels (Solow, 1956; Romer, 1990; Altmann, Ebersberger, 2013). Their participation in triple-helix structures—linking academia, business, and government—illustrates the increasingly interdependent nature of economic development in the digital era (Etzkowitz, Leydesdorff, 1999; Truskolaski, Waligóra, 2015). The evolution toward quadruple and quintuple helix models (Carayannis et al., 2012) further reflects how digitalisation widens the policy arena to incorporate civil society and ecological sustainability as integral dimensions of innovation-driven development.

Economic development policy in the digital age is also characterised by a strategic reorientation of competitive models. Whereas earlier industrial paradigms relied heavily on low labour costs or material efficiencies, contemporary economic advantage derives increasingly from capabilities in knowledge production, technological innovation, and digital resource integration. These conditions require strengthened collaboration and resource sharing between universities, enterprises, public administration, and social organisations—the full spectrum of actors embedded in digitally mediated entrepreneurial ecosystems (Etzkowitz, Zhou, 2018). Moreover, the escalating costs and complexity of research and development, particularly in frontier technologies, have prompted renewed recognition of the state's role as a key catalyst of innovation. Recent analyses emphasise that public institutions frequently initiate or enable the development of transformative technologies, challenging assumptions that innovation is solely the domain of private enterprise (Mazzucato, 2019).

In this context, economic development policy becomes both a regulatory framework and an active instrument for shaping digital transformation. Governments increasingly influence the pace and direction of technological change by establishing standards for digital infrastructure, environmental sustainability, and resource efficiency; by designing incentive mechanisms for technological upgrading; and by directly participating in markets where necessary. Innovation leaders—entities whose solutions become dominant within a technological regime—serve as important drivers of digital restructuring, and may emerge from either the private or public sector (Nelson, Winter, 1982). Leadership in the digital age is defined not only by technological capacity but by the ability to reimagine goods, services, and organisational processes through digital transformation, thereby making them more personalised, efficient, and accessible (Sacavém et al., 2025). Table 1 illustrates how economic development policy has evolved across successive paradigms: from traditional enterprise-oriented policies, through

growth-oriented approaches, to ecosystem-based frameworks, and finally toward an increasingly individual-centred perspective. This evolution reflects a fundamental recalibration of policy goals, instruments, and governance arrangements necessitated by digital transformation. Within the European Union, current economic policy places strong emphasis on the creation of entrepreneurial ecosystems and networks of technology centres as mechanisms for supporting digitally advanced organisational structures across industry, production, trade, and services. These frameworks align with broader European objectives related to digitalisation, decarbonisation, and cross-sector innovation.

Table 1.

Traditional, Growth-Oriented, Entrepreneurial Ecosystem and Individual-oriented policy

Policy and its components	Traditional Enterprise Policies	Growth-Oriented Enterprise Policies	Entrepreneurial Ecosystem Policies	Individual-Oriented policy
<i>Main unit of focus</i>	On specific actors, such as individuals, entrepreneurs, geographic clusters of firms.	On specific types of entrepreneurs, networks of entrepreneurs or 'temporary' clusters.	On leaders of innovations in the field of high and digital technologies, AI, and ecology.	On science, technology and innovation, on individual open access to the markets.
<i>Policy objectives</i>	Generate more entrepreneurs and grow more new ventures.	Focus on the high potential or 'blockbuster entrepreneurs' with the largest economic potential, high growth firms (HGFs).	Projects, startups, and enterprises increasing digitisation and resource reduction, strengthening "technopreneurship"	Generate more innovators and entrepreneurs, grow more new projects, market, private ownership and free entrepreneurship.
<i>Policy targets</i>	Specific focused interventions aimed at parts of entrepreneurial systems (i.e. non-systemic).	At connecting components within ecosystems to enable the system to better function (i.e. systemic).	Growth through the use of technology, awareness, self-sufficiency, development based on recycled materials.	Limited Access Order to Open Access Order. Free access to the economic circulation.
<i>Main forms of assistance</i>	'Transactional' forms of support such as grants, tax incentives, subsidies etc.	'Relational' forms of support such as network.	Hubs, accelerators, centres for startups.	Simplification of regulatory frameworks, assistance at the microeconomic, local level.
<i>Main forms of assistance by policy makers</i>	Generating and promoting entrepreneurial sources of finance aimed at start-ups, particularly in the form of venture capital and business angel funding.	Building, developing connections between entrepreneurial actors, institutional alignment of priorities, fostering peer-based interactions.	Technological centres (that are key actors in innovation ecosystems due to their technical expertise and their ability to bring together and steer collaboration among various types of actors in their own ecosystems and beyond).	Increasing forms of cooperation, collaboration, and subcontracting between organisations and individual entrepreneurs and innovators.

Cont. table 1.

<i>Recognition of vital and supportive spheres</i>	New firm-based intellectual property and innovation, R&D and the protection of intellectual property rights.	Different funding requirements such as debt finance, peer to peer, crowdfunding, etc. due to businesses growth and upscale firms require access to a 'funding escalator' and 'cocktails' of different funding sources.	Support in two areas: (1) digitalisation and industrial modernisation, (2) greening, energy and resource efficiency.	Creation of new versions of existing tasks, in which labor has a comparative advantage.
<i>Tactical policies</i>	Strong encouragement to technology and innovation within hightech sectors.	Focus on developing innovation systems and fostering connections with customers, end users, suppliers, universities etc. increasing recognition of unprotected and 'open' sources of innovation. Innovation is porous transcending many sectors and industries – both new and traditional.	Dedicated to technology generating industrial ecosystems.	State intervention through regulatory legal measures during periods of turmoil and economic difficulties.
<i>Top-down policy vs bottom-up policy (direction)</i>	The level of policy making is mostly 'top down'.	The bulk of systemic policies are enacted at the regional or local level.	The level of policy making is 'top down' along technological path and/or ecological path. The key role of state institutions and corporations in the implementation of modern technologies.	Policy of liberalising people's activities and reclaiming economic areas protected by regulations friendly to public entities and large private ones.
<i>Economic policy centres</i>	The implementation of policy is mostly undertaken at national level but some initiatives are devolved.	Multi-scalar policy frameworks are emerging.	Policy implementation regulations and tools are undertaken at above national level. Centralisation of planning.	Decentralisation of planning.

Source: own elaboration on: Mason, Colin, Brown, Ross (2014). Entrepreneurial Ecosystems And Growth Oriented Entrepreneurship Background paper prepared for the workshop organised by the OECD LEED Programme and the Dutch Ministry of Economic Affairs, Monitoring European industrial ecosystems, Conceptual, Monitoring and Indicator Framework (2023) & Radu G., Liviu A., Warnke P. (2022). ISIS&T&I for 2050. Science, Technology and Innovation for Ecosystem Performance – Accelerating Sustainability Transitions. Case Study: Data As Representation.

Building on empirical insights from the systemic transformation of centrally planned economies and contemporary scenario modelling of future development trajectories, the authors propose an additional paradigm: an economic development policy centred on individual agency

and digitally empowered entrepreneurship. As presented in the final column of Table 1, this perspective highlights open access to markets, decentralised participation, and regulatory environments that enable individuals to engage directly in economic activity. In the digital age—where technological tools increasingly democratise access to knowledge, data, and markets—such an approach complements ecosystem-oriented strategies by emphasising the micro-level drivers of innovation and adaptability.

3. The Digital Transformation in the European Industrial Strategy

Contemporary European Union policy continues to rely on long-standing mechanisms designed to influence social, economic, cultural, and political development through the coordination of shared strategic objectives among Member States. This approach emphasizes coherence between the economic system and the broader socio-political order, aiming to increase inclusiveness, strengthen governance efficiency, and enhance overall prosperity, cohesion, and justice within a framework grounded in political democracy and the rule of law (North et al., 2009). The transition toward a more structured and sustainable market economy is supported by an inclusive legal-economic system based on the principles of markets, private property, and free entrepreneurship (Fiedor, 2023). The expansion of inclusiveness within the European legal-economic order is embedded in the growing openness of political, social, and economic domains—an openness intended to transform the system from a limited access order into an open access order. This openness does not imply institutional laxity; rather, it signifies increased access to markets, resources, and economic opportunities, subject to clear legal and regulatory frameworks (Table 1). State intervention through regulatory and strategic measures becomes particularly important during periods of economic instability. In response to disruptions caused by the COVID-19 pandemic and the Russian–Ukrainian conflict, EU policy shifted toward economic resilience and recovery. Within this context, the European Commission introduced the European Industrial Strategy (EIS), a comprehensive framework articulating nine strategic priority areas: digital transformation, ecosystems, energy-intensive industries, clean hydrogen, skills for industry, interregional partnerships, innovation, industrial policy dialogue and expert advice, and intellectual property. These strategic domains—defined in 2020—were accompanied by timelines and implementation pathways tailored to the varying levels of advancement across Member States (Fig. 1). Among them, digital transformation and ecosystems represent two interdependent pillars: one technological, the other political-economic. Their integration marks an innovative attempt to connect digitisation with specific industrial sectors and policy-driven development processes.



Figure 1. European industrial strategy 2020.

Source: own elaboration Monitoring European industrial ecosystems, Conceptual, Monitoring and Indicator Framework (2023).

Modern EU industrial policy recognizes the emergence of interconnected sectors—FinTech, MedTech, e-banking, e-governance, and others—that did not previously exist in such codified forms. These sectors constitute new forms of economic ecosystems, creating value for both individual and institutional users (Ruohomaa, 2020). The literature on digitalisation highlights how digital technologies—automation, data mining, machine learning, and new communication tools—enhance efficiency, reduce processing times, expand service offerings, and increase transparency within production and service chains (Layne, Lee, 2001; Norris, Reddick, 2011; Matheus et al., 2018).

Within EU development strategies, sectoral ecosystems function as multidimensional constructs that combine technological–digital and ecological pathways, each representing distinct yet interrelated transformation trajectories. These ecosystems encompass coordinated activities among industry, public institutions, social partners, and other stakeholders. They collectively develop transformation pathways across both dimensions, supported by initiatives such as the Monitoring European Industrial Ecosystems (MEI) project, which tracks changes and progress (MEI, 2023).

The ambitious development trajectory envisioned by the European industrial strategy suggests that both the ecological and technological paths—rooted respectively in the Green Deal and the Fourth Industrial Revolution—will evolve through ecosystem-based approaches. Importantly, the EU’s use of the term “ecosystem” narrows its traditional ecological meaning, while expanding its common economic interpretation to encompass systems of institutional support for innovation and entrepreneurship. This reconceptualization was formalized in 2022, when the EU identified 14 industrial ecosystems functioning as microeconomic environments (“smart units”) and socio-economic environments (“smart markets”), operating in both urban (smart cities) and rural (smart villages) settings (Fig. 2).

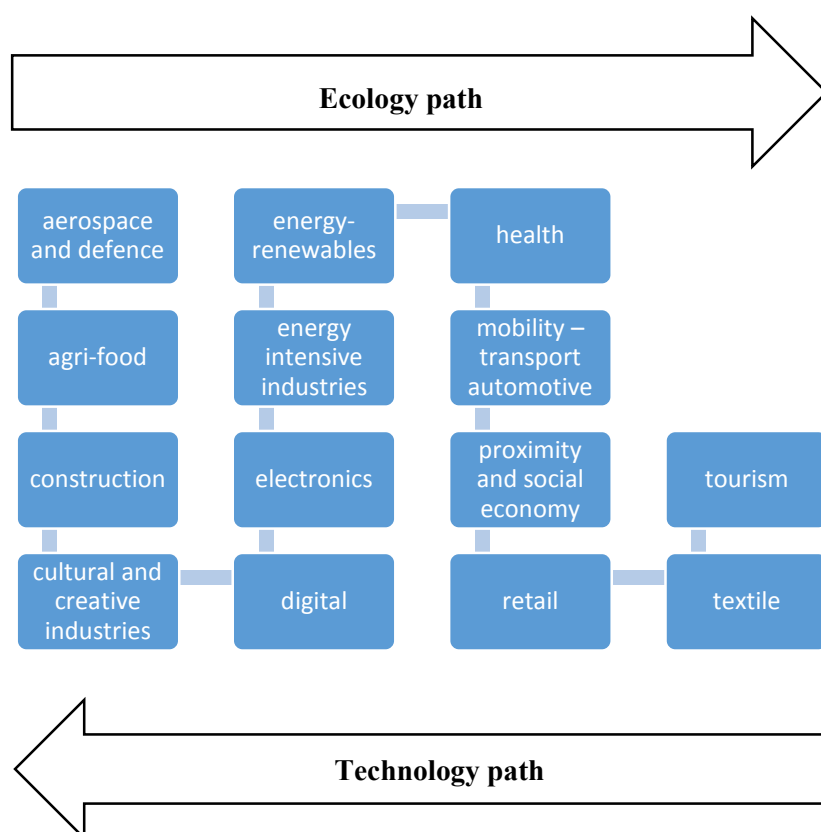


Figure 2. 14 industrial ecosystems as highlighted in the European industrial strategy in 2020.

Source: own elaboration on European industrial strategy 2020.

These ecosystems—ranging from aerospace and defence to agri-food, cultural and creative industries, digital, electronics, renewables, mobility, social economy, retail, textiles, and tourism—represent the foundation of EU industrial transformation. They demonstrate how digital technologies are not merely tools but structuring principles for industrial organization, sectoral interdependence, and value-creation processes. By accelerating the **twin transitions**—green and digital—the EU aims to transform traditional sectors into dynamic industrial ecosystems capable of meeting future economic and environmental challenges. Many actions outlined in the 2020 Industrial Strategy to support these transitions have already been initiated across Member States.

4. The Digital Transformation Gap Between Poland and the European Union

The digital transformation gap between Poland and the European Union (EU) has become increasingly evident when assessed against international benchmarks. According to the *International Benchmarking of the Digital Transformation 2024* report, the EU as a whole displays only moderate competitiveness compared with global digital leaders; however, Poland

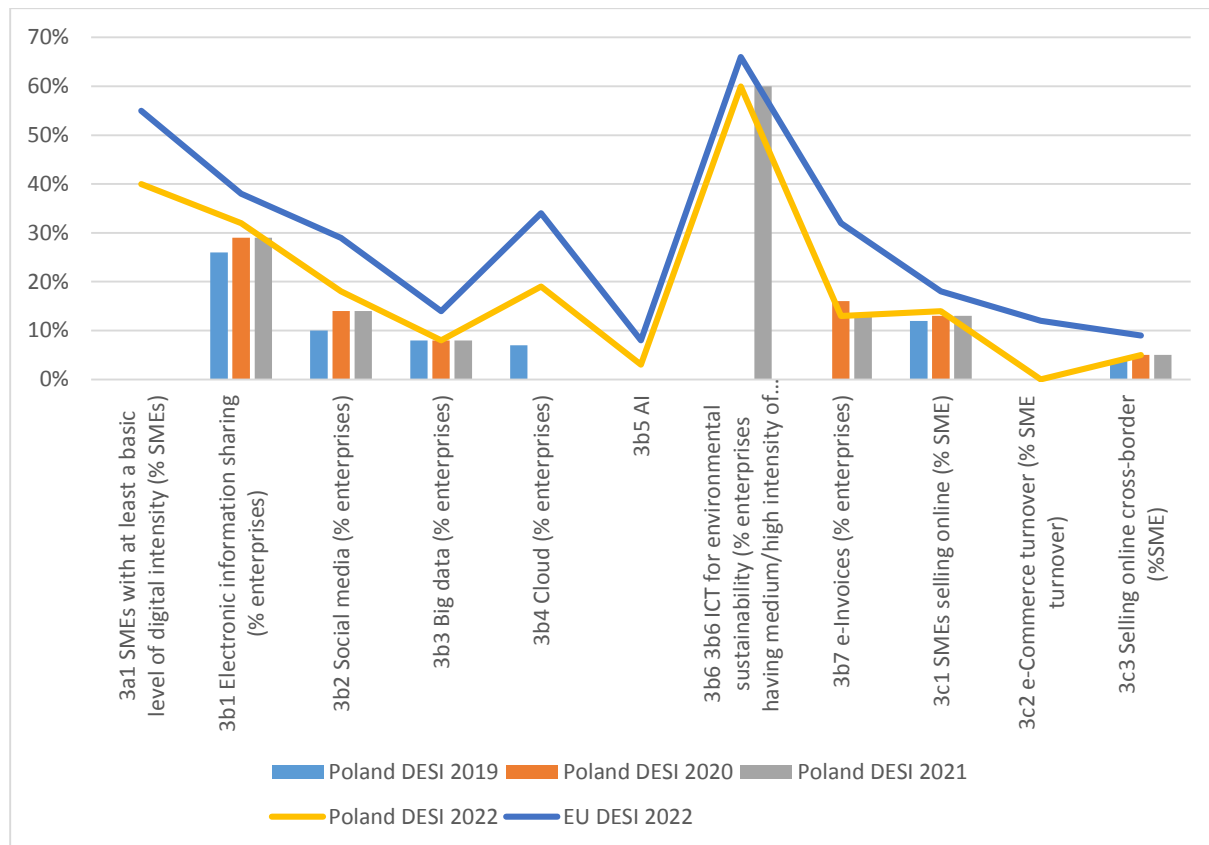
consistently performs below the EU average across most examined dimensions (Bednorz et al., 2024). This divergence underscores persistent structural, infrastructural, and organisational barriers that inhibit Poland's pace of digital advancement relative to European standards.

The EU's digital transformation is typically evaluated through multidimensional indices such as the International Index of Digital Economy and Society (IDESI), the World Digital Competitiveness Index (WDSI), the Network Readiness Index (NRI), the Digital Intelligence Index (DII), and the UN E-Government Development Index (EGDI). When benchmarked against these indicators, Poland's progress remains limited, weakening its position within the European digital ecosystem (Bednorz et al., 2024).

Since 2023, the process of identifying Key Performance Indicators (KPIs) that monitor progress toward the objectives of the Digital Decade has included DESI. KPIs were developed using the DESI exercise, which was already in existence and tracked the annual state of the digital transformation in Europe. Since that year, the strategy of digitising the economy and society has been implemented. Its implementation in EU countries has been based on the Digital Decade policy program (DDPP), and the "State of the Digital Decade 2025" reports monitor the progress and changes in digitisation. The DDPP promotes investments in digital skills, digital transformation of businesses, digitalisation of public services, and the deployment of gigabit and 5G networks that are safe and sustainable. This is driven by the governance framework, which is founded on an annual cooperation mechanism including the Commission and Member States, according to the Communication - 2030 Digital Compass: the European strategy for the Digital Decade. The objectives of the Digital Decade Program are based on the four cardinal elements of the program: a population with high levels of digital competence and experience; safe and sustainable digital infrastructures; business transformation; and digitisation of public services.

Although some EU member states demonstrate excellence in digital skills, infrastructure deployment, and enterprise transformation, Poland's slower development in these areas widens the internal EU gap. A central component of this disparity is the insufficient level of advanced digital competencies in Poland. Challenges persist in the supply of ICT graduates, the diffusion of high-speed connectivity, and the deployment of 5G networks. These gaps affect Poland more severely than the EU average, thereby constraining its ability to participate fully in the region's digital transition (Bednorz et al., 2024). Furthermore, Poland significantly underperforms in frontier areas such as semiconductor uptake, quantum-technology-related patents, and the scaling of high-growth technology enterprises. While the EU as a whole struggles with these strategic sectors, the gap between Polish and EU performance remains substantial.

The divergence is further illustrated by enterprise-level indicators. Poland ranks 24th out of 27 EU member states in the Digital Economy and Society Index (DESI), with particularly low scores in digital technology integration (Fig. 3).



X-axis label: DESI Indicator Categories.

Y-axis label: DESI Score (percentage share).

Figure 3. Integration of digital technology.

Source: Authors' own study on DESI for 2022, Poland, p.13 and DESI for 2019-2021.

Polish companies are less likely to use electronic information-sharing systems, social media, big data analytics, cloud solutions, artificial intelligence, or cross-border e-commerce compared with the EU average. For example, cloud computing adoption in 2022 was significantly lower in Poland than in the EU, and the use of AI technologies was also markedly behind European benchmarks. At the same time, disparities within the EU often exceed the distance between EU averages and global digital leaders—yet Poland typically falls near the bottom of the EU distribution (DESI 2019-2022). The difference in enterprise digital maturity is also notable. Only 6.8% of medium-sized and 22% of large Polish enterprises have reached advanced digitalisation levels, compared with 9.6% and 26.3% in the EU, respectively. Although productivity in Polish firms improved between 2021 and 2023, these gains were still smaller than improvements recorded across the EU, further intensifying the productivity gap linked to digitalisation. E-commerce participation also remains weaker in Poland (21% of SMEs) compared with the EU average (30%). These discrepancies demonstrate that Poland's business sector remains less capable of using digital tools to enhance competitiveness, efficiency, and market reach (Olszynka et al., 2024). Despite these gaps, Poland shows strengths in specific areas that may help narrow the divergence. Cloud adoption, for instance, has risen substantially: 56% of Polish companies used at least one cloud solution in 2023—a 27%

increase over two years. This acceleration outpaced the rate of change in several EU states, although overall Polish adoption levels still trail behind leading European performers. The growing interest in process automation and data analytics also suggests an emerging readiness to bridge the digital divide, as confirmed by surveys showing widespread recognition of digital transformation as a strategic necessity (Olszynka et al., 2024). Nevertheless, structural obstacles continue to widen the gap. Many Polish enterprises remain reliant on manual workflows: 38% maintain paper-based documentation and 58% use manual data entry, compared with significantly lower levels in the EU. Adoption of advanced planning systems (APS), typical of Industry 4.0 environments across Europe, has dropped to 6% in Poland. Barriers cited by Polish companies—security concerns, integration difficulties, and cost pressures—appear more acute than those reported by many EU peers, indicating national-level constraints affecting digital readiness (Olszynka et al., 2024).

Regulatory developments in the EU, such as the National e-Invoicing System (KSeF), the VAT in the Digital Age (ViDA) initiative mandating electronic invoicing by 2028, and the Corporate Sustainability Reporting Directive (CSRD), further highlight Poland's lag in aligning enterprise systems with evolving European standards. While many EU firms have already integrated advanced reporting, invoicing, and sustainability-tracking technologies, a significant share of Polish enterprises continues to adapt reactively rather than strategically. This dynamic reinforces the structural dimension of the Poland–EU digital gap (Olszynka et al., 2024). Closing this gap requires substantial strategic investment. According to estimates cited in the analysed reports, effective implementation of AI could improve operational efficiency by up to 20%, but Polish firms remain less capable of identifying and deploying viable AI use cases compared with their EU counterparts. The National Recovery and Resilience Plan (KPO), which offers over one billion euros to accelerate Industry 4.0 adoption, represents an opportunity to converge with EU digital standards—yet its success will depend on firms' capacity to overcome existing organisational and infrastructural barriers (Olszynka et al., 2024).

Overall, the digital transformation gap between Poland and the European Union is multifaceted and persistent. It stems from disparities in digital skills, infrastructural investment, enterprise digital maturity, regulatory readiness, and technological innovation. While Poland demonstrates progress in selected areas, the structural nature of the gap indicates that without coordinated public policy, stronger enterprise capabilities, and sustained investment in advanced technologies, Poland will continue to lag behind the EU average, potentially limiting its economic competitiveness and strategic resilience in the digital era.

5. The Key Factors Shaping and Driving the Processes of Polish Companies' Digitalisation (Empirical Research)

The purpose of this empirical study was to identify and analyse the key factors shaping and driving the digitalisation processes in Polish enterprises. Recognising that digital transformation is embedded within a broader entrepreneurial ecosystem (EE), the study sought to determine which ecosystem components play the most significant role in stimulating, enabling, or accelerating digital adoption at the firm level. To this end, a nationwide CATI survey of 302 enterprises—stratified by sector and employment size—was conducted using a reference population of 98,153 firms (Fig. 4).

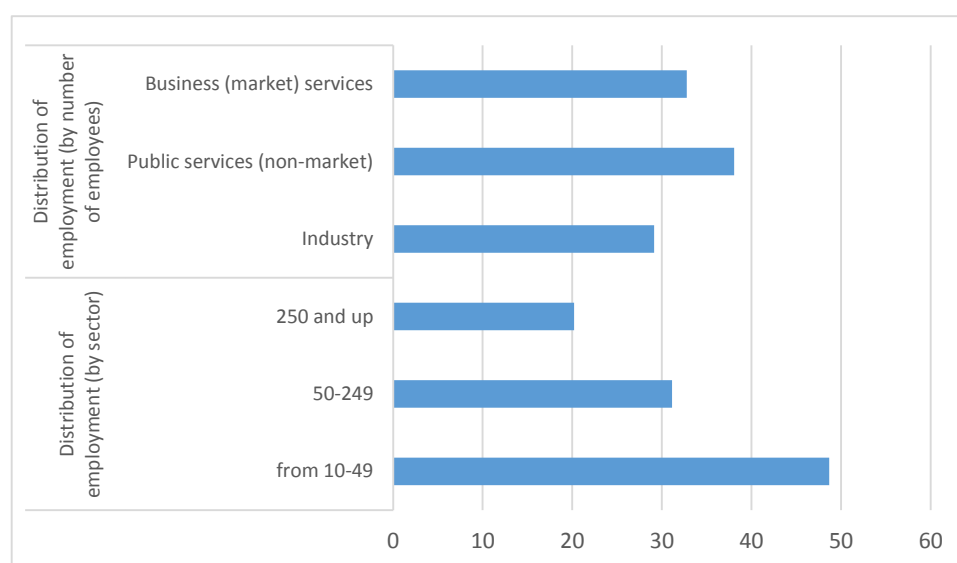


Figure 4. Structure of the research sample (percentage).

Source: own elaboration.

The inclusion of entrepreneurial ecosystem models featuring universities and knowledge generating institutions reflects the assumption that digitalisation processes develop through interactions between firms and their institutional, regulatory, educational, and technological environments.

Two research questions guided the empirical analysis:

- Q1. Which elements of the entrepreneurial ecosystem exert the strongest impact on firms' digitalisation processes?
- Q2. Do enterprises perceive their internal conditions and external surroundings as favourable for implementing digital transformation?

5.1. Key External Drivers of Firms' Digitalisation (Q1)

The first research question focused on identifying the **critical ecosystem elements** that shape and drive digitalisation in Polish companies. Respondents assessed the influence of ten ecosystem components using a 7-point scale. Across all sectors and enterprise sizes, the most powerful driver of digitalisation was **government policy and legal regulation** (Fig. 5).

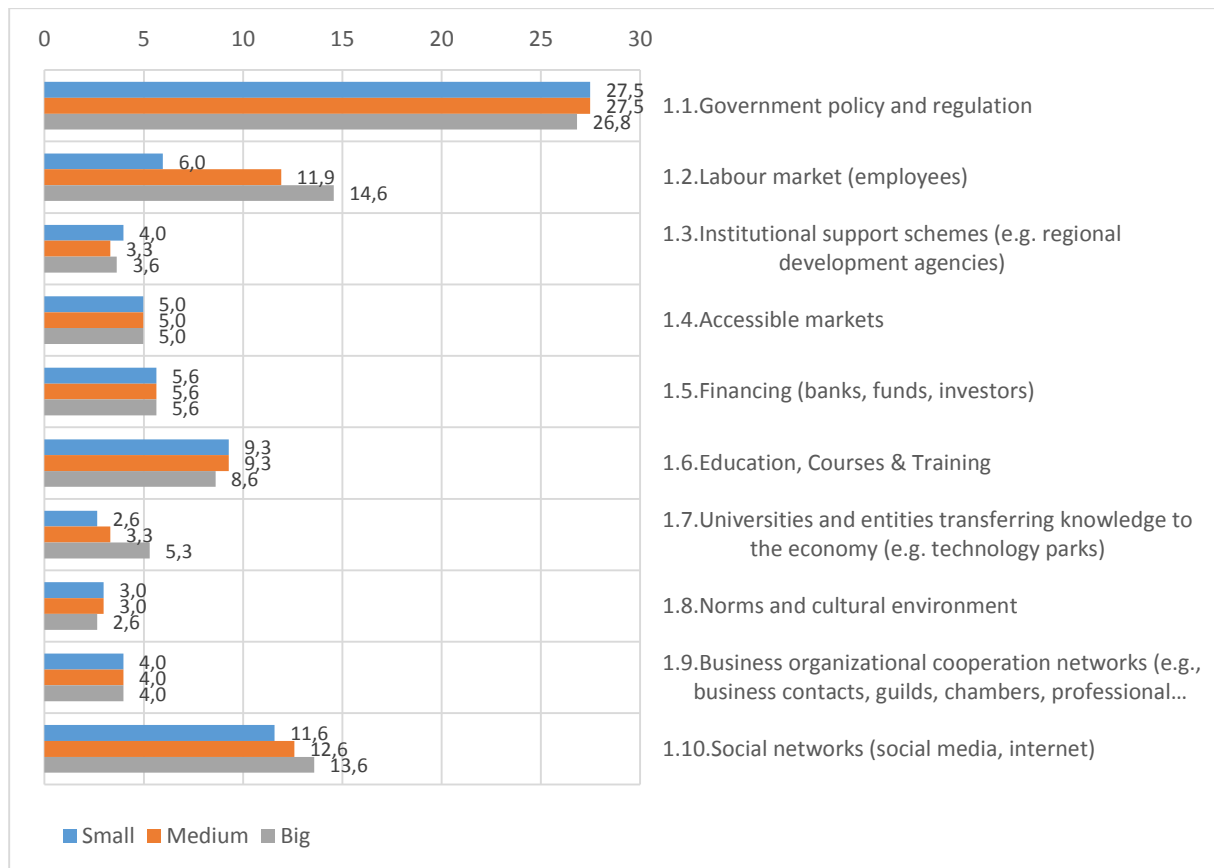


Figure 5. Significant elements of the ecosystem in digitalisation processes.

Source: Own elaboration.

With 27% of firms ranking this factor as most significant, public policy emerges as the dominant structural force directing digital transition. This reflects both regulatory pressures (e.g., obligatory digital reporting systems) and state-supported incentives encouraging the adoption of digital solutions.

Two additional ecosystem factors strongly shaping firm-level digitalisation were identified:

- Social networks (Internet and social media), highlighted by 12% of firms as a major driver due to their centrality in communication, marketing, and customer interaction.
- Education, courses, and training, pointed out by 9% of respondents, indicating that skill development constitutes a relevant—though secondary—mechanism enabling digital transformation.

Other ecosystem components—such as the labour market, external financing, and cultural norms—exert a moderate yet meaningful influence.

Importantly, firm size differentiates how these drivers are perceived:

- Small enterprises emphasise government policy, labour market characteristics, and cultural norms.
- Medium-sized enterprises recognise the role of social networks and workforce skills alongside public policy.

- Large organisations particularly stress the labour market and the availability of skilled employees as central drivers of digitalisation.

Sectoral differences also reveal divergent digitalisation drivers (Fig. 6). For instance, education and healthcare identify government policy as a decisive force, reflecting their regulatory intensity.

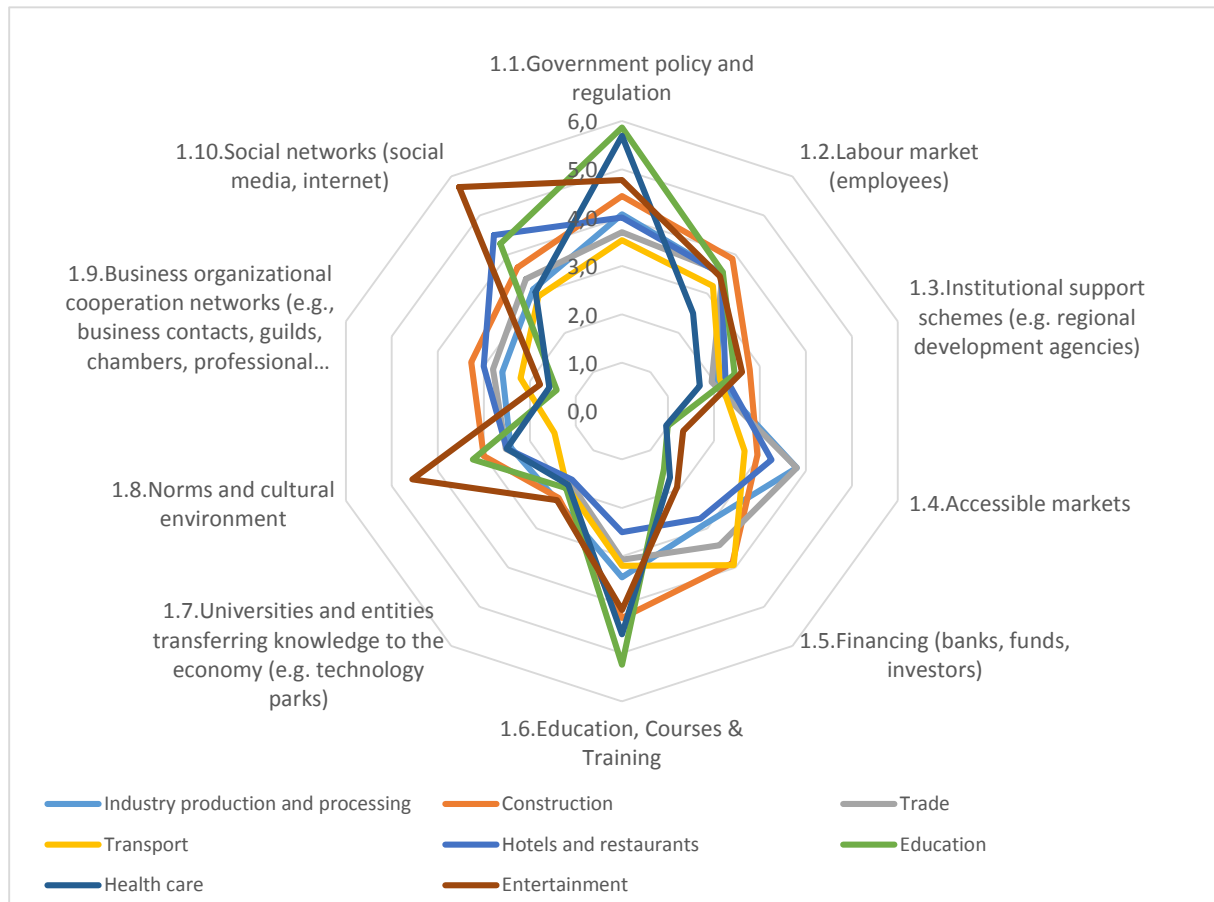


Figure 6. Assessment of the impact of ecosystem elements on the business digitalisation in a sectoral approach.

Source: Own elaboration.

Conversely, entertainment enterprises view digital social networks as their primary digitalisation driver, underscoring the sector's dependence on online channels.

Across the sample, universities, research institutions, and formal institutional support schemes were assessed as weak drivers of digitalisation, suggesting that these actors—although essential in many theoretical EE frameworks—currently play a marginal role in shaping the digital transformation of Polish firms (Fig. 7).

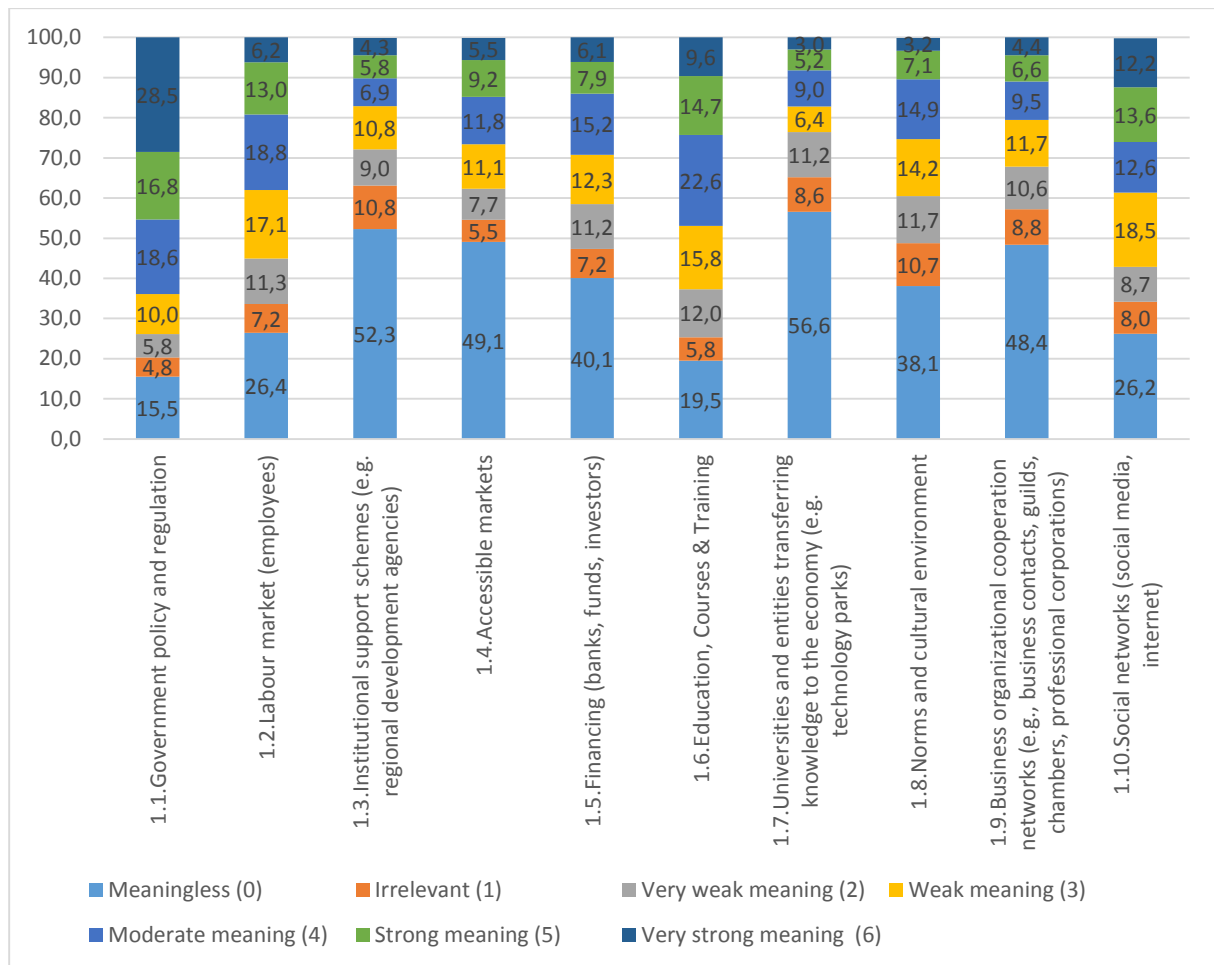


Figure 7. Assessment of the impact of ecosystem elements on the business digitalisation of enterprises.

Source: Own elaboration.

5.2. Internal and Relational Factors Driving Digital Transformation (Q2)

The second research question explored whether firms perceive their internal environment and network relationships as conducive drivers of digitalization. Respondents evaluated five statements related to human capital, partner readiness, and the use of digital platforms.

Two factors emerged (Fig. 8 and Fig. 9). as particularly strong internal or relational drivers of digitalisation processes:

1. The engagement of qualified employees who understand the need for change (Q2.3).
2. Partners (suppliers, customers) perceiving digitalisation as an opportunity for growth (Q2.2).

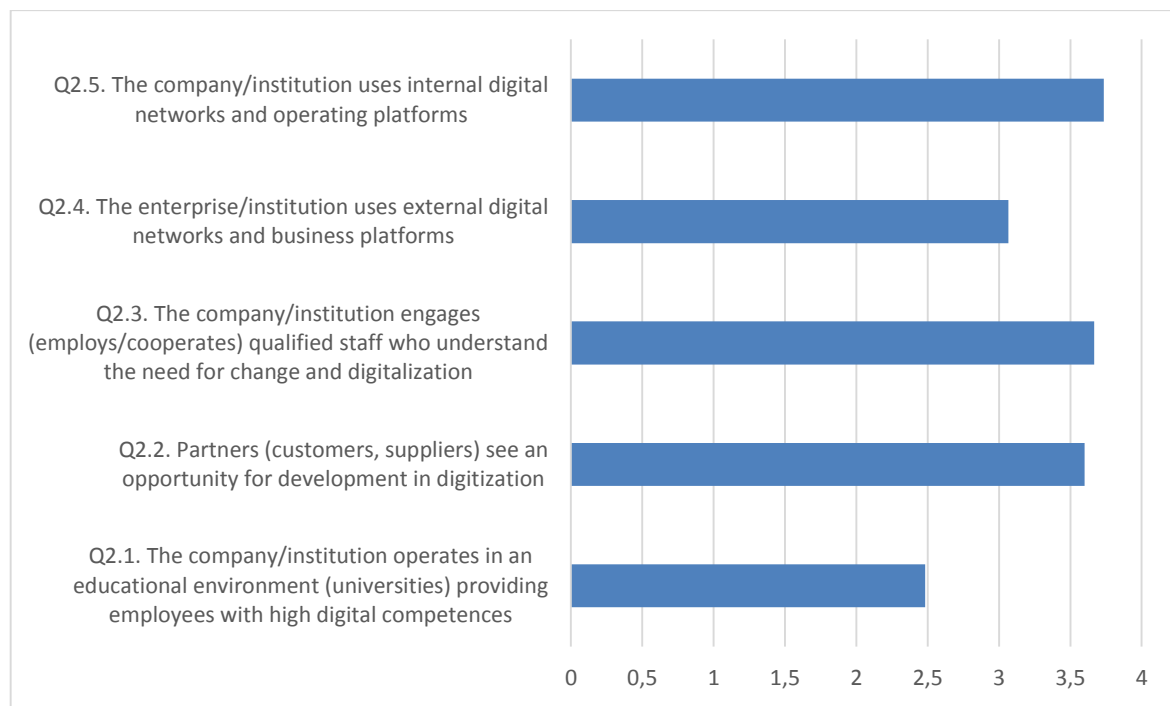


Figure 8. Assessment of the elements of the entrepreneurial ecosystem creating conditions conducive to the introduction of digital transformation in the surveyed enterprises (arithmetic mean of the responses).

Source: own study.

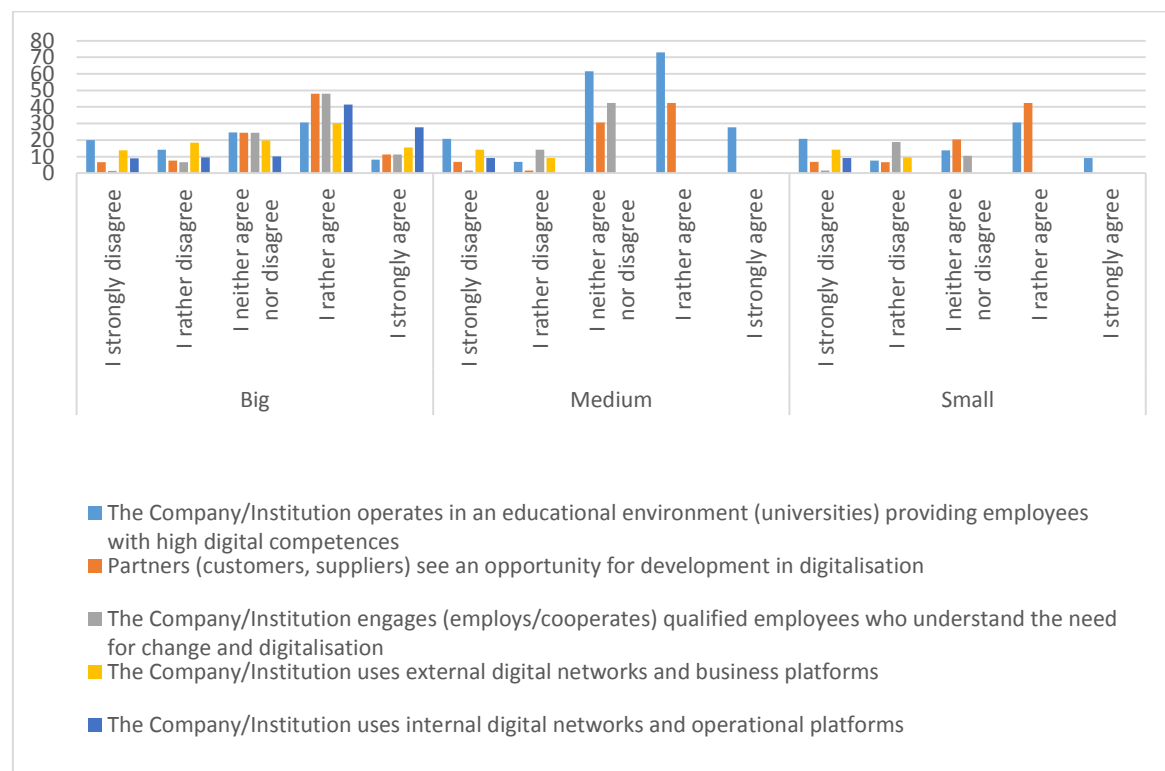


Figure 9. Assessment of the elements of the entrepreneurial ecosystem and its surroundings creating conditions conducive to the introduction of digital transformation in the surveyed enterprises by size (percentage of the responses).

Source: own study.

These findings highlight the importance of micro-level relational dynamics in driving digital transformation. Digitalisation is not isolated within the firm but co-constructed through cooperation networks, especially in supply chains and customer relationships.

The role of these internal drivers varies by firm size:

- SMEs show especially strong dependence on digitally oriented partners and employees, indicating that relational and human-capital-based drivers compensate for resource constraints.
- Large enterprises, in contrast, report extensive use of internal and external digital platforms, demonstrating more advanced digital infrastructure as a driver of ongoing transformation.

5.3. Interactions Between Drivers: Correlational Insights

Correlation analysis (Spearman's coefficient, $\alpha = 0.05$) revealed several significant interdependencies that help explain how digitalisation processes develop within firms:

- Firms with partners who see digitalisation as a development opportunity tend to place greater importance on business cooperation networks as drivers of digital transformation.
- The perceived influence of cooperation networks correlates with the strategic importance of employing qualified staff, highlighting a joint relational–human-capital mechanism driving digitalisation.
- The importance assigned to education and training corresponds with both the perceived necessity of skilled employees and the use of external digital platforms.
- The increasing relevance of cooperation networks is linked with the adoption of internal digital platforms, showing that relational factors stimulate technological investment.

These correlations indicate that digital transformation is shaped by interacting drivers, not isolated influences. Systemic relationships between partners, workforce capabilities, and digital infrastructure collectively drive the digitalisation trajectory.

5.4. Synthesis: The Key Factors Shaping and Driving Digitalisation Processes

Overall, the study identifies three categories of key drivers shaping the digitalisation processes of Polish companies:

1. Regulatory and institutional drivers

With government policy clearly emerging as the most influential factor, regulatory frameworks shape digital adoption across all enterprise types and sectors.

2. Relational and network-based drivers

Customer-supplier relationships and digital social networks play a central role, indicating that digitalisation is network-driven and highly dependent on interactions within the business ecosystem.

3. Human-capital and capability drivers

The availability of digitally skilled employees and access to training significantly shape firms' ability to implement digital change.

By contrast, universities, research institutions, and formal support organisations currently do not function as major drivers of digitalisation, despite their theoretical importance in entrepreneurial ecosystem models.

The empirical evidence demonstrates that digitalisation in Polish enterprises is primarily driven by a combination of state policy, network interactions, and workforce capabilities. These forces—acting simultaneously—shape the pace, direction, and depth of digital transformation processes.

6. Conclusions

This study advances an evidence-based account of the key factors shaping and driving the digitalisation processes of Polish companies within the broader frame of the European Industrial Strategy. The results demonstrate that government policy and legal regulation constitute the dominant structural driver of enterprise digitalisation, consistently outstripping the influence of other entrepreneurial-ecosystem components across sectors and firm sizes. Regulatory mandates and incentives—covering digital communication, reporting, fiscal-administrative systems, and platform use—act as the principal levers that initiate, coordinate, and scale digital adoption at the firm level.

At the same time, the analysis reveals limited recognition of universities, research institutions, and formal support schemes as proximate drivers of firms' digitalisation. Despite their prominent place in ecosystem theory and EU policy discourse, surveyed firms ascribe comparatively weak influence to these actors, signalling a persistent translation gap between the knowledge-production subsystem and enterprise-level digital capability building. Beyond regulation, the relational and capability mechanisms of digital transformation emerge clearly in the data. Firms that employ digitally competent staff and operate with partners who see digitalisation as an opportunity report stronger progress, while correlations indicate that cooperation networks are associated with both human-capital investments and the adoption of internal and external digital platforms. This pattern supports a network-embedded view of digitalisation in which regulatory pressure, ecosystem relations, and firm capabilities jointly determine the pace and depth of transformation. Finally, firm size and sector shape how drivers are prioritised. SMEs emphasise regulatory guidance alongside labour-market and cultural factors; large firms more often combine regulation with capability-oriented drivers (training, platformisation). Sectors with high regulatory intensity (e.g., health, education) foreground policy as decisive; relationship-intensive sectors (e.g., entertainment) elevate digital social networks. Collectively, the evidence indicates that Polish companies' digitalisation trajectories are driven by an interplay of regulatory–institutional, relational–network, and human-capital forces, with knowledge-infrastructure actors currently underutilised.

This study offered a number of complementary viewpoints on the digital transformation issue. In contrast to previous studies, such as Sacavém et al. (2025), which focus on internal organisational dynamics and highlight leadership behaviour, emotional intelligence, and micro-level mechanisms of technological integration, our analysis turns its focus to the external entrepreneurial ecosystem and the macro-level factors that influence firms' digital trajectories. While Sacavém et al. see leaders as key players who use AI-enhanced decision making to strengthen adaptive capacities and align organisational goals with innovation processes, the nationwide empirical findings show that, in the Polish context, state policy and regulatory mandates constitute the predominant forces driving digital adoption, which 27% of surveyed enterprises identified as the primary catalyst for transformation. Despite the general consensus in the literature that technological advancement alone is insufficient to produce significant organisational change, there is still a clear disagreement about the basic initiating mechanism: the top-down, regulatory impetus highlighted in the authors' results versus the leadership-driven, vision-anchored perspective.

6.1. Implications for Policy and Management Policy

Given the centrality of state policy, effectiveness depends not only on what is mandated but how mandates connect to firms' absorptive capacity. Instruments that combine clear compliance pathways (standards, deadlines, templates) with capability scaffolds (targeted training, interoperable public platforms, vendor-neutral toolkits, and SME-friendly financing) are likely to accelerate adoption while reducing compliance-driven cost burdens. Strengthening university–industry interfaces (e.g., practice-oriented microcredentials; joint labs anchored in sectoral ecosystems; brokered placements of ICT talent into SMEs) can convert currently weak knowledge links into actionable capabilities.

Management. For firms—especially SMEs—the data suggest three priorities:

1. Codify partner-centric roadmaps (co-design use cases with customers/suppliers).
2. Invest in role-specific digital skills (pair training with process redesign, not just tools).
3. Platform readiness (progressive onboarding to external and internal platforms to unlock data flows and automation). These steps align with the identified synergy between partner readiness, skilled staff, and platform adoption.

6.2. Limitations and Future Research

The study relies on a cross-sectional CATI survey and perceptual measures of influence, which constrain causal inference and may under-represent fast-moving technological niches. Future research should (1) triangulate perceptions with objective digital-maturity indicators (e.g., transactional e-invoicing rates, API usage, cloud workload shares), (2) employ panel designs to track transformation pathways under evolving EU regulatory timelines, and (3) examine intervention logics that link policy instruments to firm-level capability accumulation, including the role of universities and technology intermediaries as active co-producers of enterprise outcomes.

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FROM AI ADOPTION TO ORGANISATIONAL STABILISATION

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Purpose: Artificial intelligence (AI) is increasingly framed as a transformative organisational capability whose benefits are assumed to follow from technological adoption. However, in probabilistic AI environments, adoption does not automatically lead to stable organisational integration. The purpose of this study is to find mechanisms that enable or hinder the organisational stabilisation of AI-supported work in startup environments.

Design/methodology/approach: This study adopts an explanatory mixed-method design to examine the organisational stabilisation of AI in startup environments. The quantitative part analyses relationships among environmental awareness, trust in AI, psychological sustainability and digital competence using Partial Least Squares Structural Equation Modelling (PLS-SEM) based on a survey of Generation Z employees in AI-enabled startups (N = 120). The qualitative part applies reflexive thematic analysis of open-ended responses and semi-structured interviews with founders and accelerator representatives responsible for AI implementation.

Findings: The results reveal a selective stabilisation structure in AI-supported work. Trust in AI appears as the only statistically significant predictor of psychological sustainability and acts as the key mechanism linking AI use with stable organisational routines. Environmental awareness and digital competence show no independent effect. The findings further show that AI systems may remain widely used while generating hidden validation effort and coordination costs, resulting in a condition described as *stabilisation drift*.

Research limitations/implications: This study has several limitations. First, the cross-sectional dataset from employees in AI-enabled startups limits the ability to capture long-term stabilisation dynamics. Second, the focus on Generation Z employees may influence feelings of AI use and trust formation. Future research should employ longitudinal and multi-source designs to examine how reliance on AI evolves over time and to explore stabilisation mechanisms across different organisational contexts and technological domains.

Practical implications: The findings suggest that organisations should treat trust in AI as a strategic infrastructure of digital transformation rather than a secondary outcome of implementation. Managers should evaluate AI initiatives not only through technical performance but also through reliance intensity and the validation effort generated in everyday workflows. AI systems requiring persistent checking may create hidden coordination costs; therefore, organisations should prioritise transparency, behavioural predictability, and clear communication of system limitations to support stable human–AI collaboration.

Social implications: The findings highlight trust as a key condition for sustainable human–AI collaboration. By focusing on stabilisation rather than simple adoption, the study contributes to debates on trustworthy and human-centred AI and may inform organisational governance and public policy on responsible AI deployment.

Originality/value: The study advances AI adoption research by distinguishing diffusion from organisational stabilisation and introducing the concept of *stabilisation drift*. It reconceptualises trust as an organisational coordination infrastructure in probabilistic AI environments, contributing to socio-technical perspectives on sustainable AI integration in startups and technology-driven organisations.

Keywords: Artificial intelligence; AI stabilisation; Trust in AI; Startup ecosystems; Diffusion of innovation.

Category of the paper: Research paper.

1. Introduction

Artificial intelligence (AI) has rapidly evolved from an experimental technology into a strategic capability across contemporary organisations. Firms increasingly invest in AI to enhance decision-making process, optimise operations, and accelerate innovation. Yet a continuing productivity paradox stays: many AI initiatives do not generate sustained organisational performance gains despite formal adoption. This problem highlights a conceptual limitation in management research, which often treats diffusion as a discrete technological event rather than a continuous process of socio-technical integration. As Brooks (2017, pp. 139-159) sees, the development of artificial intelligence has historically followed a nonlinear trajectory characterised by alternating periods of rapid progress and stagnation (Pilny et al., 2025).

The organisational challenge is intensified by the nature of present generative AI systems. Unlike deterministic legacy technologies, Generative AI (GenAI) works on probabilistic logic and may produce ambiguous or incorrect outputs, often referred to as hallucinations (Joshi, 2025, pp. 38-50). These characteristics introduce interpretive uncertainty and require ongoing validation of AI-generated results. Therefore, the managerial challenge increasingly shifts from technical optimisation toward setting up organisational conditions that enable dependable human–AI collaboration (Ćwiertniak, 2025, p. 80; Lipińska, 2024, pp. 369-383). From a socio-technical perspective, generative AI should therefore be understood not as a single technology but as a system running across interconnected levels of models, technical systems, and organisational applications (Feuerriegel et al., 2024, pp. 111-126).

To address this challenge now, the study conceptualises AI integration through the lens of organisational stabilisation. This balance is understood as the organisational condition in which AI-supported work becomes routinised without generating persistent validation effort, task duplication, or coordination costs that offset expected efficiency gains. Within this new perspective, trust functions not merely as an individual attitude but as a coordination mechanism enabling users to rely on probabilistic AI outputs without excessive monitoring. When trust is absent, organisations experience added coordination costs and technostress (De Cremer, Koopman, 2024; Kim, Lee, 2024).

These dynamics are particularly visible in startup environments running within rapidly evolving technological and regulatory ecosystems. In Europe, AI development is increasingly embedded in strategic initiatives such as the Strategic Technologies for Europe Platform (STEP) and the regulatory framework introduced by the EU Artificial Intelligence Act (European Commission, 2024). Poland's expanding startup ecosystem therefore provides a relevant empirical context for examining how organisational mechanisms enable or hinder the stabilisation of AI-supported work.

In this context, named challenges, the purpose of this study is to name and analyse the mechanisms that enable or hinder the organisational stabilisation of AI-supported work in complex environments. By distinguishing diffusion from stabilisation in the context of AI adoption, the paper contributes to management research in three ways. First, it extends the Diffusion of Innovation (DOI) perspective by introducing a process-oriented and cost-sensitive understanding of organisational AI integration. Second, it reconceptualises trust as a coordination mechanism necessary for navigating probabilistic AI environments. Third, it introduces the concept of *stabilisation drift* as a condition in which AI stays formally adopted yet does not become operationally stabilised within everyday organisational practices.

This perspective also responds to broader critiques within AI research. Contemporary debates often focus on speculative scenarios of superintelligence (GAI), despite limited empirical evidence supporting such projections. Studies on sociotechnical risk suggest that too much attention to isolated technological futures may divert attention from immediate organisational, ethical, and governance challenges associated with current AI deployment (Stilgoe et al., 2013, pp. 1568-1580). By focusing on stabilisation, this study shifts analytical attention toward the organisational conditions under which AI systems become reliably embedded in routine work practices. An added contribution of the research is the development of an empirically grounded profile of next-generation AI users and the proposal of a Sustainable AI Adoption Canvas designed to support managerial decision-making in AI implementation processes.

2. Theoretical background and hypothesis development

2.1. Conceptual background

AI has been framed as a disruptive innovation (Christensen, 1997) and analysed through the lens of Diffusion of Innovation (Rogers, 2003). In this paradigm, adoption is treated as a function of perceived relative advantage, compatibility, and complexity. The implicit assumption is that once an innovation crosses the threshold of perceived utility, it naturally transitions into sustained use. However, contemporary probabilistic AI, specifically Large

Language Models (LLMs) and generative systems, breaks this deterministic connection. Unlike other IT tools, these systems are performative and inconsistent; they require ongoing validation and entail hidden coordination costs (Joshi, 2025, pp. 38-50). Consequently, formal adoption (diffusion) does not necessarily translate into routinised organisational integration. I therefore propose the concept of *stabilisation drift*. While diffusion is a discrete strategic event, stabilisation is a socio-technical process (Orlikowski, 1992, pp. 398-427) through which AI use becomes cognitively sustainable and institutionally normalised. Stabilisation is achieved only when the system ceases to require compensatory monitoring routines and defensive verification efforts that often offset the very efficiency gains AI was intended to provide (Ćwiertniak, 2024, p. 48).

Trust constitutes a central mechanism in AI diffusion. Multidimensional confidence models emphasise competence, integrity, and benevolence as key evaluative dimensions shaping whether AI is perceived as supportive or threatening (Dang, Liu, 2025; Marszałek-Kotzur, 2023, pp. 373-385). Although AI systems are often rated highly in terms of technical ability, scepticism toward fairness and goodwill persists, shifting responsibility toward the organisations that design and deploy them (Glikson, Woolley, 2020, pp. 627-660; Li et al., 2024). Within Rogers's (2003) framework, trust conditions perceived relative advantage and compatibility; when trust erodes, scaling AI becomes difficult regardless of technical performance. Trust therefore functions as a practical precondition for meaningful and sustained AI adoption (Bach et al., 2023).

Environmental considerations increasingly function as a compatibility filter in AI diffusion. The growing energy and water demand of AI infrastructures raise concerns about their legitimacy as sustainable innovation (Henderson et al., 2020, pp. 1-43; Verdecchia et al., 2023, pp. 1-26; Hosseini et al., 2024, pp. 1-3). In response, Green AI research focuses on energy-efficient architectures, carbon reporting, and environmentally responsible system design (Bolón-Canedo, Morán-Fernández, 2024; Tabbakh, 2024). From a strategic perspective, the effectiveness of AI-enabled sustainability initiatives depends on organisational green capabilities and credible ESG positioning (Rahman et al., 2025, pp. 2502-2525; Tetrelová et al., 2025, pp. 3311-3337). Importantly, environmental awareness does not translate directly into trust or positive psychological outcomes. Instead, it uses as a normative filter shaping how AI systems are evaluated. For environmentally conscious users, AI perceived as ecologically irresponsible may lack legitimacy despite strong technical performance, showing that environmental awareness functions as a contextual condition rather than a linear driver of trust.

In the European context, this tension is intensified by the technological sovereignty agenda. For startups in critical technology sectors, environmental awareness runs as an evaluative boundary condition. It sets the normative ceiling for AI initiatives. While sustainability may not directly drive adoption, it conditions the institutional justification of AI, influencing whether trust formation is viewed as socially responsible or ethically precarious. The Strategic Technologies for Europe Platform (STEP) shows AI as a critical sector for European

sovereignty (European Commission, 2024). However, as this study argues, institutional backing via STEP is insufficient without a robust AI Stabilisation Theory to manage the cognitive load of Gen Z employees.

I argue that AI stabilisation is as much a cognitive problem as an institutional one. I define psychological sustainability as the capacity of AI-supported work to support a practical effort-benefit ratio without increasing cognitive force. Existing research links AI opacity to technostress (De Cremer & Koopman, 2024). However, from a stabilisation perspective, the critical variable is not temporary stress but the accumulation of micro-costs (e.g., interpretive ambiguity, validation fatigue). If *the cognitive tax* of using AI persistently exceeds its performance utility, the stabilisation process collapses into *stabilisation drift*, leading to under-reliance or total rejection of the system (Ćwiertniak, 2025a, pp. 79-94; 2025b, pp. 57-72).

Generation Z plays a critical role in shaping AI diffusion as a cohort combining technological fluency with heightened ethical and environmental expectations (Varese et al., 2025). Their adoption of AI is conditional on perceived usefulness, trustworthiness, and alignment with ESG and fairness norms (Deloitte, 2024a, 2024b; Medina-Molina et al., 2025). At the same time, concerns about job displacement and technological unemployment influence their risk feelings (Nigar et al., 2025). Although AI adoption creates new career paths and entrepreneurial opportunities in the digital economy (Brynjolfsson, McAfee, 2017, pp. 66-77), digital competence within Generation Z is still heterogeneous. Beyond a minimum threshold that enables interaction with AI systems, higher competence does not necessarily translate into greater trust or improved psychological well-being. Digital competence therefore functions primarily as a baseline condition shaping how individuals interpret and interact with AI rather than as a reinforcing driver of positive adoption outcomes.

Organisations may experience *stabilisation drift*, a condition in which AI systems stay formally adopted and widely used yet do not achieve stable organisational integration. As users confront probabilistic outputs and uncertainty, they increasingly rely on other verification, monitoring, or parallel decision processes. These compensatory practices generate hidden validation effort and coordination costs, gradually eroding reliable confidence on AI despite continued system use.

2.2. Hypothesis development

While Diffusion of Innovation theory explains the first adoption of technological artifacts (Rogers, 2003), it often does not account for the post-adoption resistance inherent in probabilistic AI. Present AI systems, unlike deterministic software, impose hidden costs of validation and interpretive labour (Joshi, 2025, pp. 38-50). Stabilisation is threatened by compensatory monitoring, a redundant layer of human oversight that appears when trust is missing. To capture the micro-foundations of this process, I introduce psychological

sustainability as the core indicator of stabilisation, reflecting the user's ability to support high performance without reducing cognitive resources through constant system verification.

In the European startup ecosystem, AI deployment is increasingly analysed through the lens of institutional legitimacy. The high energy intensity of large-scale models creates a legitimacy gap that can trigger user scepticism (Bolón-Canedo, Morán-Fernández, 2024). I argue that environmental awareness is not merely an external ESG metric but an evaluative filter that conditions trust. When users perceive a misalignment between AI deployment and sustainability values, the resulting normative dissonance undermines the perceived integrity of the system. In opposition, alignment reinforces the moral dimension of trust, helping the transition from technical interaction to organisational confidence (Toderas et al., 2025). From an organisational legitimacy perspective, environmental awareness may function as a normative signal that shapes initial confidence in AI systems.

H1: Environmental awareness is positively associated with trust in AI systems

In probabilistic environments, trust serves as a cognitive heuristic that allows users to bypass exhaustive verification routines. When trust is high, users delegate agency to the AI, thereby reducing technostress and the cognitive load associated with monitoring (De Cremer, Koopman, 2024). From a stabilisation perspective, trust is the mechanism that prevents validation weakness. By lowering the perceived risk of incorrect outputs, trust enables a favourable benefit ratio, which is the hallmark of psychological sustainability in AI-supported work. Trust therefore acts as a coordination mechanism that reduces verification effort and supports psychologically sustainable human–AI collaboration.

H2: Trust in AI positively influences psychological sustainability

Impact of institutional values (environmental awareness) on operational outcomes (sustainability) is not direct but mediated by trust. Environmental evaluations shape the normative acceptance threshold, but they only influence day-to-day work patterns if they are internalised as trust in the system's integrity. Trust, therefore, translates macro-level legitimacy into micro-level cognitive relief. Without this mediation, even the greenest AI will not stabilise if users do not trust its operational reliability (De Cremer, Koopman, 2024; Huang, Rust, 2021, pp. 3-21). In contrast, ecological dissonance, recognising the environmental impact of AI while relying on it, may generate stress or moral tension. Trust can mitigate this dissonance by signalling that AI use stays compatible with sustainability values. Environmental awareness may provide a normative foundation for trusting AI systems, but its influence on psychologically sustainable human–AI collaboration is expected to run primarily through trust as a coordination mechanism.

H3: Trust in AI mediates the effect of environmental awareness on psychological sustainability

Digital competence is often mistaken as a direct driver of adoption. I re-conceptualise it as a moderating variable that governs the calibration of trust. Highly competent users have the interpretive schemas necessary to navigate AI's probabilistic nature. For these individuals, trust

is more effectively converted into psychological sustainability because they can distinguish between systemic uncertainty and operational failure. In contrast, for users with low competence, trust stays fragile and less effective in mitigating the strain of interpretive ambiguity. Digital competence may shape how effectively users translate trust in AI into sustainable collaboration, as more competent users are better able to interpret probabilistic outputs and integrate AI into their work routines (Feuerriegel et al., 2024, pp. 111-126).

H4: Digital competence positively moderates the relationship between trust in AI and psychological sustainability

The integrated model proposes a selective stabilisation structure that moves beyond traditional additive adoption frameworks. In this perspective, environmental awareness functions as an institutional precursor that provides the normative legitimacy necessary for the development of trust in AI systems. Trust is positioned as the central mechanism of stabilisation, being the primary pathway through which interaction with AI systems translates into psychological sustainability in everyday work practices. Rather than treating AI integration as a natural consequence of adoption, the framework conceptualises stabilisation as a fragile socio-technical process. Sustained collaboration with AI appears only when trust effectively offsets the hidden cognitive costs associated with probabilistic systems, including monitoring effort, validation work and coordination friction. The inclusion of digital competence as a moderating factor further suggests that stabilisation is not uniform across users. Instead, the strength of the relationship between trust and psychological sustainability depends on the user's ability to interpret and calibrate reliance on non-deterministic AI outputs.

Overall, the proposed framework shifts analytical attention from diffusion, understood as the spread of technology, to organisational stabilisation, known as the management of cognitive and organisational resources needed for sustainable human–AI collaboration in the high-velocity environments of the European startup ecosystem.

3. Methodology

This study employs a sequential explanatory mixed-methods design combining quantitative PLS-SEM analysis with qualitative thematic analysis. Such an approach reflects the socio-technical nature of AI integration: quantitative analysis shows relationships between constructs, while qualitative interviews provide insight into organisational routines and coordination mechanisms that shape AI-supported work.

The quantitative part examines Generation Z employees ($N = 120$) aged 20-27 working in technology-intensive startups, including fintech and AI-enabled services. This cohort was selected due to its important level of digital fluency and frequent interaction with AI systems. The sample size satisfies methodological requirements for Partial Least Squares Structural

Equation Modelling (PLS-SEM), exceeding the ten-times rule and ensuring adequate statistical power (Hair et al., 2021).

To complete the operational perspective, semi-structured interviews were conducted with 32 decision-makers from the Polish startup ecosystem, including founders, senior managers, and accelerator directors. Many of these organisations take part in European innovation programmes such as the Strategic Technologies for Europe Platform (STEP) (European Commission, 2024), providing insight into how AI deployment interacts with regulatory frameworks including the Artificial Intelligence Act (2024).

The survey instrument consisted of twenty-three Likert-scale items measuring four constructs: environmental awareness, trust in AI, psychological well-being in AI use, and digital competence. The conceptual definitions and operationalisation of these constructs are presented in Table 1. Prior to the main study, the questionnaire was pilot tested with AI-using startup employees to ensure clarity and contextual validity.

Table 1.
Overview of user-centred constructs shaping Sustainable AI Adoption

Construct	Description	Items	Scale
Environmental awareness	Sensitivity to AI's environmental footprint and sustainability expectations.	5	1-5
Trust in AI	Perceived reliability, transparency, fairness, controllability, and safety.	5	1-5
Psychological well-being in AI use	Cognitive load, technostress, autonomy, and emotional comfort when using AI.	6	1-5
Digital competences	Ability to interpret AI outputs, detect errors and understand basic AI functioning.	7	1-5

Note. Constructs capture environmental, psychological, and cognitive dimensions relevant to organisational AI adoption.

Source: own elaboration based on the study.

Quantitative data were screened for completeness, internal consistency, and response patterns. Reverse-coded items were adjusted, and composite construct scores were created. Descriptive statistics and correlation matrices were examined prior to structural analysis to assess distributional properties and potential anomalies. Qualitative responses were anonymised, cleaned, and prepared for coding.

Hypotheses were examined using PLS-SEM. This approach is right for exploratory research involving latent constructs, emerging theoretical relationships, and complex socio-technical phenomena where theory development and mechanism exploration are prioritised over predictive optimisation. In line with the study's systems-oriented aim, PLS-SEM was employed to find relational patterns and boundary conditions rather than to maximise model fit. Analytical procedures included assessment of collinearity (VIF), reliability and validity evaluation (indicator loadings, composite reliability, AVE, HTMT), estimation of direct and indirect effects, and bootstrapping with 5000 resamples. Model explanatory power was assessed using R^2 and SRMR, following established methodological guidelines.

The thirty-two managerial interviews and open-ended survey responses were analysed using reflexive thematic analysis. The process involved iterative coding, identification of recurrent themes, and development of higher-order interpretive categories. Coding focused on trust calibration, monitoring intensity, validation routines, sustainability framing, and perceived cognitive and organisational costs. Qualitative findings were used to contextualise and interpret quantitative patterns, particularly in relation to non-significant effects and cross-level tensions. All participants were informed about the purpose of the study and provided voluntary consent.

4. Results

4.1. Descriptive Insights

Descriptive statistics provide a first overview of AI use in early-stage startup environments. Respondents (M age = 23.1; SD = 2.4) held cross-functional roles spanning product development, analytics, operations, automation, and customer support. In line with the flat structures typical of startups, AI tools were embedded directly in task execution rather than peripheral experimentation. AI exposure was intensive: 81% of respondents reported daily interaction with AI systems. However, only 18% had received formal organisation-sponsored AI training. This imbalance shows that AI diffusion occurred faster than structured capability development. In acceleration-driven environments, such asymmetry may increase validation effort and reliance volatility. Trust in AI was moderate (M = 3.28), while environmental awareness was slightly higher (M = 3.41). Psychological sustainability scores revealed variability in perceived cognitive load and effort–benefit balance, suggesting heterogeneity in stabilisation experiences.

4.2. Measurement model assessment

Given the exploratory and theory-building nature of the study, construct retention was prioritised over strict threshold adherence. Indicator-level collinearity was not problematic, with VIF values ranging from 1.26 to 4.27. The psychological well-being construct showed strong internal consistency and convergent validity ($CR > 0.70$; $AVE > 0.50$). For the remaining constructs, composite reliability exceeded the recommended threshold of 0.60. Although AVE values for some constructs fell below the conventional 0.50 threshold, they were kept following the recommendations of Hair et al. (2021), who note that constructs with adequate composite reliability and strong theoretical grounding may be preserved in exploratory research. Discriminant validity was confirmed using the HTMT criterion, with all values below the 0.85 threshold. Overall, the measurement model was considered suitable for structural analysis.

4.3. Structural model results

The structural model was estimated using PLS-SEM with a bootstrapping procedure of 5000 resamples. Inner VIF values remained below 3.0, showing that multicollinearity did not bias parameter estimates. The model explained 10% of the variance in trust ($R^2 = 0.10$) and 30% of the variance in psychological well-being ($R^2 = 0.30$). In line with recommendations for exploratory PLS-SEM (Hair et al., 2021; Sarstedt et al., pp. 197-217), the explanatory power for psychological well-being can be considered moderate, given the complexity, subjectivity, and context-dependence of the phenomena under investigation. Of the four hypothesised relationships, one was empirically supported. Environmental awareness showed no significant association with trust (H1: $\beta = 0.130$, $p = .118$). Trust in AI showed a strong and statistically significant relationship with psychological well-being (H2: $\beta = 0.415$, $p < .001$), appearing as the sole stable predictor in the model. Neither the direct nor indirect effects of environmental awareness on psychological well-being were significant (H3: direct $\beta = -0.003$, $p = .970$; indirect $\beta = -0.044$, $p = .670$). The interaction effect between trust and digital competence was also non-significant (H4: $\beta = 0.128$, $p = .468$). Rather than saying weak explanatory power, this pattern reveals a selective structure of influence, in which trust in AI functions as the primary stabilising mechanism linking AI use to psychological well-being. Detailed coefficients and significance levels are reported in Table 2.

Table 2.
Structural path factors and hypothesis testing results

Hypothesis	Path	β	p-value	Supported
H1	Environmental Awareness $\rightarrow$ Trust in AI	0.130	.118	No
H2	Trust in AI $\rightarrow$ Well-being	0.415	<.001	Yes
H3	Environmental Awareness $\rightarrow$ Well-being (direct)	-0.003	.970	No
	Environmental Awareness $\rightarrow$ Trust $\rightarrow$ Well-being (indirect)	-0.044	.670	No
H4	Trust $\times$ Digital Competence $\rightarrow$ Well-being	0.128	.468	No

Note. β = standardised path coefficients; bootstrapping based on 5000 resamples.

Source: own elaboration based on the study.

Overall, the findings reveal a selective pattern of relationships, where trust in AI serves as the primary stabilizing mechanism for user well-being. These results highlight the conditions under which trust-centered AI adoption may influence psychological outcomes in organizational environments. Moreover, the structural model explains 30% of the variance in psychological sustainability, suggesting that additional organisational conditions also contribute to the stabilisation of AI-supported work. Future research could therefore incorporate variables such as workload intensity, governance policies, or task complexity.

4.4. Qualitative analysis

The qualitative analysis was based on thirty-two semi-structured interviews conducted with startup founders and senior managers responsible for AI implementation and scaling decisions. The purpose of this analysis was to interpret the quantitative findings from the employee survey

and to examine how managerial governance practices align with or challenge the structural model (H1-H4). Four dominant themes appeared.

First, managers consistently described AI as efficiency enhancing but requiring structured oversight. Several interviewees indicated that AI-generated outputs are systematically reviewed before deployment, particularly in client-facing, regulatory, or data-sensitive contexts, e.g. *AI accelerates output, but final responsibility stays with us; We treat AI as support, not as decision authority; AI works like an intern in our company – it gets the job done quickly, but a senior must always check and approve it before it's sent to the client. Accountability simply cannot be transferred to an algorithm; Final responsibility always stays with the human lead. We use AI to accelerate the process, but the 'human-in-command' rule is non-negotiable for our high-stakes projects.* This confirms that monitoring routines are institutionally embedded. The centrality of trust in the quantitative model (H2) is therefore consistent with managerial emphasis on calibrated reliance rather than unconditional delegation.

Second, while managers acknowledged environmental concerns related to AI infrastructure, e.g. *Energy consumption is part of the ESG discussion; Ecology is a brand-building tool at the strategic level, but it has zero impact on our developers' daily choices. They need the most powerful tool available, regardless of its carbon footprint; Green legitimacy helps us secure funding from Brussels, but it does not translate into operational constraints. In the scaling phase, survival, and speed trump environmental concerns,* these considerations were primarily framed as legitimacy or investor-related issues. They were not described as determinants of day-to-day reliance decisions. This managerial perspective helps explain the non-significant association between environmental awareness and both trust (H1) and psychological sustainability (H3) seen in the structural model.

Third, trust was described as situational and task dependent. Managers showed that reliance levels vary according to risk exposure, task criticality, and reputational consequences, e.g. *We increase oversight when stakes are high; Trust depends on context; Our reliance on AI is dialled up or down based on risk. If a mistake could cost us a key client or a regulatory fine, we switch back to manual oversight at once"; Trust is not a permanent state; it is managed daily. We only rely on the system as far as we can predict and control its potential for failure.* Trust is therefore actively managed rather than assumed. This directly reinforces H2, trust functions as the primary mechanism linking AI use to sustained operational viability.

Fourth, managers emphasised the importance of employee training and AI literacy. However, competence was described as improving calibration and error detection rather than eliminating monitoring needs, e.g. *Training improves usage quality, not autonomy; Raining didn't make people trust the system more; On the contrary – a competent employee catches errors and AI hallucinations faster, so they check the system even more thoroughly; High AI literacy doesn't lead to blind faith; It leads to better calibration. Our most skilled team members are the ones who are the most sceptical of unverified outputs; We invested in digital skills to reduce technostress, but it has not changed our oversight. Even a pro knows that*

a probabilistic system always requires a safety net. This managerial view aligns with the non-significant moderation effect (H4): digital competence enhances interpretive capacity but does not structurally alter the trust–psychological sustainability relationship.

Table 3.

Managerial themes in relation to hypotheses H1-H4

Theme	Illustrative Manager Statements (n = 32)	Interpretation	Link to Hypotheses
Verification as governance practice	“AI accelerates output, but we always review”	Oversight is structurally embedded.	Supports H2
Environmental legitimacy framing	“ESG matters strategically, not operationally”	Sustainability shapes discourse, not reliance.	Explains non-significant H1 & H3
Conditional trust	“Trust depends on task criticality”	Trust is calibrated and managed.	Dedicated support for H2
Competence as calibration	“Training improves use, not autonomy”	Competence refines monitoring but does not cut it.	Clarifies non-significant H4

Note. Based on thirty-two semi-structured interviews with startup founders and senior managers.

Source: own elaboration based on the study.

Overall, the managerial interviews corroborate the selective structure found in the quantitative model. Trust appears as the key stabilising mechanism in AI-supported work, while environmental considerations and digital competence shape governance narratives and calibration practices rather than directly finding sustained reliance

4.5. Integrated interpretation

The integration of quantitative and qualitative evidence shows a coherent and selective structure of influence. The structural model (Table 2) finds trust in AI as the only statistically robust predictor of psychological well-being, while managerial interviews (Table 3) clarify the organisational mechanisms underlying this effect. Together, these findings delineate a trust-centred architecture of AI-supported work in startup environments.

Trust applies a direct influence on psychological sustainability (H2), confirming its role as the primary stabilising mechanism linking AI use with perceived control and manageable cognitive demand. Qualitative evidence shows that trust is actively calibrated through governance routines, oversight practices, and risk-sensitive deployment strategies. Managers do not cut monitoring, they regulate it. In this sense, trust runs as a control-adjustment mechanism rather than as unconditional reliance. While the interviews reveal the presence of monitoring routines and human-in-command governance structures, the present study does not quantify how frequently these verification practices occur across organisation.

In contrast, environmental awareness and digital competence do not produce stable linear effects in the structural model (H1, H3, H4). The qualitative findings clarify this pattern. Environmental considerations function mainly as legitimacy and positioning factors shaping evaluative discourse rather than operational confidence. Similarly, digital competence improves

users' interpretive capacity and calibration behaviour but does not fundamentally alter the trust–well-being relationship. Competence refines the quality of AI use but does not replace governance protections.

Taken together, the results reveal a differentiated pattern of influence in which trust functions as the central mechanism of psychological sustainability, while environmental awareness and digital competence run as conditional and context-sensitive factors shaping evaluation and calibration processes. Within this framework, Generation Z employees in startup environments can be characterised as adjusting AI users. Despite elevated levels of digital fluency, their reliance on AI is not driven by technological enthusiasm but by pragmatic, task-oriented evaluation of system reliability and cognitive efficiency. When trust infrastructures are present, AI becomes integrated into everyday work routines, when they are absent, users increase monitoring and validation efforts, which can undermine perceived efficiency.

Overall, the findings suggest that AI diffusion in startup environments is not decided by uniform adoption drivers but by calibrated reliance under conditions of organisational acceleration. Effective integration depends less on technical optimisation alone and more on the establishment of trust as a stabilising infrastructure within socio-technical systems.

5. Discussion and practical implications for AI-driven organisations

The confirmed relationship between trust and psychological sustainability (H2) reinforces the concept of trust as a coordination structure rather than a mere attitudinal variable. In the absence of bureaucratic buffering, a hallmark of early-stage startups, trust becomes the primary mechanism for delegating agency to AI. Qualitative evidence further clarifies that this trust is never blind, it is standardized. Managers do not cut monitoring; they regulate its intensity based on trust levels. Consequently, trust functions as a control-adjustment mechanism that reduces the cognitive tax on employees. When trust is set up, the transition from defensive monitoring to routine reliance enables psychological sustainability by preventing the depletion of cognitive resources.

The non-significance of environmental awareness (H1, H3) and digital competence (H4) in the structural model is a significant theoretical finding. The qualitative data suggest a structural decoupling between strategic discourse and operational reality:

- While sustainability is a critical legitimacy wrapper for startups seeking European VC funding or compliance with ESG standards, it stays an external-facing construct. It shapes the justification of AI adoption but does not yet perceive the micro-routines of daily work. This explains why it does not trigger measurable changes in trust or psychological well-being at the operational level.

- Similarly, digital competence tasks as a tool for interpretive mastery rather than a driver of autonomy. Managers view competence to better editing rather than less oversight. Therefore, while competence improves the quality of AI outputs, it does not structurally alter the psychological strain-reliance nexus, explaining the lack of a robust moderation effect.

Finally, the integrated evidence suggests that AI integration among Generation Z employees is driven by calibrated reliance under acceleration pressure. In startup ecosystems, where structural slack is minimal, AI stabilisation is not a product of uniform adoption determinants. Instead, it is a fragile balance. Effective AI diffusion depends less on technical optimisation or sustainability rhetoric and more on the establishment of trust as a stabilising infrastructure. Without this infrastructure, AI initiatives are prone to *stabilisation drift*, where the technology is formally adopted but is still functionally difficult due to the persistent need for compensatory human control.

AI integration is not an automatic byproduct of technical deployment but a strategically conditioned stabilisation process. For startup leaders, the primary challenge shifts from technical implementation to reliance management, as illustrated in Table 4 – the Sustainable AI Adoption Canvas (Agrawal et al., 2018). The canvas represents the conceptual result of this research, integrating the study's empirical insights into a stabilisation framework that captures how trust calibration, monitoring practices, and cognitive sustainability structure durable human–AI collaboration:

- Efficiency in probabilistic AI environments – **Prediction** – is not driven by marginal gains in model accuracy, but by behavioural predictability. Managers should check validation intensity, the frequency and depth of human cross-checking. High validation intensity is a leading indicator of *stabilisation drift*, where the cognitive tax of using AI offsets its productivity gains.
- **Training** should move beyond prompt engineering toward trust calibration. Employees need to understand the risk-tiered nature of AI outputs, knowing exactly when to trust the system and when to intensify scrutiny. This interpretive mastery is what prevents burnout and sustains psychological sustainability.
- Based on the **Action and Outcome** dimensions, leaders must evaluate whether AI outputs are integrated into workflows without defensive duplication. True stabilisation is achieved when the system reduces the net coordination cost, allowing the lean structure of a startup to remain agile without bureaucratic oversight.
- Sustainability – **Feedback** – should be treated as an internal governance pillar, not just an external reporting requirement. While ESG awareness may seem decoupled from daily tasks, it functions as a legitimacy infrastructure. Transparency on AI's environmental footprint reduces normative dissonance among Generation Z employees, reinforcing their long-term commitment to the system.

In resource-constrained startup settings, where hidden inefficiencies cannot be absorbed through bureaucratic buffering, stabilisation becomes linked to strategic existence.

Table 4.
Sustainable AI Adoption Canvas - example

Dimension	Guiding Question	Implication Based on Findings
A. Strategic Decision Layer		
Prediction	What uncertainty does AI meaningfully reduce for the user rather than merely increasing technical accuracy?	Predictive value is experienced in terms of reduced cognitive effort rather than technical accuracy alone; excessive prompting undermines perceived efficiency.
Judgement	How are efficiency gains weighed against cognitive load, technostress, and environmental ambiguity?	Trust mediates these trade-offs; when perceived effort outweighs benefit, AI use becomes frictional.
Action	Is AI deployed as automation, recommendation, or decision support, and with what degree of human oversight?	Decision-support configurations better sustain trust and psychological stability than full automation.
Outcome	How is success evaluated beyond short-term productivity metrics?	Sustained trust and adaptive psychological balance constitute the relevant indicators of successful AI adoption.
B. Interpretive and Learning Conditions		
Input	What data are needed without increasing perceptions of intrusiveness or cognitive overload?	Data sufficiency should be balanced against psychological and ecological concerns, not maximised.
Training	How is the system trained to prioritise consistency and transparency rather than aggressive optimisation?	Behavioural predictability and explainability support trust more than marginal performance gains.
Feedback	How are system behaviour, errors, and limitations communicated to users?	Feedback loops reinforce trust by supporting learning, perceived control, and technostress reduction.

Note. Author's adaptation of the AI Canvas framework informed by PLS-SEM results (H2 supported) and qualitative evidence highlighting trust as a psychological stabiliser.

Source: own elaboration based on Agrawal et al. (2018).

AI systems that drift toward effort-intensive use may not fail visibly, yet they erode execution speed and decision confidence. Continuous monitoring of reliance patterns and validation intensity is therefore essential for supporting competitive agility. However, the quantitative component of this study relies on cross-sectional survey data collected from employees of AI-oriented startups, which limits the ability to observe the long-term dynamics of organisational stabilisation.

6. Conclusion

This research addresses a central tension in the contemporary management of critical technologies, the disconnect between the rapid diffusion of AI and its long-term organisational stabilisation. Evidence from the Polish startup ecosystem suggests that AI integration is not a linear implementation milestone but a fragile socio-technical process. The findings reposition

trust as the core coordination infrastructure of human–AI collaboration and show it as the primary pathway to psychological sustainability in probabilistic AI environments.

In the high-stakes environment of critical technologies, where AI systems often govern dual-use infrastructures, sensitive data, or strategic decision-support, the failure to stabilise integration is not merely an operational setback but a strategic vulnerability. This empirical evidence reveals a selective stabilisation mechanism, while environmental awareness and digital competence are essential for institutional legitimacy, they do not directly drive operational reliance. Instead, the engine of permanent integration is the improvement of the cognitive tax on employees. When trust is effectively adjusted, it drops the need for the excessive, compensatory monitoring that often paralyzes early-stage startups under acceleration pressure. At the same time, the results say the emergence of *stabilisation drift*. Despite continued organisational use of AI systems, reliance on probabilistic outputs requires ongoing verification and compensatory coordination. The resulting validation effort generates hidden coordination costs and gradually weakens stable human–AI collaboration (Ćwiertniak, 2025a, pp. 79-94).

The implications of this research resonate with the European Union’s pursuit of technological sovereignty and the mandates of the EU AI Act. As Europe intensifies its focus on critical digital infrastructures, the robustness of the startup ecosystem becomes a proxy for systemic resilience. This research suggests that for Europe to keep its competitive edge, policy and management frameworks must move beyond diffusion metrics toward stabilisation depth.

Beyond the theoretical distinction between diffusion and stabilisation, the study also develops an empirically grounded profile of next-generation AI users working in startup environments characterised by high uncertainty and rapid technological iteration. On this basis, the research proposes the Sustainable AI Adoption Canvas as a managerial tool that supports organisations in diagnosing stabilisation barriers and designing implementation strategies that account for cognitive load, validation effort, and trust calibration.

Finally, the long-term success of AI-enabled capabilities in Europe depends not on the mere speed of deployment, but on the capacity of startups to foster environments where trust enables durable, transparent, and cognitively sustainable reliance. By distinguishing diffusion from stabilisation, this research provides a roadmap for ensuring that digital transformation in critical sectors leads to genuine organisational capability rather than superficial adoption. In the race for global technological leadership, the ability to stabilise AI within the human-centric framework of the European model may well be the ultimate competitive advantage.

Future research should therefore extend the present findings through longitudinal and multi-source research designs that would allow a more systematic observation of how trust, reliance, and monitoring practices evolve as AI systems become embedded in organisational routines and either stabilise or drift into compensatory verification cycle.

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THE ROLE OF SOCIAL MEDIA IN SHAPING THE PURCHASING DECISIONS OF GENERATION Z IN THE DIETARY SUPPLEMENTS MARKET

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Purpose: Social media shapes consumer behaviour by offering various forms of information and advertising that can support purchasing decisions. The aim of the article is to determine the role of social media in shaping Generation Z's purchasing decisions in the dietary supplements market.

Design/methodology/approach: A literature review method and a survey targeting 124 Generation Z students who regularly use social media were employed.

Findings: Social media plays a key role in the marketing strategy of companies selling dietary supplements, helping them promote their products and educate consumers about new trends and products. They have a significant impact on shaping online purchasing behaviours by offering various forms of advertising and information that help consumers make informed purchasing decisions. Research indicates an inverse relationship between the frequency of social media use and susceptibility to advertising influence, meaning that more experienced users may be less susceptible to marketing stimuli.

Research limitations/implications: A limitation of the survey is its focus on a sample of 124 economics students. Non-random sampling prevents generalising the results to the entire population. In the future, it is recommended to conduct studies involving diverse groups of young people, taking into account criteria such as field of study, level of education, and other relevant variables.

Practical implications: The study's results offer practical recommendations and serve as a valuable resource for stores and online platforms that sell dietary supplements. These entities should adapt their marketing strategies to the dynamically changing preferences of Generation Z consumers. The study results can also help understand the behaviours of young consumers and develop preventive strategies against the misuse of supplements.

Social implications: The growing awareness of healthy lifestyles and preventive health is driving increased consumer interest in dietary supplements. Consumers are seeking products that support health and well-being, and their choices are influenced by emotions, beliefs, and the impact of digital technology. Social media plays a key role in educating consumers about products and the latest market trends. Particular attention should be paid to the improper use of dietary supplements, as this can lead to adverse health effects. It is crucial that the information shared on social media is based on scientific research and provides users with the knowledge necessary to make informed decisions about their health.

Originality/value: Social media is an essential tool in marketing strategies. However, not all consumers make purchasing decisions solely on the basis of the information found there. Young consumers seek authenticity and easy access to reliable and comprehensive product information. The opinions of other users play a crucial role in the purchasing decision-making process. Specifically, in the context of dietary supplements, the availability of information requires consumers to exercise great caution and the ability to critically filter content.

Keywords: social media, Generation Z, purchasing decisions, dietary supplements market.

Category of the paper: research paper.

1. Introduction

The role of social media in shaping the purchasing decisions of Generation Z in the dietary supplements market has become increasingly significant as social awareness of healthy lifestyles, health prevention, and health education grows. The trend towards healthy eating, regular physical activity, and the use of dietary supplements is becoming increasingly widespread.

Generation Z includes young people born between 1995 and 2012, being the first generation fully raised in the digital era. They use digital tools such as social media, virtual communication, and online communities to communicate, entertain themselves, acquire knowledge, make purchases, and seek information about products and services.

Social media has a significant impact on the purchasing decisions and recommendations of young people. These choices are often shaped by the diverse content available on online platforms such as Facebook, TikTok, Instagram, and YouTube. These platforms serve as a source of inspiration in various aspects of life, including health and dietary supplementation.

For Generation Z, online shopping is not just a matter of convenience but also a way to discover new brands and products and gain consumer experiences. The purchasing decisions of young people are significantly influenced by influencers and bloggers promoting a healthy lifestyle, as well as by online reviews and recommendations.

Moreover, social media enables users to interact and share experiences. Young consumers can share opinions and receive advice. It is also worth noting that social media provides quick access to the latest trends and innovations in the dietary supplements industry. This way, Generation Z can stay up to date on new developments and adjust their choices to current health standards.

Nevertheless, social media can also exert manipulation, pressure, and introduce misinformation. Young people striving for ideal beauty may make impulsive purchases due to a lack of skills in assessing the credibility of sources. Therefore, it is important for them to be aware of the potential risks associated with unconsidered purchasing decisions and to be able to critically evaluate the content presented on social media.

The aim of the article is to determine the role of social media in shaping Generation Z's purchasing decisions in the dietary supplements market. The study is both theoretical and empirical. As part of the literature review, detailed objectives were achieved, which include:

- characteristics of Generation Z,
- presenting the attractiveness of the dietary supplements market.

In relation to the empirical research, answers were obtained to the following research questions:

- How often do young consumers use social media to obtain information about dietary supplements?
- Where do they most frequently search for information on social media?
- What are the motives for online shopping, and what role do social media play in shaping knowledge about products and trends?
- What forms of promotion and advertising for dietary supplements most attract the attention and interest of young consumers?
- What are the relationships between the frequency of seeking information and the propensity to purchase supplements after viewing an advertisement or recommendation?

The analyses conducted provide a better understanding of the dynamics of social media's impact on the purchasing decisions of Generation Z and identify key factors influencing their consumer preferences.

A limitation of the survey study is its focus on a sample of 124 economics students. Non-random sample selection prevents generalising the results to the entire population. In the future, it is recommended to conduct studies involving diverse groups of young people, taking into account criteria such as field of study, level of education, or other significant variables.

The study's results provide practical recommendations and serve as a valuable resource for stores and online platforms that sell dietary supplements. The findings also have significant social implications. Social media plays a key role in educating consumers about products and the latest market trends. Particular attention should be paid to the improper use of dietary supplements, as this can lead to adverse health effects.

2. Literature review

2.1. Characteristics of Generation Z

Generation Z demonstrates high proficiency in using technology, which is integral to their personal and professional lives. They grew up in the era of smartphones, laptops, the internet, and digital media. Consequently, their approach to life, work, shopping, and interpersonal relationships differs from that of previous generations.

They are characterised by mental activity, sensitivity, openness to new experiences, and a love for entertainment and unique experiences (Chen, Lin, 2024). They emphasise the need for spontaneity and personalisation in interpersonal interactions (Chen, Lin, 2024). They exhibit great diversity, which is reflected in their communication methods (Jayatissa, 2023). In addition to face-to-face conversations, they often communicate via text messages, virtual meetings, and social media platforms (Jayatissa, 2023).

Social media platforms such as Facebook, Instagram, and TikTok have become spaces where influencers exert significant influence on the purchasing decisions of Generation Z. Young people often rely on recommendations from those they follow, which provides them with a better understanding of the practical application of products than traditional advertisements (Kotarbiński, 2025). Generation Z is also described as more sceptical and critical in their purchasing processes (Ho et al., 2026). They value personalisation and interactivity, which is reflected in their shopping preferences. They expect brands to tailor their offerings to individual needs and preferences, made possible by advanced technologies such as artificial intelligence (Schroth, 2019). They are particularly sensitive to content enhanced by artificial intelligence (Taylor, Armes, 2024). AI-generated advertisements garner more interest than traditional ads (Jackson et al., 2025).

Social media provides Generation Z with quick access to the latest product and service information, helping them stay up to date with current trends and promotions. This availability of information significantly influences their purchasing behaviour (Zhang et al., 2024). Young consumers often rely on reviews and opinions from other users before making a purchase decision. They value others' authentic experiences, which helps them assess the quality and functionality of products (Ho et al., 2024).

Generation Z demonstrates a greater awareness of sustainable development and environmental protection. They prefer eco-friendly and socially responsible products, which significantly influences their consumer choices (Mohr et al., 2022; Abbasi et al., 2024).

2.2. The attractiveness of the dietary supplements market

The dietary supplements market is extremely attractive due to its dynamic growth, product diversity, and the development of online distribution channels. This growth is linked to increasing consumer health awareness and interest in alternative methods to support health, as well as to a large number of internet advertisements (Nuworsu, 2025).

In Poland, the value of the dietary supplements market in 2022 amounted to 7.7 billion PLN, and forecasts for the coming years indicate the potential to exceed 20 billion PLN (Dateshidze et al., 2024). The increased health awareness of consumers and their concern for their own health contribute to the growing demand (Wang et al., 2023). Dietary supplements include a wide range of products, such as vitamins, minerals, herbs, and probiotics, allowing the offer to be tailored to individual consumer needs (Dateshidze et al., 2024). This diversity increases the market's attractiveness, enabling producers to reach different customer segments.

There are various distribution channels operating in the market. E-pharmacies and online stores are gaining significance due to the convenience of online shopping and the availability of a wide range of products and information (Starek et al., 2025). It is predicted that by 2029, online sales will increase their share at the expense of stationary sales by approximately 2 percentage points (Marszałek, 2025). Dietary supplements are considered food and are not subject to pharmaceutical law, so they must be safe for consumers (Zovi et al., 2024).

High demand for dietary supplements is associated with the risk of excessive consumption, which can lead to health problems (Hassan et al., 2020). Therefore, it is crucial to provide consumers with education on the rational use of supplements. Such education will raise awareness and counter unwarranted consumerism (Hys, 2020).

3. Research methodology

The aim of the study was to understand the impact of social media on the preferences and consumer decisions of young Generation Z individuals studying economics at a Polish university. A purposive sampling method was used to select participants who met two criteria: being Generation Z and being active social media users.

The study involved 124 students, of which 60% were male and 40% female. The research was quantitative, and the research tool was a developed survey questionnaire. Respondents were asked about the influence of social media on their consumer behaviour, particularly regarding online purchases of dietary supplements. Key aspects of social media use were analysed.

3.1. How often do young consumers use social media?

Social media use among Generation Z is widespread and intense. Data analysis indicates that men constitute the largest group of users, spending 3 to 4 hours daily on platforms such as Instagram, TikTok, or Facebook (22.2% of respondents). Women use social media less frequently (16.7%). Among users who spend 1 to 2 hours daily on social media, men also dominate (21.4%) compared to women (7.9%). Among the very active users who spend 5 to 6 hours daily on these platforms, men (13.5%) outnumber women (11.1%). However, among the most engaged users, who spend 7 or more hours daily, women (3.2%) surpass men (2.4%).

The analysis revealed significant differences in the intensity of social media platform usage between genders. Men dominate most time categories, especially in groups spending 1 to 6 hours daily on social media. The largest difference is observed in the 3-4 hours per day range, where men account for 22.2% of respondents, while women account for only 16.7%. However, among the most engaged users who spend 7 or more hours daily on social media, women outnumber men (3.2% compared to 2.4%). This indicates that while men are more likely to use social media moderately, women are more inclined to engage intensively.

3.2. How often do young consumers use social media to obtain information about dietary supplements?

The study reveals diverse approaches among respondents to seeking information about dietary supplements on social media. Only 6% of respondents report using this source of information very frequently. 16% of respondents frequently use social media, while 26% use it occasionally, suggesting that it is one of many sources of information but not a dominant one.

The largest group, consisting of 35% of participants, rarely uses this channel, and 16% never use it, indicating a preference for other ways of obtaining information.

In summary, the study found that respondents' approaches to seeking information about dietary supplements on social media are varied. Most people use this channel infrequently, suggesting that social media is just one of many sources of information.

3.3. Where do young consumers most often search for information on social media?

TikTok is a platform that has gained immense popularity among internet users. 37% of respondents report using this platform. Thanks to short videos, TikTok has become a place where users can express themselves and share their passions and interests. In second place in terms of popularity is Instagram, used by 35% of those surveyed. It is a platform that allows users to post photos and short videos, share experiences and inspiration, and build relationships with other users. The next spots are occupied by Allegro (28%) and YouTube (24%). Facebook is used by 17% of respondents. Reddit is a platform offering a wide variety of content, from memes to discussions on diverse topics; it is used by 10% of respondents, similar to Pinterest. The least popular among respondents were the platforms X (formerly Twitter) (9%)

and Snapchat (1%). It is worth noting that each of the mentioned platforms has unique features and advantages, which make young people choose them based on their own needs and preferences.

3.4. On which online platforms do young people buy dietary supplements?

According to the survey, 51% of customers most frequently purchase dietary supplements on the Allegro platform. This indicates the immense popularity of this service among people searching for dietary supplements. A significant 46% of customers are eager to shop at Gemini Pharmacy. The Super-Pharm is less popular, with 35% of customers choosing to purchase dietary supplements there. It is also interesting that more and more people are deciding to shop at the online store Zdrowie i Uroda (Health and Beauty) (13%) and on the Ceneo platform (10%). This may be due to the search for better purchasing conditions, promotions, or a wider product selection.

Surprisingly, platforms such as Amazon, eBay, iHerb, and OLX attract less consumer interest. Only 10% of customers choose to shop on Amazon, 5% on eBay, 6% on iHerb, and just 4% on OLX. This may be due to lower availability of dietary supplements on these platforms, a lack of promotions, or customer concerns about the authenticity of the products offered. It is worth noting that the dietary supplements market is rapidly evolving, and customers have an increasing number of options for where to purchase. Despite globalisation, domestic preferences play a key role in consumers' purchasing decisions.

3.5. What are the online shopping motivations of young Generation Z consumers, and what is the role of social media in shaping product knowledge and trends?

Based on analyses of data on online shopping motivations and the role of social media in shaping product knowledge and trends, interesting conclusions can be drawn (Figure 1). Respondents indicated a wide range of products (96%) as the primary motivation for online shopping. The internet provides consumers with access to a vast number of stores and brands, allowing for thorough analysis and comparison of products. Additionally, online shopping enables price comparisons and user reviews, which facilitate purchasing decisions.

In second place is the attractive price of products (91%). Consumers often use price comparison tools to quickly find the most advantageous offers. Promotions and discounts are an important factor for 87% of respondents. Consumers are more inclined to make purchases when they feel they are saving money, making promotional strategies a key element of e-commerce marketing. Opinions and reviews from other customers support the purchasing process for 84% of those surveyed. This highlights the importance of building a positive brand image and encouraging customers to share their experiences.

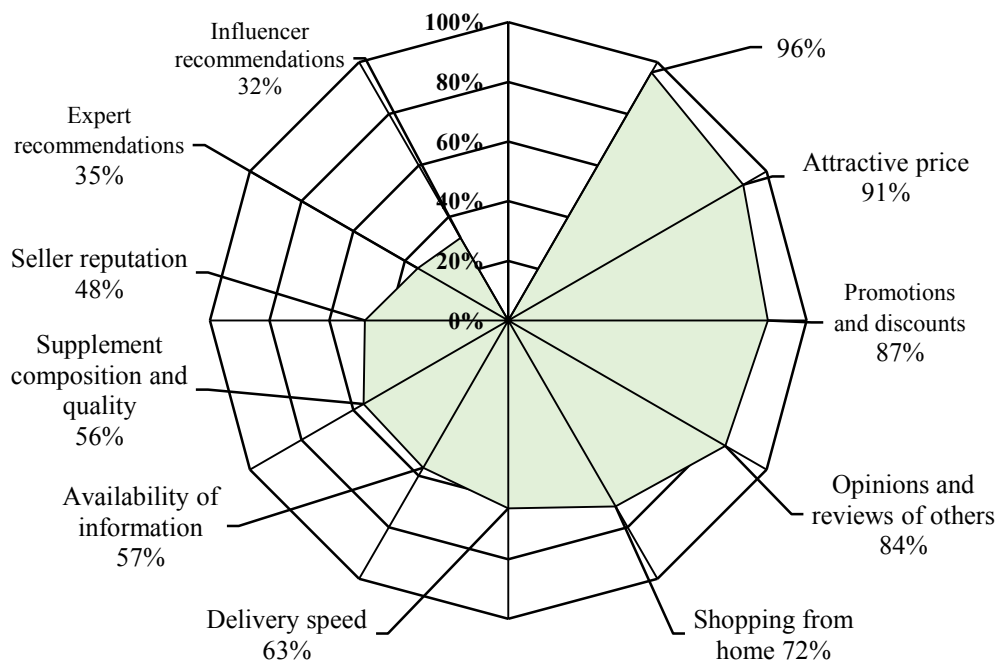


Figure 1. Main reasons for online shopping among young consumers.

Source: own elaboration.

Online shopping, which allows transactions to be completed without leaving home, is particularly valued by 72% of respondents who emphasise time savings and convenience. Delivery speed is important to 63% of consumers and has become a standard in the e-commerce industry. The composition and quality of dietary supplements matter to more than half of those surveyed (56%). Thanks to platforms like Facebook, Instagram, and YouTube, numerous articles, videos, and posts are available regarding nutritional ingredients, their impact on health, and potential side effects.

Unfortunately, this information is not always reliable and valuable. In the age of fake news and disinformation, it is important to exercise particular caution and critical thinking when consuming content on social media. Many people running profiles or channels dedicated to a healthy lifestyle and supplementation often lack appropriate scientific knowledge, which can lead to the spread of false information. 57% of respondents find access to information about dietary supplements on social media important. Providing complete and transparent information not only meets customer needs but also builds their trust, enabling the establishment of long-term relationships. According to the respondents, platforms such as TikTok (17.5%) and Instagram (16.7%) offer a space for exchanging experiences and opinions, contributing to building consumer trust. This interactive environment allows for the exchange of experiences and reviews, which is particularly important for young consumers who value transparency and authenticity.

The role of algorithms that personalise the content displayed to users cannot be overlooked. Thanks to them, dietary supplement advertisements are precisely tailored to consumers' individual preferences and needs, increasing the likelihood of purchase. Research indicates that even among people who have not made a purchase influenced by social media, there is a belief in their impact on expanding product knowledge. In this group, 23% of respondents believe the media helps, and 14.3% say it definitely helps them acquire information about supplements.

Consumers show greater trust in recommendations from specialists than in opinions from influencers. Only 35% of respondents value recommendations from specialists, while 32% attach importance to influencers' opinions. Influencers, often perceived as authorities in health and wellness, shape young people's purchasing preferences.

In contrast, educational posts and articles are significant for only 13.5% of respondents. This indicates that, in health matters, the opinions of scientific authorities and professional knowledge are valued more than those of social media personalities. To avoid the pitfalls of misinformation, it is essential to develop critical thinking skills and consciously use available online resources. It is recommended to use reliable sources of information, such as websites of specialists in dietetics, medicine, or pharmacology.

3.6. What forms of promotion and advertising for dietary supplements most attract the attention and interest of young consumers?

An analysis of data on various forms of dietary supplement promotion and advertising on social media provides valuable insights into the preferences of Generation Z consumers (Figure 2).

The most commonly used form of promotion during online shopping is customer reviews and opinions. 78% of respondents recognise their positive impact on increasing product awareness. Trust in reviews varies by platform. Consumers show greater trust in local platforms such as Allegro (23%) and online pharmacies (20.6%), while international platforms like Amazon (2.4%) and eBay (0.6%) are less favoured. Educational posts on health, nutrition, and the benefits of supplementation are highly appreciated, with up to 60% of respondents rating them positively. Consumers are increasingly seeking valuable content that not only promotes products but also educates and provides reliable information. Building customer engagement and relationships is also important.

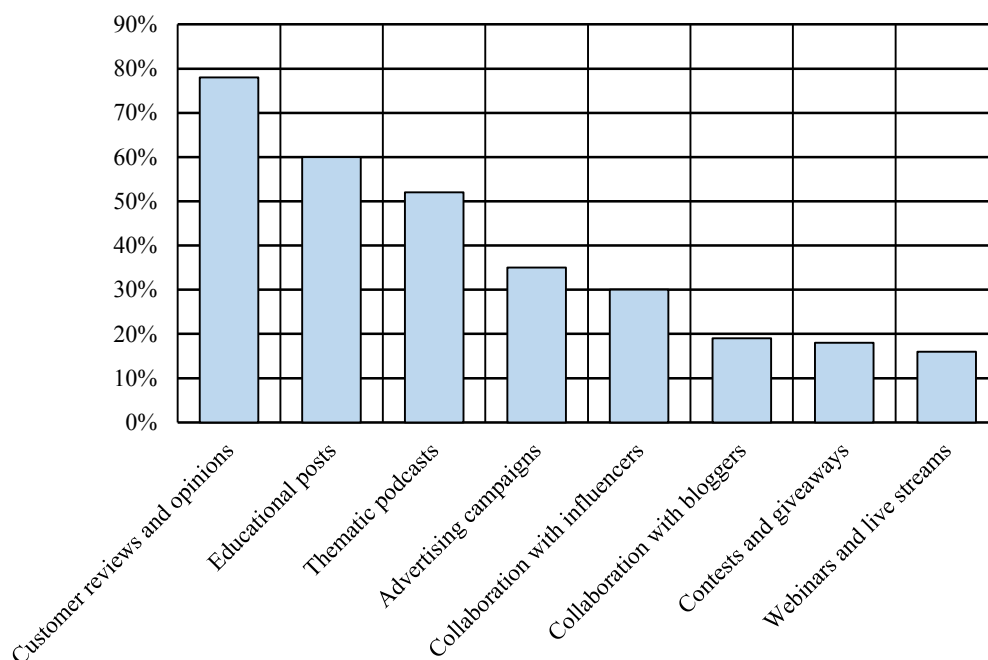


Figure 2. Forms of promotion and advertising of dietary supplements.

Source: own elaboration.

Thematic podcasts are less popular compared to reviews and educational posts. Although their impact is moderate (52%), they are gaining significance due to their focus on health and lifestyle topics. They require diversity and adaptation to the specific needs of different audience segments. Advertising campaigns, collaborations with influencers, and contests or giveaways have varying effectiveness. Advertising campaigns are effective for 35% of respondents, highlighting their important role in marketing strategies. Collaborations with influencers, although effective for 30% of respondents, require careful partner selection to ensure authenticity and alignment with brand values.

Collaboration with bloggers was reported by 19% of respondents, suggesting that bloggers have loyal readers who trust them and are willing to follow their recommendations. Contests and giveaways, aimed at attracting users' attention and encouraging their active participation, are used less frequently (18%).

On the other hand, webinars and live streams have the least impact on consumers' purchasing decisions (16%), which may be due to their nature and limited reach. They are often perceived as hidden forms of advertising that do not always provide reliable information about the product.

3.7. What are the relationships between the frequency of information seeking and the tendency to purchase supplements after seeing an advertisement or recommendation?

The conducted study provides significant insights into the impact of the frequency with which customers seek information on their tendency to purchase supplements after encountering an advertisement or recommendation on social media. Customers who rarely seek

information about supplements on social media are most likely to purchase products after seeing an advertisement or recommendation (28.3%). This indicates that less engaged customers are more susceptible to the influence of advertisements and recommendations. On the other hand, customers who very frequently seek information about supplements exhibit the lowest purchase intent (21.4%). This may suggest that they are more critical and demanding of advertisements and recommendations, making them harder to convince to make a purchase. Meanwhile, customers who occasionally seek information are more likely to purchase (14.7%) than those who do so frequently (8.3%).

3.8. What are the relationships between the form of promotion and advertising of dietary supplements and the frequency of user engagement on social media?

The interaction between the type of promotion and the frequency of social media engagement is complex and depends on many factors.

An analysis of the interaction between promotion type and the frequency of Generation Z's social media engagement reveals diverse preferences among young people. The majority of users engaging with promotions through reviews and opinions are those who rarely (27.0%) or occasionally (18.3%) use social media. On the other hand, those who use social media very frequently show low engagement (5.6%), suggesting they prefer other, more attractive forms of promotion.

Educational posts about health and supplementation attract the attention of 21.4% of people who rarely and occasionally engage (15.1%). A low level of engagement was noted among those who engage very frequently on social media (3.2%).

The largest group of respondents listens to health and lifestyle podcasts occasionally (15.1%) or rarely (15.9%). This indicates an interest that is not yet strong enough to become a regular habit.

Similarly, advertising campaigns most often engage people who do so occasionally (11.9%) and rarely (8.7%). Meanwhile, those who engage very frequently and frequently indicated advertising campaigns only to a small extent (4.0% each).

Collaboration with influencers is more attractive to people with lower social media engagement frequency (12.7%), while collaboration with bloggers attracts moderately active users (7.1%).

Contests and giveaways are effective in engaging users with varying levels of activity. The highest engagement was observed among those who rarely engage in other activities (4.8%).

Webinars and live streams are not effective in attracting users who regularly engage on social media (5.6%).

In summary, the interaction between the form of promotion and engagement on social media shows that consumers prefer content related to reviews and authentic opinions, as well as educational content tailored to their needs. Trust in various forms of promotion is varied, and social media, although important, is not the main source of information for most consumers.

4. Summary

The role of social media in shaping Generation Z's purchasing decisions in the dietary supplements market is complex and multifaceted. Social media users often engage with various online platforms multiple times a day, creating numerous opportunities for companies in the dietary supplements industry to promote their products. Social media serves as a popular source of information about dietary supplements, including product offerings, attractive prices, promotions, and discounts. Users are eager to rely on recommendations and opinions from others.

What are the relationships between the frequency of seeking information and the tendency to purchase supplements after seeing an advertisement or recommendation?

Platforms like Instagram, TikTok, and YouTube not only provide young people with information but also encourage them to make purchasing decisions. They are filled with content about a healthy lifestyle, including dietary supplementation. Influencers model the behaviours of their followers by showcasing various products.

Social media offers diverse advertising options and provides easy access to reviews and opinions from other users. They play a key role in consumer education by publishing educational content about new products and trends. In this way, social media becomes not only a source of information but also a platform for exchanging experiences and building relationships with consumers, sellers, and brands.

Thanks to online interactions, young consumers become more aware of their needs and opportunities, leading to more thoughtful, conscious purchasing decisions. Research indicates an inverse relationship between the frequency of information seeking and the tendency to purchase supplements after seeing an advertisement or recommendation. This means that customers who frequently use social media are less likely to make purchases influenced by advertisements, while those who use them sporadically are more susceptible to the influence of individual ads or recommendations. This may suggest that less engaged users are more vulnerable to marketing messages.

Despite the many advantages social media offers, it is important to remember that the internet is rife with false information and to exercise caution to avoid falling for false promises. It is advisable to use professional sources of information and consult with experts to ensure that we are making the right decisions.

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THE IMPACT OF SOCIAL AWARENESS ON THE DEVELOPMENT OF RENEWABLE ENERGY SOURCES

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Purpose: The purpose of the article is to analyse the impact of social awareness on the development of renewable energy sources in Poland. The study focuses on assessing the level of public knowledge, attitudes toward the energy transition, and the degree of social acceptance of RES technologies. The article also examines public perceptions of the benefits and risks associated with the use of renewable energy sources, including environmental, economic, and infrastructural aspects.

Design/methodology/approach: The article is based on the analysis of survey results and on the analysis of domestic and foreign literature, which allowed for the comparison of the obtained results with the current state of research on social awareness and energy transformation.

Findings: Research results indicate that in Poland, the public awareness of both opportunities and threats resulting from the implementation of renewable energy sources is relatively high. The key factor influencing society's willingness to undertake pro-ecological activities is the level of education and access to information, while economic factors, such as income, play a lesser role in this process.

Research limitations/implications: In the future, it is advisable to expand research to include comparative analysis between regions as well as economic and cultural factors influencing the acceptance of renewable energy sources. The results may provide a basis for further study on the relationship between social awareness and the implementation of energy innovations.

Practical implications: The article points out the need to conduct social campaigns and trainings, and to create local initiatives supporting the development of the power industry. The conclusions are also important for decision-makers developing energy strategies and investment support schemes in the RES sector.

Social implications: Increasing knowledge and social acceptance can contribute to reducing greenhouse gas emissions, improving air quality and increasing citizen involvement in pro-environmental activities. The results can also support the development of public policies promoting sustainable development and environmental responsibility.

Keywords: renewable energy sources; social awareness; energy transformation; environmental education; social acceptance.

Category of the paper: Research paper.

1. Introduction

The modern world is facing the need for a profound energy transformation resulting from growing environmental pressure, ongoing climate change and the depletion of fossil fuel resources (IPCC, 2023). In the face of these challenges, renewable energy sources (RES) are becoming increasingly important, as they constitute the foundation of sustainable economic and ecological development. The implementation of solutions based on solar, wind, water, geothermal or hydrogen energy is no longer just a technological issue, but also a social and cultural one (Devine-Wright, 2017).

Public awareness of renewable energy plays a key role in the success of the energy transformation (Oksman et al., 2021). The level of social acceptance for new technologies, willingness to change consumer behaviour and trust in institutions responsible for the development of the energy sector are fundamental factors determining the success of climate policy. Properly shaped pro-ecological attitudes can accelerate the process of abandoning traditional fossil fuels in favour of cleaner and more sustainable energy sources (Sütterlin, Siegrist, 2017).

In recent years, there has been an increase in public interest in RES, which results from both global ecological trends and the increase in the cost of energy derived from conventional raw materials (Suhaib et al., 2023). The development of photovoltaic technologies, wind turbines and hydrogen solutions has contributed to their increased availability and popularisation. At the same time, however, there are still barriers related to limited public knowledge, lack of infrastructure and concerns about the safety and cost-effectiveness of new technologies (International Energy Agency, 2023).

The purpose of the research was to determine the level of knowledge, attitudes and social concerns regarding the use of renewable energy sources. The analysis aimed to identify factors contributing to and barriers hindering the acceptance of RES in Polish society, as well as to determine the needs for environmental and information education.

2. Review of literature

Contemporary technological development and rising climate goals make renewable energy sources (RES) a key element of the energy transformation (Mielczarski, 2021). However, the mere availability of RES technologies does not guarantee their widespread implementation – more and more attention is being paid to social factors, including the level of social awareness, social acceptance and citizens' knowledge of the benefits and requirements of energy transformation (Żywiołek et al., 2022).

The concept of social awareness in the energy context refers to the level of knowledge, attitudes and willingness of citizens to accept and participate in the RES system. Research shows that the higher the level of knowledge and trust in renewable sources, the greater the likelihood of supporting and implementing such solutions (Żywiołek et al., 2022). Environmental education plays a significant role here, especially from the early stages of education, which shapes long-term orientation towards pro-ecological behaviour and energy decisions (Yüksel Köseoğlu, 2016).

The literature on the subject highlights the important distinction between social awareness and social acceptance (Tortop, 2012). While social awareness mainly refers to the level of knowledge, familiarity with a topic and general understanding of a given technology or phenomenon, social acceptance is more practical and complex in nature. It includes not only a positive attitude towards specific technologies (e.g. renewable energy), but also the willingness of individuals and communities to actively participate in their implementation, financing and even co-management.

Social acceptance is not a one-dimensional phenomenon, but consists of three complementary dimensions:

1. Socio-political (institutional) – including trust in public institutions, energy policies and the legal framework regulating the development of new technologies. In this respect, transparency of decision-making processes and perceived social justice are crucial (Menegatto et al., 2025).
2. Community (local) – relating to relationships within local communities, a sense of belonging and shared responsibility for the implemented projects. Acceptance at this level often depends on the degree of residents' involvement in the consultation process and the actual benefits for the local community (Menegatto et al., 2025).
3. Market (commercial) – related to market functioning, investment attractiveness of technologies, as well as trust in economic entities which implement solutions. This dimension reflects the belief that the development of new technologies is economically rational and consistent with the principles of sustainable development (Devine-Wright et al., 2020).

The aforementioned study proves that only by taking these three aspects into account simultaneously, it is possible to fully understand the mechanisms of social acceptance of technological innovations – including renewable energy sources and energy communities.

The literature on the subject emphasizes that social awareness is an important factor in the development of renewable energy sources (RES). Its impact is realised through complex cognitive, institutional and psychosocial mechanisms that determine both the level of acceptance of technology and the actual readiness to participate in the energy transformation.

One of the key aspects is knowledge and education. Understanding the principles, benefits and limitations of renewable technologies translates into a higher level of trust and openness towards energy innovations (Tomaszewski, Sekściński, 2020). As noted by Cichowska, Mreła

and Sokolov (2021), education in the field of renewable energy not only serves an informative function, but also shapes values, beliefs and pro-environmental attitudes among citizens, especially the younger generation, who will co-create the national energy policy in the future.

Trust also plays a significant role in the process of shaping social acceptance – both in the technologies themselves and in the institutions responsible for their implementation. Institutional and technological trust reduces the perceived threat, promotes the legitimacy of public actions and strengthens the willingness to participate in energy projects (Dworska, 2023). Empirical research confirms that the level of trust is positively related to the level of knowledge and willingness to learn, which indicates a close relationship between cognitive competences and attitudes towards innovation (Żywiołek et al., 2022).

Another factor determining readiness to implement RES is pro-environmental attitudes and social norms. The value system and normative behaviour patterns within a given community shape individual decisions regarding participation in the energy transition (Ruszkowski et al., 2024). Research by Fazal et al. (2023) conducted in developing countries shows that positive social norms, pro-environmental attitudes and aspirations related to improving the quality of life are important factors motivating the use of renewable energy.

Equally important is the sense of social agency, understood as the belief in the possibility of real influence of individuals and local communities on the development directions of energy policy (Neves et al., 2024). Increasing awareness of one's own role in decision-making processes fosters citizens' involvement in energy communities and infrastructure co-management projects. A high level of civic agency enhances the sustainability and effectiveness of implemented renewable energy solutions (Bögel et al., 2023).

Consequently, social awareness is not only a cognitive component of attitudes towards RES, but also plays an integrating role – combining knowledge, trust, social norms and a sense of agency into one coherent system of factors promoting social acceptance and active participation in the energy transformation.

A higher level of social awareness and acceptance of RES translates directly into their development by increasing private and community investments, reducing implementation barriers and shaping a pro-ecological energy culture (Oksman et al., 2021). Social acceptance thus becomes not only a condition for technical progress, but also a catalyst for a mental transformation in which citizens perceive themselves as active participants in the energy system, not just its recipients (Batel et al., 2013).

3. Research methodology

In the first quarter of 2025, a study was conducted to determine the level of social awareness and acceptance of renewable energy sources (RES) and hydrogen technologies in Poland. The survey was conducted on a sample of 315 respondents using the CAWI (Computer-Assisted Web Interview) technique, which allows for remote data acquisition while maintaining high quality of responses.

The gender structure of the sample was almost balanced: women constituted 50.96% of the respondents and men 49.04%. In terms of education level, the majority were people with higher education (35.8%) and secondary education (34.8%). The analysis of the age structure showed that the largest group consisted of respondents aged 36-45 (28.8%), followed by people aged 46-55 (26.5%). This means that the majority of participants represented a professionally active population with a stable life and economic situation. Younger people, under 25 years of age, constituted approximately 10% of the sample. In terms of the place of residence, inhabitants of urban communes dominated (61.5%), while 24.1% of participants came from urban-rural communes, and 14.4% from rural communes. Detailed characteristics of the respondents are presented in Table 1.

Table 1.
Characteristics of the study sample

Gender	Male	49.04%
	Female	50.96%
Education	Primary	9.03%
	Vocational	20.32%
	Secondary	34.84%
	Higher	35.81%
Age	Under 18	4.15%
	18-25	5.75%
	26-35	15.02%
	36-45	28.75%
	46-55	26.52%
	56-65	12.14%
	Over 65	7.67%
Place of residence	urban commune	61.54%
	urban-rural commune	24.08%
	rural commune	14.38%

Source: own study.

The research questionnaire covered issues related to attitudes towards replacing fossil fuels with renewable sources, assessment of their efficiency, environmental friendliness and profitability, as well as willingness to bear higher energy costs in exchange for environmental benefits. A separate block of questions was devoted to hydrogen technology – its perceived safety, commercialisation prospects in the five- and ten-year horizon, implementation barriers, infrastructure assessment and educational needs in this area.

4. Findings

The first question aimed to assess respondents' attitudes toward replacing fossil fuels with renewable energy sources. The responses are presented in Figure 1.

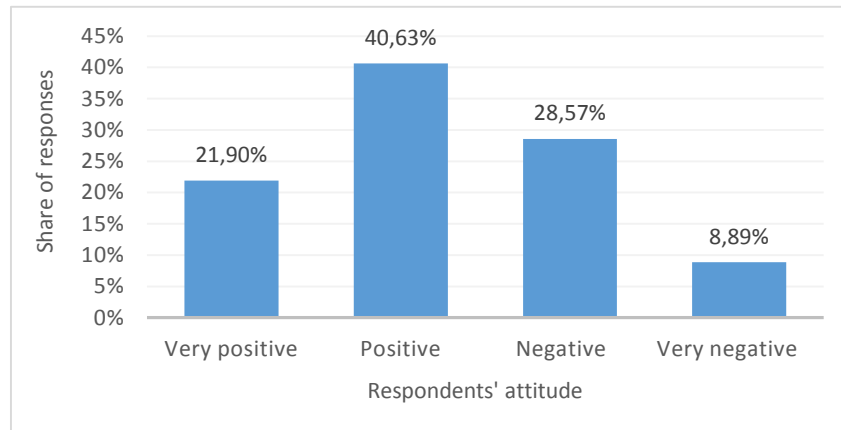


Figure 1. Respondents' attitude towards replacing fossil fuels with energy from renewable energy sources.

Source: own study.

The analysis of the obtained results indicates that the general attitude of society to energy transformation towards renewable energy sources (RES) is mostly positive. Replacing fossil fuels with energy from renewable sources was assessed positively or very positively by a total of 62.5% of respondents (40.63% and 21.90%, respectively). In turn, 37.46% of the study participants expressed a negative (28.57%) or very negative (8.89%) attitude. These results confirm that support for energy transformation in Poland is moderately high, but heterogeneous.

These results are confirmed by the research of Żywiołek et al. (2022), according to which social acceptance for renewable energy sources is strongly correlated with the level of knowledge, trust in public institutions and transparency of decision-making processes in the field of energy. This means that scepticism towards RES does not necessarily have to result from a negative attitude towards the idea of sustainable development, but rather from a deficit of information and trust in the entities responsible for implementing changes. In a broader context, it can be stated that social acceptance for renewable energy sources in Poland is in the stage of gradual consolidation – most citizens understand the need for transformation and notice its benefits, but some still perceive it through the prism of uncertainty and risk.

The next question concerned the selection of one of the individual energy sources that the respondent considers to be the most efficient, cost-effective and ecological. The summary of responses is presented in Figure 2.

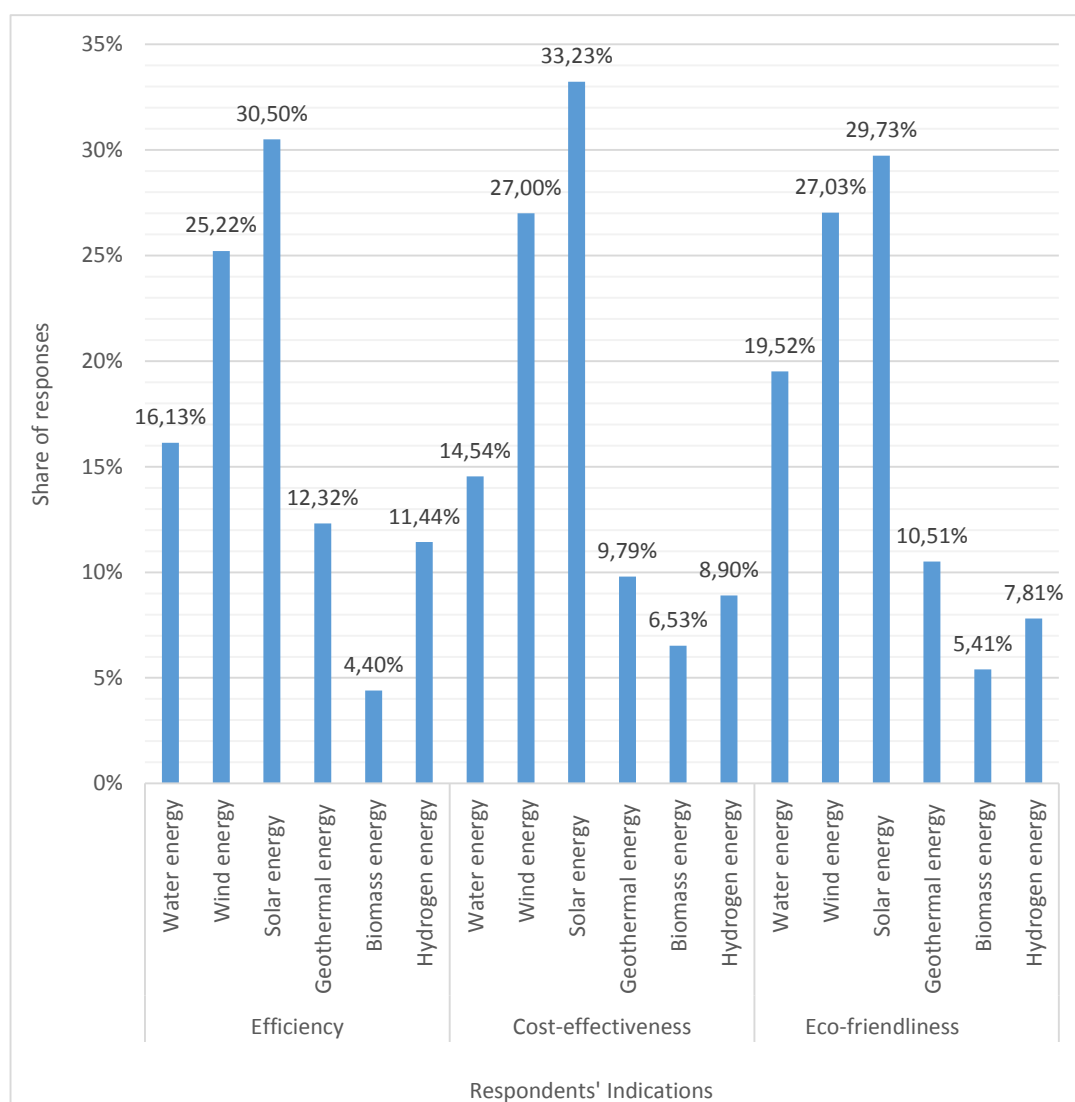


Figure 2. Indications of the most efficient, cost-effective and ecological energy source.

Source: own study.

Solar energy (30.50%) and wind energy (25.22%) were considered the most efficient energy sources, which implies that society identifies these technologies as the most effective in converting natural resources into useful energy. Hydropower (16.13%) came third, followed by geothermal energy (12.32%), while biomass (4.40%) and hydrogen energy (11.44%) received the lowest ratings. This distribution of opinions reflects the widespread recognition of solar and wind technologies, which are most visible in public spaces (e.g. wind farms or photovoltaic installations on residential buildings). On the other hand, lower assessments of biomass and hydrogen may result from limited public knowledge about their functioning and possibilities of use.

In terms of perceived profitability, i.e. cost-effectiveness, the results are similar. Solar energy (33.23%) and wind energy (27.00%) were considered the most profitable energy sources, while hydropower (14.54%) and geothermal energy (9.79%) were rated as moderately cost-effective. Only 8.90% of respondents considered hydrogen energy to be an economically

advantageous solution. These results confirm the established belief in the economic advantages of photovoltaics and wind energy, supported by numerous financial programmes (e.g. „My Electricity”, „Clean Air”) and the development of the prosumer model. The high ratings of these sources result from their availability, scalability and relatively short payback period. The public perception of the high cost of producing hydrogen (especially green hydrogen) may further reinforce scepticism towards this technology.

With regard to the ecological criterion, similar trends prevail. Solar energy (29.73%) and wind energy (27.03%) were considered the most environmentally friendly, followed by hydropower (19.52%) and geothermal energy (10.51%). The least ecological in the opinion of respondents were biomass (5.41%) and hydrogen energy (7.81%). The high ratings of solar and wind energy result from their symbolic status as "clean energy", perpetuated in media coverage and public discourse.

The juxtaposition of three categories – efficiency, profitability and environmental friendliness – reveals a coherent structure of social perception. Solar and wind energy occupy the highest positions in all analysed dimensions, which confirms their dominant status in the social awareness of Poles as future sources. On the other hand, biomass and hydrogen remain marginal technologies in public perception.

The purpose of the third question was to indicate the greatest benefit of using renewable energy sources out of 5 options. The summary of responses is presented in Figure 3.

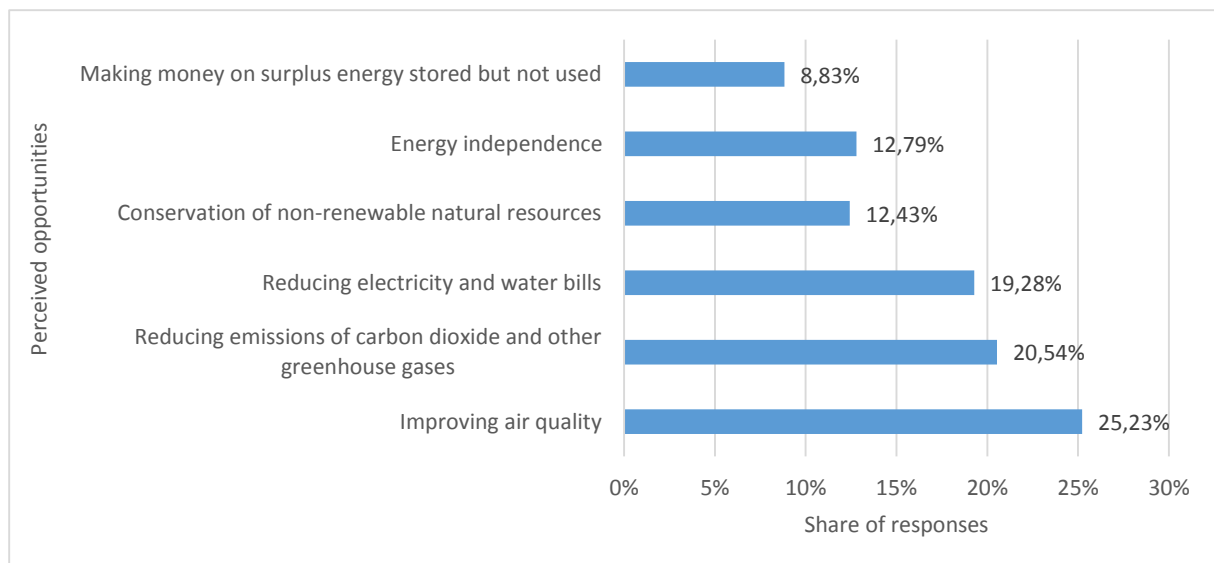


Figure 3. Perceived opportunities related to renewable energy sources.

Source: own study.

The analysis of responses regarding perceived opportunities arising from the development of renewable energy sources (RES) indicates that environmental and health-related motives dominate the social awareness of Poles. The most frequently indicated benefits were: improved air quality (25.23%) and reduced greenhouse gas emissions (20.54%). Subsequently, respondents mentioned reducing energy bills (19.28%) and increasing energy independence

(12.79%). The possibility of obtaining income from energy surpluses was indicated much less frequently (8.83%), which suggests limited knowledge of prosumer mechanisms and economic aspects of energy transformation.

The relatively low percentage of responses indicating the possibility of earning money from surplus energy proves that the potential of RES remains insufficiently recognised and utilised. This may be due to limited knowledge about the functioning of net-billing systems, complicated legal regulations or lack of a sense of real influence on the energy market. According to the research by Mirowski and Sornek (2015), awareness in Poland is still fragmented, and for many households, investment in RES is not perceived as a source of income, but rather as an ecological activity or a symbolic gesture of social responsibility.

Similarly, it was decided to examine public opinion on the threats associated with the use of renewable energy sources. Respondents' responses are presented in Figure 4.

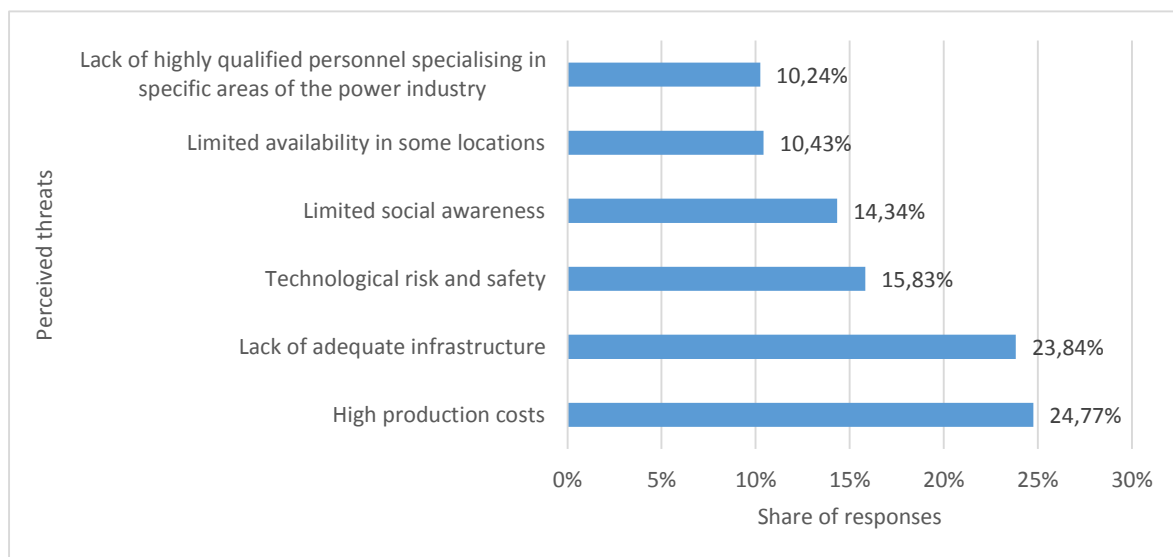


Figure 4. Perceived threats to the implementation and use of renewable energy sources.

Source: own study.

In the opinion of respondents, the greatest threats to the development of renewable energy sources (RES) are economic and infrastructural factors. The most frequently indicated factors were high energy production costs (24.77%) and insufficient technical infrastructure (23.84%). Other barriers included technological risk (15.83%) and limited social awareness (14.34%). The structure of the responses clearly indicates that public concerns primarily relate to the practical aspects of implementing the energy transformation.

The high position of the factor related to the lack of infrastructure can be interpreted as a manifestation of the growing social understanding of the complexity of the energy transformation process. Respondents realise that renewable energy production itself is not sufficient without an appropriate storage, transmission and distribution system. This observation is confirmed by research conducted by the European Environment Agency (2022), which indicates that confidence in the development of RES increases where citizens see

specific infrastructure investments – e.g. modernisation of energy networks, local energy storage projects or the development of hydrogen transport.

High indications of technological risk and limited social awareness confirm that energy transformation is perceived not only as a technical process, but also as a cognitive and communication challenge. Lack of understanding of how new technologies work, especially hydrogen ones, may increase the fear of their failure or the danger of operation.

The next part of the study focused on examining opinions on the level of public knowledge and educational needs in the field of renewable energy sources. The results are presented in Figure 5.

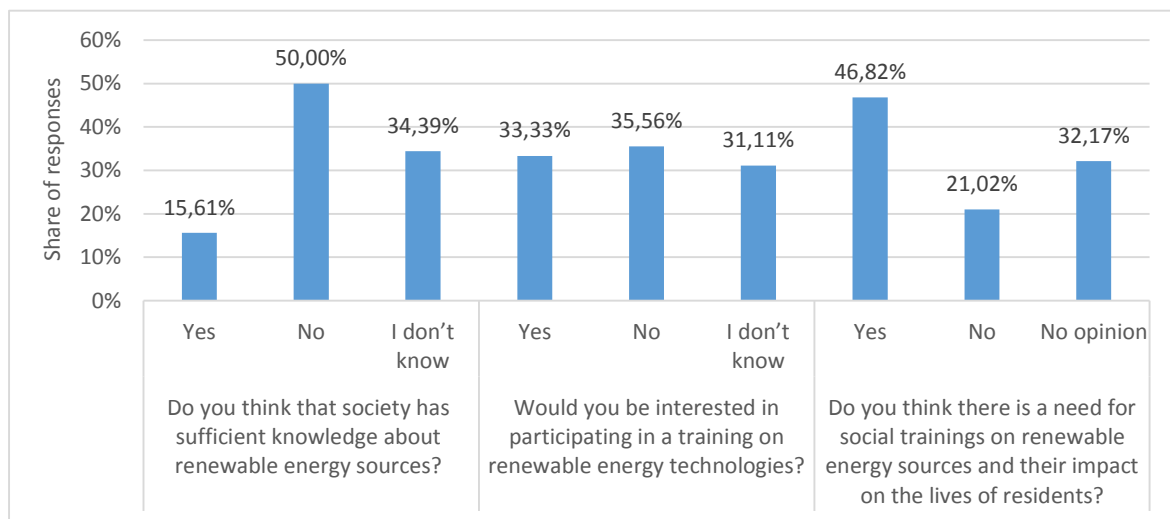


Figure 5. Knowledge and educational needs of society regarding renewable energy sources.

Source: own study.

The analysis of respondents' answers regarding the level of public knowledge about renewable energy sources reveals a significant cognitive gap, which constitutes a potential barrier to the further development of energy transformation. Half of the respondents (50%) stated that society does not have sufficient knowledge about RES, while only 15.61% assessed this level positively. This means that despite the growing presence of energy topics in the public debate and media, Poles' knowledge in this area remains superficial and fragmented.

The lack of in-depth technical and ecological awareness is also confirmed by earlier analyses by Yüksel Köseoğlu (2016) and Żywiołek et al. (2022), indicating that insufficient social knowledge is one of the main factors limiting the acceptance and willingness to participate in the energy transformation. The literature emphasises that knowledge about the principles of operation of technologies, their safety and environmental effects is the foundation of social trust in innovation (Devine-Wright, 2020). Thus, the educational gap not only slows down the process of implementing RES but also increases the susceptibility of society to disinformation and stereotypes regarding renewable energy sources.

The results regarding interest in RES trainings confirm this diagnosis. One-third of respondents (33.33%) declared willingness to participate in such trainings, 35.56% expressed disinterest, and 31.11% had no opinion.

At the same time, the results of the question regarding the need to conduct social training in the field of RES (46.82% of "yes" indications) prove that respondents recognise the social importance of energy education, even if they themselves do not declare their willingness to participate in such a training. This can be interpreted as a manifestation of the so-called *normative consciousness* – the belief that environmental education is needed for the common good, regardless of individual participation plans.

The comparison of the three analysed indicators (knowledge assessment, readiness to participate in trainings, need for social education) allows us to indicate that in Poland there is a significant deficit of knowledge about renewable energy sources, but at the same time there is a growing demand for education in this area. This indicates the need to develop integrated educational programmes – both formal (in schools and universities) and informal (local workshops, information campaigns).

5. Summary

The conducted research shows that society has a predominantly positive attitude towards energy transformation and replacing fossil fuels with renewable energy sources. Both in the sphere of perception of environmental friendliness and profitability, beliefs about the advantage of solar and wind energy dominate, which confirms their established position in the public consciousness as modern, effective and environmentally friendly technologies.

On the other hand, development barriers are still noticeable – primarily high investment costs, lack of infrastructure and limited social awareness. More than half of the respondents admitted that the level of knowledge about renewable energy sources is insufficient, and at the same time almost half of them see the need for social training in this area. This indicates the need to intensify educational and information activities that can actually increase the level of acceptance and participation of citizens in the energy transformation processes.

Based on the conducted research and literature review, it can be concluded that social awareness (including knowledge, attitudes, trust and sense of empowerment) is an important element supporting the development of renewable energy sources. At the same time, there is a need for further research, including, among other things, how specific educational campaigns raise awareness and influence decisions regarding renewable energy sources, and how demographic, cultural and geographic differences affect the relationship between public awareness and renewable energy adoption. Beyond quantitative research, it appears essential to

employ qualitative methods (such as in-depth interviews) to better understand psychological barriers, as well as behavioral experiments to test the effectiveness of various communication strategies (e.g., those based on financial vs. environmental benefits) in the decision-making process regarding renewable energy sources investments. Additionally, it should be noted that the issue of trust in sources and exposure to misinformation were not directly measured in this study; therefore, these claims represent an inference that requires further empirical confirmation.

In summary, the collected data confirm that the energy transformation in Poland is at the stage of gradual social acceptance, the further development of which requires parallel strengthening of educational competences, building trust in institutions implementing climate policy and ensuring a coherent technical infrastructure enabling the wide use of renewable energy sources.

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ARE TRANSLATORS STILL NEEDED IN THE AGE OF ARTIFICIAL INTELLIGENCE? VERBAL HUMOUR AS A TRANSLATION CHALLENGE: AI VS. HUMAN TRANSLATOR

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Purpose: The present paper evaluates the quality of AI-generated translation compared with a professional translation in the particularly challenging area of verbal humour translation. The objective of the paper is to establish whether AI-driven translation tools are able to recognise verbal humour mechanisms in a source text and recreate these mechanisms in translation from English into Polish.

Design/methodology/approach: The study applies a comparative method to assess the quality of translation provided by four AI-driven tools: two NMT-based tools (DeepL and Google Translate), and two LLM tools (ChatGPT-5 and Gemini 2.5 Flash) against a professional human translation. Translation quality was evaluated based on the reconstruction of verbal humour mechanisms. The research followed a communicative approach, prioritizing the humorous effect over literal accuracy.

Findings: It has been found that professional translation outperforms all four AI-driven translation tools in recreating mechanisms of verbal humour. While LLM-based tools are able to recognise various mechanisms of verbal humour and double meaning in the source text, neither NMT nor LLM tools can provide an effective translation of humour mechanisms operating on word ambiguity (homonymy, polysemy, and homophony). Google Translate, DeepL, and ChatGPT concentrate on the explicit meaning of the source fragments. Gemini's translation demonstrates an effort in rendering the ambiguity in some cases; however, the output tends to be flawed by calques from English and errors, which affects the communicative effect. The analysed NMT and LLM tools are able to reconstruct humour based on language style (blending of registers).

Research limitations/implications: The study is limited to English–Polish.

Originality/value: The paper responds to the growing concern regarding the future of translation as a profession. It shows that professional human translation outperforms AI-based tools in the complex task of humour translation, while pointing to specific areas in which AI tools fall behind and in which they prove useful. The research sees AI-powered applications as practical tools and not a substitute for professional translators in Society 4.0.

Keywords: machine translation, verbal humour, Society 4.0, AI, NMT, LLM.

Category of the paper: Research paper.

1. Introduction

Amid the rapid development of generative AI technologies, a growing number of workers are expressing anxiety about their career stability, a concern that has been making headlines across various media outlets. The fear of replacement by AI is the primary contributor to AI anxiety, a phenomenon described in psychological studies (see Kim et al., 2025). Benedikter (2023) argues that AI reshapes humans instead of serving them. Translators are among the professions considered particularly exposed to AI influence. Translation studies have raised concerns about the future of translation in the AI age. Schilling (2018, p. 181) observes that AI-driven translation tools have achieved substantial advancements in recent years in their pursuit of parity with human translation. The author describes AI tools as a potential threat to human translators and notices the shift in the role of human translators towards post-editing. Similarly, Tavares et al. (2023, p. 2) point out the improvement in the accuracy of translation tools, referring to the study by OpenAI, Open Research, and the University of Pennsylvania on large language models (Eloundou et al., 2023) which classified interpreting and translation as one of the professions with high exposure to AI. Łukasik (2024, p. 36) finds that translators, translation students, and university teachers in Poland are concerned about the future of translation and consider that AI might overcome limitations such as human-level creativity. A general conclusion drawn in his study is that the components of the translation process have evolved and the human translator can now be substituted with a machine translation tool. When included in the system, the translator's role is reduced to pre-editing, operating the tool, and post-editing (Łukasik, 2024, p. 38). In a similar vein, Tavares et al. (2023, pp. 19-20) indicate that translators are afraid of the devaluation of the profession caused by the use of AI in translation. However, according to the authors, the roles of human professionals will probably "evolve to focus on more complex or specialized tasks, or depreciate, while AI tools will be used for more routine or repetitive tasks".

Several studies have assessed the quality of AI-generated translations. Constantin et al. (2023) describe a high level of accuracy in translating economic texts achieved by AI tools. In view of the results, the authors warn of the need for the reconfiguration of the profession. Gutiérrez Rubio (2024) conducted a study in which language users evaluated translations of various types of texts, prepared by AI tools and professional translators. The author considers the results alarming, given the fact that the respondents manifested a general high level of satisfaction with the automatic translation (DeepL and Google Translate), close to the results obtained by professional translation¹. Some scholars indicate that creative texts are the least likely to be translated successfully by AI-powered tools (e.g., Kirov, Malamin, 2022, p. 9; Tavares et al., 2023, p. 20); however, the study conducted by Constantine (2019, p. 473),

¹ Although professional translations still received a higher score.

in which the author assessed the quality of a literary text performed by Google Translate, concluded that in some fragments the translation was “surprisingly competent”.

The rapid development of AI-powered translation tools, the popularization of their use, and the growing concern among translators indicate the need for further research on machine translation and a scientific assessment of translation quality. The present paper assesses the quality of AI-generated translation compared with professional translation in one of the most challenging tasks: the rendering of verbal humour, which requires creative thinking from the translator. Despite the challenges posed by the task, comedies and comedy series that use verbal humour are translated on a daily basis. Professional translators understand the mechanism of humour. The question that remains is whether popular AI translation tools are able to recognise and recreate mechanisms of verbal humour. The present paper addresses this question with regard to translation from English into Polish. The study adopts a communicative approach, as the humorous effect is considered to take precedence over literal accuracy in a successful translation of verbal humour. We apply a comparative method by looking into four popular AI-powered translation tools: two NMT-based tools (DeepL and Google Translate) and two LLM tools (ChatGPT-5 and Gemini 2.5 Flash). The study is based on 30 fragments of the American TV situation comedy *How I Met Your Mother*, in which various mechanisms of verbal humour were identified. The quality of translation is assessed based on the reconstruction of humour mechanisms. Although several studies have investigated AI translation, little is known about the ability of AI systems to translate humour. To our knowledge, the present paper provides the first systematic analysis of AI tools’ capabilities in recognising and reconstructing mechanisms of verbal humour.

2. Literature Review

2.1. Machine translation

Ungvarsky (2024) defines machine translation (MT) as “a technological process that enables the conversion of text from one language to another without human involvement”. The concept of machine translation was first introduced by Warren Weaver in 1947 (Wang et al., 2022, p. 143). Since then, MT has undergone a series of fundamental methodological transformations, evolving through distinct technological paradigms that reflect broader advances in computational linguistics and artificial intelligence.

Early methodological developments in the field were dominated by Rule-Based Machine Translation (RBMT) approaches, which relied on manually constructed rules and bilingual dictionaries (Wang et al., 2022, p. 143). With the advent of large bilingual corpora, corpus-based methods gradually supplanted RBMT after the 2000s, giving rise to Example-Based

(EBMT), Statistical (SMT), and later Neural Machine Translation (NMT) techniques. Statistical machine translation, first proposed by Brown et al. in 1990, shifted the paradigm by enabling machines to learn translation patterns directly from data. This data-driven approach underpinned major commercial translation systems, including Google's 2006 SMT service (Wang et al., 2022, pp. 143-144).

The rapid progress of deep learning research in the early 2010s then catalysed a transition toward neural machine translation, with Google shifting to an NMT system in 2016. Wang et al. (2022, p. 145) describe NMT as an end-to-end approach that learns semantic representation and translation patterns directly from training data. The core principle of NMT is to employ a neural network that encodes the source text into a continuous semantic representation and decodes this representation with the help of attention mechanisms to produce the target text (Wang et al., 2022, p. 144). Many of the currently available modern applications are based on NMT, for example, Google Translate, Microsoft Translator, Reverso, and DeepL.

However, as Lewin et al. (2024) note, a new form of machine translation has recently emerged: generative artificial intelligence, which relies on large language models (LLMs). LLMs are deep-learning AI models trained on vast amounts of data. Their extensive training enables them to handle a wide range of language processing tasks, including translation. Although LLMs were not created specifically for translation, their broad linguistic capabilities allow them to perform in this area. LLMs can deliver fluent, natural-sounding translations. According to Lewin et al. (2024), LLMs have the potential to become dominant technologies in machine translation. ChatGPT, Gemini, and Claude are the most famous, yet not the only, examples of LLMs currently used. The study by OpenAI, Open Research, and the University of Pennsylvania on AI large language models (Eloundou et al., 2023, p. 4) indicates that ChatGPT is a general-purpose technology that excels in translation, classification, and creative writing. The cited study by OpenAI states that LLMs should be integrated as building blocks for more comprehensive tools, a recommendation that appears to be currently implemented through hybrid translation solutions. For example, DeepL has recently introduced a new model which adds an LLM technology to its previous classic model. Traditionally used CAT tools, like MemoQ, have also been implementing generative AI into their offer. There are other online platforms that combine machine translation and human editing, e.g., Unbabel, Smartcat, Phrase, or Smartling.

2.2. Translation of humour

Translation is an act of communication. The most basic, and arguably the most influential, communication model is the one created by Jakobson (1960), which differentiates six elements present in any act of verbal communication: addresser, addressee, message, context, channel, and code. When considering translation, two communicative situations, separate in time and space, should be distinguished. A translator is the mediator between these two situations. In the first situation, the translator is the addressee; in the second, the addresser. Any act of

communication has a determined function. The task of a translator as an addressee is to capture both explicit and implicit meanings in the source text, as well as the author's intention. Subsequently, as an addresser, they should reconstruct the same message in the target language, maintaining the purpose of the source text (Lipiński, 2004, p. 20). The purpose of humorous texts is to produce laughter.

The humorous effect can be achieved through extralinguistic and linguistic measures. In the first type, language describes a situation, object, relation, or person, but the comic effect arises from the situation or world model and not the language itself. In the second type, the source lies in the language itself (e.g., wordplay or puns). The second type is known as verbal (or linguistic) humour (Kalaga, 1997, p. 12). The present paper concentrates on verbal humour; however, we should bear in mind that it is not possible to separate the linguistic unit from its connotations, culture, and world-models embedded in the language. Therefore, the linguistic and extralinguistic underpinnings of humour cannot always be separated.

A joke consists of a setting of a scene followed by a punch line, with its basis being an incongruity between the punch line and what comes before (Alexander, 1997, p. 15). Jokes might rely on puns, that is to say a specific kind of wordplay based on the polysemy of a single word (one form with multiple meanings), or the use of homophones, homonyms, or near-homonyms (lexical items sharing the same or similar phonetic or graphic form but different meanings). In a wider sense, strict homonymy is not necessary; it is enough for the speaker to allude to a word or a distant formal similarity (Alexander, 1997, pp. 17-18). Alexander uses the term in a broader sense and defines a pun as wordplay that depends on lexical ambiguity. In other words, puns depend on combining two meanings in one form. Beyond homonymy, polysemy, and homophony, other mechanisms of verbal humour differentiated by Alexander (1997, pp. 27-54) include:

- operating on rhythm and rhyme,
- alliteration and assonance,
- changing word boundaries,
- changing of the voice quality (e.g., imitating other person's way of speaking),
- creation of portmanteau words and other neologisms,
- punning acronyms,
- errors in hard words.

The foregoing list can be complemented by humour mechanisms distinguished by Buttler (2001, pp. 68-150), namely:

- mechanisms of general humour based on excess and exaggeration, contrast of different elements, and stylistic disharmony,
- modification of idioms, phrases, collocations, or the form of lexemes,
- blending of different styles and registers.

Translation of humour is considered a complex task, and scholars often describe humour in terms of its untranslatability (see Gumul, 2005). Nevertheless, the translation of humorous texts is a common practice and translators apply different techniques to convey humour.

2.3. Audiovisual translation

In the most general terms, we can define audiovisual translation (AVT) as the translation for cinema, television, and video, in which audiovisual texts such as films, teleplays, and documentaries are translated. What distinguishes audiovisual translation from other types of translation is the way in which the meaning is conveyed. While in other types of translation, information is represented exclusively at the linguistic level, the audiovisual message is transmitted by means of sounds, images, music, and language. A translator can intervene only at the linguistic level, which complicates the task. In other words, audiovisual translation is constrained by other non-linguistic elements (Hurtado Albir, 2004, p. 77).

Audiovisual texts are translated using various modes. Chaume (2004, pp. 31-38) defines an AVT mode as a technical method used to accomplish the linguistic transfer of an audiovisual text from one language to another and enumerates several AVT modes, among which the most popular ones are dubbing and subtitling. Each translation mode determines the work of a translator. In the case of subtitles, there are technical constraints related to the fact that subtitles cannot occupy too much space on the screen and hinder the perception of the image. As Tomaszekiewicz (2008, pp. 112-113) explains, about 30-40% of the original text is omitted in subtitling.

3. Methods

The primary criterion for evaluating translation quality in this study is the humorous effect achieved in the target text and its equivalence to the effect achieved in the source text. In order to assess the humorous effect, we focus on the recreation of the verbal humour mechanisms used in the original version. We identify these mechanisms in the source text referring to the classifications proposed by Alexander (1997) and Buttler (2001) and analyse their representation in translation. Using a contrastive methodology, the study examines the differences between AI and human translation, assessing their respective strengths and weaknesses, as well as the level of communicative equivalence achieved. The study does not take into account the technical constraints usually imposed by the mode of translation (e.g., the length of the output text); instead, the focus remains on the communicative goal.

The study is based on 30 examples of verbal humour selected from the American sitcom *How I Met Your Mother*, directed by Pamela Fryman and Rob Greenberg and produced by 20th Century Fox Film Corporation. The series was chosen due to the abundance of jokes, puns,

and other mechanisms of verbal humour within its dialogue. The analysis covers the first two seasons of the series. First, examples of verbal humour were identified and transcribed from the source text. Subsequently, they were categorised according to their specific verbal humour mechanism. For each example, respective professional and machine translations were collected.

The analysis includes five different translations into Polish, one of which is a professional translation and four are AI-generated. As the professional human translation of the series, we chose the subtitles distributed in Poland by Imperial CinePix in DVD format. The distributor does not make public the name of the author of the subtitles; however, it is assumed that such a person possesses translation competence as they translate professionally. The choice of an older DVD translation (2012) was intentional and aimed at eliminating the risk of AI involvement in the translation process. As for the AI-generated translations, two NMT-based tools (Google Translate and DeepL, free version) and two LLM-based tools (ChatGPT-5 and Gemini 2.5 Flash, free version) were used. The study does not analyse hybrid tools that combine NMT and LLM solutions, since a hybrid solution considered for the study (DeepL's Next Gen model) was not available for Polish at the time of the analysis.

The LLM-based tools were prompted to recognise the verbal humour mechanisms in the source texts and translate them into Polish, while maintaining the humorous effect and adapting the target text to the target language when necessary. Each example was fed into the respective tool separately and the tools were instructed to choose the most suitable version of translation for each example. Explanations of the situational context for each fragment were provided (e.g., location of the characters, social context). As far as the NMT-tools are concerned, there is no field dedicated for a prompt as such. However, an explanation of the context and purpose was added before the actual text selected for translation. Our hypothesis was that models based on LLMs would perform better than the ones based solely on NMT, since the latter translate based on learnt patterns between languages and the former are generative. Our estimation was that they might be able to go beyond literal accuracy to recreate some mechanisms of verbal humour and convey the humorous effect.

4. Results

4.1. Homophony

We have identified nine cases of verbal humour based on homophones or near-homophones in the analysed corpus (see Table 1). In each case, the humorous effect in the source text was achieved through phonetic similarity between two different lexemes or phrases.

Table 1.
Examples of verbal humour based on homophony

N	original	Google Translate	DeepL	ChatGPT 5	Gemini 2.5 Flash	professional translation
1	A: If things had gone your way, you'd gone out a couple of times, she definitely would 've had sex with you.	A: Gdyby wszystko poszło po twojej myśli, umówilibyście się kilka razy, na pewno by się z tobą przespała.	A: Gdyby wszystko poszło po twojej myśli, spotkalibyście się kilka razy i na pewno uprawialibyście seks.	A: Gdyby wszystko poszło po twojej myśli, spotkalibyście się kilka razy i na pewno by z tobą poszła do łóżka.	A: Gdyby poszło po twojej myśli, wyszedłbyś z nią parę razy, to na pewno by się z tobą kochała.	A: Gdybyś się z nią parę razy umówił, mógłbyś śmiało do niej walić.
	B: There's no would/wood in sex...Aaa, haha, yeah, there totally is.	B: W seksie nie ma miejsca na „chciałbym/drew no”... Aaa, haha, tak, zdecydowanie jest.	B: W seksie nie ma miejsca na „byłoby/byłoby”... Aaa, haha, tak, oczywiście, że jest.	B: W seksie nie ma żadnego „by”... A: Oj, jest, i to twarde jak drewno!	B: Gdzie tam, w seksie nie ma żadnego „kocha”... Aaa, haha, racja, jednak tam jest!	B: W seksie nie ma walenia. – Fakt.
2	A: I was such a dork, I get recognised one time and I'm starting thinking I'm Julia Roberts. I'm not a VIP, I'm not even an IP, I'm just a lowly, little P sitting out here in a gutter.	– Byłem takim palantem, raz mnie rozpoznało i zaczynam myśleć, że jestem Julią Roberts. Nie jestem VIP-em, nawet nie jestem IP, jestem tylko małym, marnym P siedzącym tu w rynsztoku.	A: Byłem takim kretynem, że kiedy raz mnie rozpoznało, zacząłem myśleć, że jestem Julią Roberts. Nie jestem <i>VIP-em</i> , nie jestem nawet IP-em, jestem tylko skromnym, małym P siedzącym tutaj w rynsztoku.	A: Ale ze mnie była sierota. Raz ktoś mnie rozpoznał i już myślę, że jestem Julia Roberts. Ja nie jestem żadnym VIP-em, nawet nie IP-em... jestem tylko małym, nędznym „P”, co siedzi tu w rynsztoku.	A: Byłem takim durniem... Nie jestem VIP-em, nie jestem nawet IP, jestem tylko takim nędznym, małym sikaczem siedzącym w rynsztoku.	A: Ale ze mnie lama. Ktoś mnie raz zauważył i już się uważam za Julię Roberts. Nie jestem VIP-em. Nawet nie jestem IP-em. Jestem samotnym małym pipem siedzącym w rynsztoku.
	B: You know something, I'd take a P in the gutter over Julia Roberts any day.	– Wiesz co, wolałbym P w rynsztoku niż Julię Roberts każdego dnia.	B: Wiesz co, wolałbym P w rynsztoku niż Julię Roberts każdego dnia.	B: Wiesz co? Ja bym tego „P” z rynsztoka wziął zamiast Julii Roberts — i to z pocałowaniem ręki.	B: Wiesz co, wolę sikać do rynsztoka niż Julię Roberts kiedykolwiek	B: Wiesz, wole pipę z rynsztoku niż sto Julii Roberts.
3	So next time you're passing City Hall, make sure and stop by New York's oldest hot dog cart. Today a delicious hot dog will cost you 2,50 but back when the stand first opened in 1955 you could get one for only a nipple.	Więc następnym razem, gdy będziesz przechodzić obok ratusza, koniecznie zatrzymaj się przy najstarszym wózku z hot dogami w Nowym Jorku. Dzisiaj pyszny hot dog kosztuje 2,50, ale kiedy budka się otwierała w 1955 roku, można go było dostać za jedynego sutka.	Więc następnym razem, gdy będziesz przechodzić obok ratusza, koniecznie zatrzymaj się przy najstarszym wózku z hot dogami w Nowym Jorku. Dzisiaj pyszny hot dog kosztuje 2,50, ale kiedy wózek został otwarty w 1955 roku, można było go kupić za jedyne 5 centów.	Następnym razem, gdy będziesz przechodzić obok Ratusza, koniecznie wstąp do najstarszego w Nowym Jorku wózka z hot dogami. Dziś pysznego hot doga kupisz za 2,50, ale kiedy stoisko otwarto w 1955 roku, można było go dostać za... sutek.	Więc następnym razem, gdy będziesz przechodził obok Ratusza, koniecznie wstąp do najstarszego nowojorskiego wózka z hot dogami. Dziś pyszny hot dog kosztuje 2,50, ale kiedy budka pierwszy raz otworzyła się w 1955 roku, można go było dostać za jedynego sutka.	Kiedy następnym razem będziecie w pobliżu ratusza, zatrzymajcie się przy najstarszym w mieście wózku z hot dogami. Zapłacicie 2,50. Ale w inauguracyjnym 1955 roku, wydaliłoby 5 centów. Cycus.

Cont. table 1.

4	Hey, is it cold in here? Cause I kind of see Robin's nickles.	Hej, zimno tu? Bo widzę, że Robin ma jakieś pięciocentówki.	Hej, czy tu jest zimno? Bo widzę piątki Robin.	Ej, tu zimno, czy to ja mam tylko wrażenie, że widać cycki Robin?	A: Hej, czy tu jest zimno? Bo mi się wydaje, że Robinowi aż grosze wychodzą.	Mam omamy czy coś tu chłodnawo?
5	A: Or we could just drink wine?	A: A może moglibyśmy po prostu napić się wina?	A: A może po prostu wypijemy wino?	A: Albo po prostu napijmy się wina?	A: A może po prostu napijemy się wina?	A: Możemy też napić się wina?
	B: Wine not?... Oh, that's the stupidest thing I've ever said.	B: Wina nie?... Och, to najgłupsza rzecz, jaką kiedykolwiek powiedziałem.	B: Wino, czemu nie?... Och, to najgłupsza rzecz, jaką kiedykolwiek powiedziałam.	B: Więc czemu nie...? Ojej, to najgłupsze, co kiedykolwiek powiedziałem.	B: Winna nie?... O rany, to najgłupsza rzecz, jaką kiedykolwiek powiedziałem.	B: Całkiem niewinnie. Kretyńska odzywka.
6	But just know that this Victoria Secret party is on a yacht. And what will be sticking to that yacht? The Barnacle.	Ale wiedźcie, że ta impreza Victoria Secret jest na jachcie. A co będzie się do tego jachtu przyklejać? Barnacle.	Ale pamiętajcie, że impreza Victoria Secret odbędzie się na jachcie. A co będzie przyklejone do tego jachtu? Barnacle.	A: Tylko wiedz, że ta impreza Victoria's Secret jest na jachcie. B: A kto będzie się przyklejał do tego jachtu? Barnakiel.	A: Pamiętaj, impreza Victoria's Secret jest na jachcie. I co będzie się do tego jachtu przyklejać? Rzep Barney!	A impreza bieliźniana jest na jachcie. A co się do jachtu przyczepi? Barnialek-ukwiałek.
7	A: So, what does a fellow have to do to get lei'd around here?	A: Więc co trzeba zrobić, żeby tu dostać lei? ... Tak.	A: Więc co facet musi zrobić, żeby dostać lei w tym miejscu? ... Tak.	A: No dobra, co trzeba zrobić, żeby tu się trochę położyć?... No właśnie.	A: Co koleś musi zrobić, żeby go tu zaliczono? ... No właśnie.	A: Hawajki to największe łatwodajki świata.
	B: Yeah. Right, cause I'm wearing a lei.	B: Jasne, bo noszę lei.	B: Racja, bo noszę lei.	B: Jasne, bo mam na sobie wieniec.	B: A tak, bo mam na sobie girlandę.	B: No tak, wysyłamy sygnał: „Cho-no lulu”.
8	It's gonna rain cats and dogs, folks, so don't step on a poodle.	Będzie lało jak z cebra, ludzie, więc nie nadepnij na pudła.	Będzie lało jak z cebra, ludzie, więc nie nadepnijcie na pudła.	Będzie lało jak z cebra, więc uważajcie, żeby nie nadepnąć na pudła.	Będzie padać kotami i psami, ludziska, więc uważajcie, żeby nie nadepnąć na pudła.	Będzie wiało i lało, więc uważajcie, by nie oberwać.
9	A: Your problem is all you do is think, think, think. I'm teaching you how to do, do, do.	Twój problem polega na tym, że tylko myślisz, myślisz, myślisz. Uczę cię, jak robić, robić, robić.	Waszym problemem jest to, że tylko myślicie, myślicie, myślicie. Ja uczę was, jak działać, działać, działać.	Twój problem polega na tym, że tylko myślisz, myślisz, myślisz. A ja cię uczę, jak działać, działać, działać. – Działać, działać...	A: Twój problem to tylko myślenie, myślenie, myślenie. Ja cię uczę, jak działać, działać, działać!	Wciąż tylko myślisz i myślisz. Naucz się działać i działać.
	B: Doo-doo.	B: Du-du.	B: Doo-doo.	B: kupa.	B: Dudu!	B: Dział dział.

The professional translation manages to convey the humorous effect in eight out of the nine examples analysed. The only one that does not achieve a humorous effect is Example 4. It is worth noticing that the professional translator does not always resolve the problem of translating homophony by seeking corresponding homophones in the target language. Instead, they employ a range of alternative mechanisms to achieve the humorous effect. Specifically, Examples 1 and 8 exploit the polysemy of the verbs “walić” and “lać” respectively, to maintain

the double meaning effect. Example 9 builds its translation on the homonymy of the forms "dział", oscillating between the nominative form of the noun "dział" ("department"), and the genitive form of the noun "działo" ("cannon"). A different approach is observed in Example 7, where a double meaning effect and the intended innuendo are achieved via a near-homophony between the sentence "chodź no lulu" (the imperative form of the verb "chodź" and "lulu" being a colloquial expression used to mean "to bed") and "Honolulu" (a city in Hawaii). Furthermore, Example 2 renders the original pun by using a near-homonymy of the vulgar noun "pipa" and a made-up word "pip" based on the expression "VIP". The translation maintains the double meaning effect and the absurdity present in the source text. Similarly, Example 5 achieves the intended effect by homonymy of the word "winny" (meaning both "guilty" and "related to wine"). The translation uses a derivative of "winny", the adverb "niewinnie", which maintains the allusion to "wino" ("wine") successfully. By contrast, Example 6 uses the mechanism of rhythm and rhyme instead of the original near-homophony. Finally, Example 3 shows how the humorous effect is achieved by the absurdity of an unexpected interjection. The equivalents of the words that formed the originally used pun are included explicitly in the translation. It is worth noting that professional translation does not concentrate on the literal meaning of the source texts, but rather exploits unexpected connections between language units and uses various verbal humour mechanisms.

As for the NMT tools, both Google Translate and DeepL concentrate on the explicit meaning of the original fragments. Example 3 shows that, while Google Translate opts for the equivalent of the noun "nipple", which is the one explicitly present in the original; DeepL opts for the equivalent of the noun "nickel", which is the one that matches the situational context. None of the analysed examples convey the double meaning effect. Both NMT tools recognise the idiom "to rain cats and dogs" and apply its Polish functional equivalent. In some cases, the English words are maintained (e.g., "lei", „Barnacle", and "doo-doo" or "du-du"), with the latter being adapted orthographically. As a general observation, NMT tools do not achieve the humorous effect and do not employ mechanisms of verbal humour in this group.

Regarding the LLM-based tools, it is important to emphasize that both ChatGPT-5 and Gemini 2.5 Flash recognise the mechanisms of verbal humour employed in the original fragments; in the case of the above examples: the homophony or near-homophony, double meanings and innuendos. The tools analysed the provided fragments with precision and proposed various versions of explanatory translation. However, when prompted to choose one version, they seem to be unable to achieve the humorous effect since neither of the analysed examples recreates the mechanisms of verbal humour and maintains the double meaning effect. ChatGPT tends to concentrate on the explicit meaning in Examples 1, 2, 3, 7, 8, and 9. Gemini attempts to create a pun based on the morphology of the verb "kochać" (Example 1); however, a double meaning effect is not achieved. It also shows a tendency towards adaptation for a Polish viewer, e.g., Example 4 shows adaptation to the Polish currency, and example 6 applies the word "rzep" ("burr") as a typical clinging object, present in Polish phraseology.

In Example 2, Gemini refers to the implicit meaning of the source text; however, the wordplay between the letter P (as an element of the acronym VIP) and the verb “pee” is lost. In Examples 3 and 7, Gemini concentrates on the explicit meaning. In Example 8, ChatGPT uses a functional equivalent of the original idiom, whereas Gemini opts for the literal translation of the English idiom to maintain the connection with the word “poodle”; however, neither of the translations recreates the humorous wordplay. In some cases, both tools use atypical forms in Polish. For instance, in Example 6, ChatGPT creates the noun “Barnakiel” which appears to be a calque of the original word, while in Example 5 Gemini applies the ungrammatical form “winna nie”.

4.2. Polysemy

The analysed corpus contains five examples of verbal humour that exploit the mechanism of polysemy, presented in Table 2.

Table 2.
Examples of verbal humour based on polysemy

N	original	Google Translate	DeepL	ChatGPT 5	Gemini 2.5 Flash	professional translation
10	– I could give you some cool guy tips. – I don’t think I need advice on how to be cool, but yeah, go ahead. Lay them on me.	– Mogłabym ci dać kilka fajnych męskich rad. – Nie sędzę, żebyś potrzebowała rad, jak być cool, ale tak, śmiało. Daj mi je.	– Mogę dać ci kilka wskazówek, jak być fajnym facetem. – Nie sędzę, żebyś potrzebował porad, jak być fajnym, ale tak, śmiało. Podziel się nimi.	– Mogę ci dać parę rad, jak być cool. – Nie sędzę, żebyś potrzebował lekcji z bycia cool... ale dawaj, słucham, guru fryzury.	– Mogę ci dać parę wskazówek, jak być gościem. – Nie sędzę, żebyś potrzebował porad, jak być cool, ale dobra, dawaj. Syp, co tam masz.	– Chcesz męskie pasemka? – Nie powinienem czytać świerszczyków przed ślubem, ale dawaj.
11	– You’re a charming devil. – I’m also a horny devil.	– Jesteś czarującym diabłem. – Jestem też napalonym diabłem.	– Jesteś czarującym diabłem. – Jestem też napalonym diabłem.	– Jesteś uroczy jak diabełek. – A ja jeszcze podniecony jak diabli!	– Uroczy z ciebie diabeł. – A do tego napalony diabeł.	– Uroczy z ciebie diabeł. – I coś mi sterczy.
12	The partners have made it very clear that this project is make or break for us so lately he’s been a little testy. You know what I mean – crotchety. I’m just saying it’s been hard on him. (...) This building is huge for the firm so it’s really important we don’t blow it.	Wspólnicy jasno dali nam do zrozumienia, że ten projekt jest dla nas kluczowy, więc ostatnio jest trochę drażliwy. Wiecie, o co mi chodzi – marudny. Mówię tylko, że było mu ciężko. (...) Ten budynek jest ogromny dla firmy, więc bardzo ważne jest, żebyśmy go nie spieprzyli.	Partnerzy jasno dali do zrozumienia, że ten projekt jest dla nas sprawą życia lub śmierci, więc ostatnio jest trochę poirytowany. Wiesz, o co mi chodzi – jest zrzędlawy. Mówię tylko, że jest mu ciężko. (...) Ten budynek jest ogromny dla firmy, więc naprawdę ważne jest, żebyśmy tego nie zepsuli.	Partnerzy jasno dali do zrozumienia, że ten projekt to dla nas sprawa życia i śmierci, więc ostatnio jest trochę nerwowy. Wiesz, o co mi chodzi – zrzędlawy. Mówię tylko, że trochę mu to ciąży... (...) Ten budynek jest ogromny dla firmy, więc naprawdę ważne, żebyśmy tego nie spartaczyli.	Partnerzy jasno dali do zrozumienia, że ten projekt to dla nas być albo nie być, więc ostatnio jest trochę jajcarski. Wiesz, co mam na myśli – taki drażliwy w kroku. Po prostu mówię, że mu staje na drodze. Ten budynek to dla firmy kolos, więc naprawdę ważne jest, żebyśmy tego nie zwalili!	Ten projekt to nasze być albo nie być, więc ostatnio trochę się stawia. No wiecie, unosi się, Mówię tylko, że ma parcie. (...) Nie możemy położyć na tym projekcie laski.

Cont. table 2.

13	Still, I've had a pretty serious week. I could sure stand to do something stupid. –I'm something stupid, do me.	Mimo to, miałem całkiem poważny tydzień. Z pewnością mógłbym zrobić coś głupiego. – Jestem czymś głupim, zrób to.	Mimo wszystko miałem dość ciężki tydzień. Chętnie zrobiłbym coś głupiego. – Jestem czymś głupim, zrób mnie.	Miałem naprawdę ciężki tydzień. Przydałoby mi się zrobić coś głupiego. – Jestem czymś głupim. Zrób mnie.	A: Mimo to miałem dość poważny tydzień. Przydałoby mi się zrobić coś głupiego. B: Jestem czymś głupim, zrób mnie.	Ale miałam ciężki tydzień. Czas na coś głupiego. –Ja jestem głupi, bierz.
14	That "Bless this mess" pillow you made for Ted – what a stitch. Stitch– did that just happen?	Ta poduszka z napisem „Błogosław ten bałagan”, którą zrobiłaś dla Teda – co za ściema. Ściema – czy to się właśnie stało?	Ta poduszka „Błogosław ten bałagan”, którą zrobiłeś dla Teda – co za szew. Szew – czy to się właśnie wydarzyło?	Ta poduszka „Błogosław ten bałagan”, którą zrobiłaś dla Teda – ale szew! Szew... właśnie się to stało?	A: Ta poduszka "Błogosław ten bałagan", którą zrobiłeś dla Teda – cóż za szyk! Szyć... Czy to się właśnie stało?	Pani makatka – „Panie błogosław w bałaganie” na klasę. Ma katka, a co to jest „katek”?

The professional translation manages to convey the wordplays by resorting to various humour mechanisms, not necessarily polysemy. Example 10 shows how the original wordplay, based on the polysemy of the noun “tip”, is translated into Polish by means of the near-homonymy of the words “pisemka” and “pasemka”. The translation does not apply the most obvious, literal equivalents of the original nouns, but rather concentrates on recreating the wordplay. In the storyline, the character falls into a trap and accidentally agrees to a bad hairstyle, having misunderstood the hairdresser’s proposal. The translation manages to convey the humorous effect. Example 11 is translated by means of the verb “sterczeć” (“to protrude”), which conveys the literal sense (the reference to the character’s devil costume and the horns that the character is wearing) and maintains the sexual innuendo present in the source text. Unlike the original fragment, the translation solution is based on one meaning of the verb rather than on polysemy. Example 12 achieves a humorous effect, combining a neutral description of a building and a sexual innuendo. In the source text, this effect is achieved through the polysemous words “hard” and “blow”, preceded by the adjectives “testy” and “crotchety”, and their respective near-homonyms “testicles” and “crotch”. The professional translation maintains the wordplay and double meaning by resorting to the polysemy of the verbs “stawiać się” and “unosić się”. Their common literal meaning is “to get up”; however, metaphorically they can also mean “to get up to someone” and “to get indignant”, respectively. The same fragment also contains the verb “przeć” (“to push”) which is not polysemous itself but opens space for double interpretation. The last element of this fragment is the colloquial and vulgar idiomatic expression “położyć na czymś łaskę” (“to ignore”), which also manages to evoke the intended associations, given the colloquial meaning of the noun “łaska” (“oral sex”). In turn, Example 13 shows how the professional translator omits the polysemous verb “to do”, while still maintaining the essence of the joke (“you need something stupid, I am stupid, take me”). Finally, Example 14 provides a solution based on an absurd neologism “katek” that

originates from the homophony of the nouns “makatka” (“tapestry”) and “ma katka” (“has got a *katek*”).

As far as NMT-based translation is concerned, wordplays based on polysemy are not effectively conveyed in any of the analysed translations. The translations focus on the explicit meanings, which might lead to a misunderstanding of the storyline, e.g., in Example 10. The lack of translation of the wordplay would affect the understanding of the events that follow the cited fragment. A similar observation applies to Examples 11, 12, and 14; although, a viewer would realize that the original dialogue contained a joke since all of the cited fragments are followed by recorded laughter. Example 13 contains a direct calque from English, “zrób mnie”, which does not sound natural in Polish.

Regarding LLM-based translation, there is considerable variation in the degree to which verbal humour is represented. Examples 11 and 13 are translated literally, concentrating solely on the explicit meaning of the original. Example 13 contains the same unnatural calque from English, discussed in the NMT-based translation. When it comes to Examples 12 and 14, there is a difference between ChatGPT and Gemini: the former appears to focus more on the explicit meaning, while the latter seeks to convey the wordplay, opting for words that are not obvious equivalents of the original ones. In fragment 12, these elements are: “jajcarski”, “stawać”, and “zwalić”. The Gemini translation conveys the double meaning effect; however, the use of the adjective “jajcarski” (“goofy”) raises concerns since it might interfere with the understanding of the storyline, as the character is speaking about his boss being in a bad mood. Example 14 is based on the resemblance between the noun “szyk” and the verb “szyć”. As for Example 10, neither of the LLM systems conveys the wordplay; however, both seem to recognise the language style and convey the colloquial tone of the original.

4.3. Changing of words boundaries

Table 3 presents an example of the humour mechanism based on changing word boundaries, identified in the analysed corpus.

Table 3.*Examples of verbal humour based on changing of words boundaries*

N	original	Google Translate	DeepL	ChatGPT 5	Gemini 2.5 Flash	professional translation
15	– Hey, guys, guess what I got. A new dart – Oh, wow, a new dart. – Hey, that new dart is great. – I didn’t know you were such a fan of new dart, Barney. – Oh, yes, Robin, I just love a new dart. Nude art.	– Hej, zgadnijcie, co mam. Nową lotkę – O, wow, nową lotkę. – Hej, ta nowa lotka jest świetna. – Nie wiedziałam, że jesteś takim fanem nowego darta, Barney. – Och, tak, Robin, po prostu uwielbiam nowego darta. Nagie sztuki.	– Hej, ludzie, zgadnijcie, co mam. Nową strzałkę. – O, super, nową strzałkę. – Hej, ta nowa strzałka jest świetna. – Nie wiedziałem, że jesteś takim fanem nowych strzałek, Barney. – O tak, Robin, po prostu uwielbiam nowe strzałki. Sztuka nagości.	– Ej, zgadnijcie, co mam. Nową strzałkę. – O, wow, nową strzałkę. – Ta nowa strzałka jest świetna. – Nie wiedziałem, że jesteś takim fanem nowej strzałki, Barney. – O tak, Robin, po prostu uwielbiam nową strzałkę... nago sztukę.	– (trzymając rzutkę): Hej, zgadnijcie co mam. Akt! – Nowy akt? Świetnie! – Ej, ten nowy akt jest super. – Ej, ten nowy akt jest super. C: Nie wiedziałem, że tak lubisz akt, Barney. – O, tak, Robin, po prostu kocham nowy... Akt nagości!	– A wiecie co ja mam? Goły grot. – Ojej! – Jest świetny! – Jesteś fanem gołych grotów? – O tak, uwielbiam nagę broń.

The characters want to suggest to their friend that they have found his nude painting. The joke is based on the phonetic similarity between the phrase “new dart” /nju: dɑ:t/ and “nude art” /nju:d ɑ:t/. One of the characters is holding an actual dart for emphasis, which complicates the translation task. The professional translator solves the problem by using the adjective “goły” (“bare”) in the phrase “goły grot” (“bare arrow tip”), which preserves the intended allusion to nudity. The translation also introduces an element of alliteration as both words begin with the same sound /g/. In contrast, NMT-based tools and ChatGPT focus on the explicit meaning and do not convey the wordplay at all. The translation proposed by Gemini introduces the noun “akt” (“nude” as well as “act”) which could provide a good solution if the character were holding an act rather than a dart. However, audiovisual translation is constrained by the visual dimension, which renders the proposed translation inadequate.

4.4. Changing of the voice quality

Five examples of humour based on changing of the voice quality have been identified in the corpus (see Table 4).

Table 4.*Examples of verbal humour based on changing of voice quality*

N	original	Google Translate	DeepL	ChatGPT 5	Gemini 2.5 Flash	professional translation
16	What be a pirate's favourite kind of sweater?	Jaki jest ulubiony rodzaj swetra pirata?	Jaki jest ulubiony rodzaj swetra piratów?	Q: Jaki sweter najbardziej lubi pirat?	A: Jaki jest ulubiony sweter pirata?	Ulubione warzywo pirata?
	–Arrr–gyle.	Arrr–gyle.	–Arrr–gyle.	A: Arrr–rykiel.	B: Arr–anowy.	– Pirat–ruszka.
17	And what be a pirate's favourite fast-food restaurant?	A jaki jest ulubiony fast-food pirata?	A jaka jest ulubiona restauracja fast food piratów?	Q: A którą sieć fast foodów uwielbia pirat?	A: A jaka jest ulubiona restauracja fast food pirata?	A ulubiony piracki samochodzik?
	– Arr...by's.	Arr...by's.	Arr...by's.	A: Arrr–by's.	B: Arr–KFC.	– Opel korsarz.
18	I'm staaaarrving.	Staaaardrrrwuj ę.	Umieram z głodu.	Jestem straaaarrdny.	A: Umierrram z głodu.	Umierrram z głodu.
19	This is gonna be a slaughter. None of these other costumes even come close to arrrrs.	To będzie masakra. Żaden z tych kostiumów nawet nie zbliża się do arrrrs.	To będzie rzeź. Żaden z tych kostiumów nawet nie zbliża się do arrrrs.	To będzie rzeź. Żadne inne kostiumy nie dorównują moim arrrom.	A: To będzie rzeź. Żaden z tych kostiumów nawet nie dorasta do arr-szych (naszych).	To będzie bomba. Żaden kostium się nie umywa do naszego.
20	–Ted, you keep going to the same bar. You're in a rut. And I am a rut buster. I'm going to bust your rut.	– Ted, ciągle chodzisz do tego samego baru. Jesteś w rutynie. A ja jestem pogromcą rutyny. Zamierzam wyrwać cię z rutyny.	– Ted, ciągle chodzisz do tego samego baru. Utknąłeś w rutynie. A ja jestem łamaczem rutyny. Złamię twoją rutynę.	A: Ted, ciągle chodzisz do tego samego baru. Jesteś w rutynie. A ja jestem pogromcą rutyn. Zaraz ci tę rutynę rozwalę.	A: Ted, ciągle chodzisz do tego samego baru. Wpadłeś w koleinę. A ja jestem pogromcą kolein. Rozwalę twoją koleinę.	–Ted, łącząc do tego samego baru popadłeś w rutynę. I wywrę ci rutynę.
	–It's not a rut, it's routine and I like it.	– To nie rutyna, to rutyna i to mi się podoba.	– To nie jest rutyna, to codzienność i lubię ją.	B: To nie rutyna, to po prostu zwyczaj i mi pasuje.	B: To nie koleina, to rutyna i ja to lubię.	–Nie musisz, lubię rutynę.
	–Ted, what's the first syllable in routine?	– Ted, jaka jest pierwsza sylaba w słowie „rutyna”?	–Ted, jaka jest pierwsza sylaba w słowie „routine”?	A: Ted, jaka jest pierwsza sylaba w „rutyna”?	A: Ted, jaka jest pierwsza sylaba w słowie rutyna?	–Ted, rutyna jest gorsza niż rycyna.

Examples 16-19 make reference to a pirate costume that the speaker is wearing. The speaker makes up riddles whose answers contain the sound /r/. The speaker pronounces the answers in the manner stereotypically associated with pirates. The translation should convey the allusion to pirates in each of the answers. The professional translation achieves this goal by modifying the riddles. What is more, the allusions to pirates are not limited to the phonetic level (as in Example 18), but are also extended to the lexical level. Instead of the original “Arrgyle”, the translation opts for a neologism “piratruszka”, based on the lexemes “pirate” (“pirate”) and “pietruszka” (“parsley”) (Example 16). Example 17 likewise modifies the riddle, instead of the

pirate's favourite restaurant, the translation asks about the pirate's favourite car. The answer to the riddle is based on near-homophony between the car name "Opel Corsa" and the noun "korsarz" ("sea rover"). Example 19 is the only one that does not convey the pirate reference.

As for AI-based translation, none of the tools successfully translates the riddles and allusions to pirates in Examples 16 and 17. The wordplay is lost in all four analysed machine translations. The reference to pirates is maintained in Example 18 in Gemini's translation; in contrast, Google Translate and ChatGPT do not seem to have recognised the meaning of the atypical original spelling and produce ungrammatical equivalents. In turn, DeepL neutralises the pirate reference in this example. It is worth mentioning that information about the context was included in the prompt. Gemini does recognise the intended meaning in Example 19, although its translation does not convey the joke and would require further correction.

In Example 20, a character is making a point by deliberately modifying the pronunciation of the word "routine" and pronouncing it as /rʌti:n/. None of the AI-based tools manages to find a solution to this translation challenge as all of them translate the fragment in which the character makes the point literally. The professional translator instead opts for a simple rhyme of two nouns, "rutyna" ("routine") and "rycyna" ("ricin"), in a slogan-like response "rutyna jest gorsza niż rycyna" ("routine is worse than ricin").

4.5. Modification of idioms and lexemes

Language users might modify the form of lexemes and idioms intentionally, as a playful, rhetoric resource (Example 21), or they might do it unintentionally, e.g., in mispronouncing or misspelling (Example 22). Examples of modification of idioms and lexemes are detailed in Table 5.

Table 5.

Examples of verbal humour based on modification of idioms and lexemes

N	original	Google Translate	DeepL	ChatGPT 5	Gemini 2.5 Flash	professional translation
21	– How fancy are we talking about here? – You'll wanna bring you're A game. (...) – Well, did I bring it... or did I bring it? I think I brought it. (...) Look who else brought it. – Oh, yeah, I thought about leaving it at home, but I figured I don't want to get there and realize I need it and have to go all the way back	– O jakiej elegancji tu mówimy? – Będziesz chciał przynieść swoją grę A. – (...) No więc, czy ja to przyniosłem... czy ja to przyniosłem? Chyba przyniosłem. (...) Zobacz, kto jeszcze to przyniósł. – Och, tak, myślałem, żeby zostawić to w domu, ale pomyślałem, że nie chcę tam dotrzeć i zdać	– O jakim poziomie fantazji tutaj mówimy? – Będziesz chciał dać z siebie wszystko. (...) No cóż, dałem z siebie wszystko... czy dałem z siebie wszystko? Myślę, że dałem z siebie wszystko. (...) Zobacz, kto jeszcze dał z siebie wszystko. – O tak, myślałem o zostawieniu tego w domu, ale	– Jak elegancko mówimy? B: Trzeba przynieść swoją najwyższą formę. (...) No dobrze, czy ją przyniosłem... czy przyniosłem? Chyba przyniosłem. (...) Spójrzcie, kto jeszcze ją przyniósł. C: Och, tak, myślałem, żeby zostawić ją w domu, ale pomyślałem, że nie chcę dotrzeć i zdać sobie	– Jak bardzo elegancko się ubieramy? B: Będziesz chciał pokazać klasę (lub przywalić). B: No i przywaliłem... czy przywaliłem? Myślę, że przywaliłem. C: Patrzcie, kto jeszcze to przyniósł. B: Och, tak, myślałem, żeby to zostawić w domu, ale stwierdziłem, że nie chcę tam być, zorientować	– Będzie bardzo A–E? – Zrób się na bóstwo. (...) – Czy mi się udało? Chyba mi się udało. (...) Ktoś się odstawił. Chciałem się odstawić do domu, ale mógłbym coś zostawić, więc wolałem się odstawić i dostawić

	to get it so, yeah, I brought it.	sobie sprawy, że tego potrzebuję i muszę po to wracać, więc tak, przyniosłem to.	pomyślałem, że nie chcę tam dotrzeć i zdać sobie sprawy, że tego potrzebuję, a potem wracać po to, więc tak, przyniosłem to.	sprawy, że jej potrzebuję i musiałbym wracać po nią, więc tak, przyniosłem ją.	się, że tego potrzebuję i wracać po to aż tu, więc tak, przyniosłem to.	
22	Lily, when dr Aurelia Birnholtz... – No, when dr Australia Birdbath– Vaseline came home from the gorillas ...	Lily, kiedy dr Aurelia Birnholtz... – Nie, kiedy dr Australia Birdbath– Vaseline wróciła do domu od goryli ...	Lily, kiedy dr Aurelia Birnholtz... – Nie, kiedy dr Australia Birdbath– Vaseline wróciła do domu z gorylami ...	Lily, kiedy dr Aurelia Birnholtz... – Nie, kiedy dr Australia Kąpiel–Ptak– Wazelina wróciła od goryli...	Lily, kiedy dr Aurelia Birnholtz...B: Nie, kiedy dr Australia Wanna–Kąpiel– w–Wazelinie wróciła od goryli ...	Lily, kiedy dr Aurelia... –Nie, kiedy doktor Australia Bucefał–Ważka wróciła do cywilizacji...

Humour in Example 21 is built on a wordplay involving the idiom “to bring sb’s A game”. The speaker uses the expression with reference to dressing up for a party and speaks about the preparations as if they were a physical object that one could actually bring. The professional translation finds a way out of the translation problem by using the verbs: “odstawić”, which has several unrelated meanings, e.g., “to dress up” and “to put back”, zostawić (“to leave”), and “dostawić” (“to move closer”). The three verbs share a common morphological root and differ in the prefixes, which enables a near-homonymy wordplay. Unlike the human translation, all four machine translation tools translate the fragment literally. DeepL and both LLM-based systems recognise the English idiom and translate using its metaphorical sense in the introductory part, whereas Google Translate uses a literal translation. However, none of them reproduces the mechanism of humour based on the modification of the idiom.

The modification in Example 22 is based on the similarity between the name of the referred person and the name of a continent (“Australia”), followed by semantically unrelated common nouns. The professional translation renders the name using common nouns in Polish that start with the same letter as the actual name of the person in order to maintain the effect of mispronunciation. The NMT tools do not recognise the wordplay and translate as if it were a genuine proper name. The LLM tools, however, do recognise it, as they use Polish common nouns. Nevertheless, the equivalents that they propose start with a different letter than the actual name of the referred person, which makes the mispronunciation effect less accurate.

4.6. Blending of contrasting elements

Table 6 lists examples of verbal humour based on blending of contrasting elements. They represent two types of such blending. The first combines linguistic forms typical of different language styles, whereas the second modifies a fixed, colloquial expression by integrating two conceptually unrelated domains: romance and vulgarity.

Table 6.*Examples of verbal humour based on blending of contrasting elements*

N	original	Google Translate	DeepL	ChatGPT 5	Gemini 2.5 Flash	professional translation
23	Dude, your narrow-minded views on professional fornicators are harshing my mellow.	Kolesiu, twoje ograniczone poglądy na zawodowych cudzołożników psują mi humor.	Stary, twoje ograniczone poglądy na temat profesjonalnych cudzołożników psują mi nastrój.	Stary, twoje ograniczone poglądy na temat zawodowych kochanków psują mi vibe.	Stary, twoje ograniczone poglądy na zawodowe uprawianie nierządu psują mi luz.	Twoje ciasne poglądy ranią mnie do żywego.
24	Kiss the crap out of that girl	Wycałuj tę dziewczynę na śmierć.	Pocałuj tę dziewczynę na śmierć.	Pocałuj tę dziewczynę na maksa.	Całuj ją, kurde, na zabój!	Wycałuj ją aż się sfajda

Example 23 mixes a slang expression “to harsh one’s mellow” with a more formal expression “narrow-minded views”, and an archaic term “fornicator”, used typically in biblical or moralistic contexts. The combination produces a humorous effect. The professional translation conveys the formal tone; however, it neutralizes the slang expression. All of the analysed AI tools convey the tone of the original and express the contrast between formality and informality.

As far as Example 24 is concerned, the professional translation uses the literal meaning of the original colloquial idiom, blending the domains of romance and excrement, which produces a humorous effect and creates an element of contrast. Both NMT translations recognise the idiom and translate the fragment using a hyperbolic expression “na śmierć” (“to death”), meaning “kiss to death”. Gemini uses the same idea. All three translations work as a humorous exaggeration in the context.

4.7. Rhyme

Three examples of humour based on absurd rhyming have been identified (see Table 7).

Table 7.*Examples of verbal humour based on rhyme*

N	original	Google Translate	DeepL	ChatGPT 5	Gemini 2.5 Flash	professional translation
25	My name is Rufus and that’s the truthus	Mam na imię Rufus i to jest prawda.	Nazywam się Rufus i taka jest prawda.	Mam na imię Rufus i mówię prawdus.	Nazywam się Kubaś i to jest Prawduś	Rufus mam na imię, jak lżę niech zginę.
26	I’m vomit free since 93. That’s funny. I’m funny.	Nie wymiotuję od 93. To zabawne. Jestem zabawny.	Od 1993 roku nie wymiotuję. To zabawne. Jestem zabawny.	Nie wymiotowałem od ’93. To zabawne. Jestem zabawny.	A: Nie rzygam od 93. To jest śmieszne. Jestem śmieszny.	Od lat tuzina nie puszczałem pingwina. Niezłe. Ale mam dowcip.
27	Hey, ain’t no thing byt a chicken wing, Mama Sita.	Hej, nie ma to jak skrzydełko kurczaka, Mama Sita.	Hej, to nic takiego, Mama Sita.	Ej, luzik, tylko skrzydełko, Mamo Sita.	Luzik–arbuzik, Siostro!	Nie ma sprawy, nie zepsułaś zabawy

The professional translation conveys the humour mechanism in all three examples, creating absurd rhymes. The NMT translations concentrate on the literal meaning and omit the original rhymes, while LLM tools convey the rhymes partially. ChatGPT uses a rhyming translation only in Example 25 and Gemini in Examples 25 and 27.

4.8. Punning acronym

Table 8 details an example of humour based on a punning acronym. The mechanism of humour in Example 28 is rooted in the contrast between a supposedly serious award that one of the characters has won and its acronym, which resembles the name of an animal (“lama”).

Table 8.
Examples of verbal humour based on a punning acronym

N	original	Google Translate	DeepL	ChatGPT 5	Gemini 2.5 Flash	professional translation
28	–Hey, something kind of cool just happened. My story on Pickles, the singing dog just got nominated for Local Area Media Award.	Hej, właśnie wydarzyło się coś fajnego. Mój artykuł o Picklesie, śpiewającym psie, został nominowany do nagrody Local Area Media Award.	– Hej, właśnie wydarzyło się coś fajnego. Moja historia o śpiewającym psie Picklesie została właśnie nominowana do nagrody Local Area Media Award.	A: Ej, coś fajnego się właśnie wydarzyło. Mój artykuł o Picklesie, śpiewającym psie, został nominowany do Nagrody Lokalnych Mediów.	A: Hej, stało się coś fajnego! Mój reportaż o Pickles, śpiewającym psie, został nominowany do Lokalnej Nagrody Mediów Artystycznych.	–Mam świetną nowinę. Mój reportaż o psie Korniszonie dostał nominację do nagrody Lokalnej Akademii Mediów Audio-wizualnych.
	– A LAMA?	LAMA?	LAMA?	B: NLM? A lama?!	L.A.M.A.?	–LAMA?

The professional translation renders the name of the award in Polish so that the initials form the animal name. NMT tools maintain the original name of the award; however, in this case the initials still form the intended pun. ChatGPT and Gemini translate the name to Polish without recognising the punning mechanism.

4.9. Portmanteau words and other neologisms

Portmanteau words and neologisms combine different concepts in one form and create an element of surprise and novelty, which produces a humorous effect. Table 9 lists examples of this mechanism.

Table 9.*Examples of verbal humour based on portmanteau words and neologisms*

N	original	google Translate	DeepL	ChatGPT 5	gemini	Professional translation
29	–Are you going to play hockey? With a basketball?	– Zamierzasz grać w hokeja? Piłką do koszykówki?	– Zamierzasz grać w hokeja? Piłką do koszykówki?	A: Zamierzasz grać w hokeja? Z piłką do koszykówki?	A: Będziesz grał w hokeja? Z piłką do kosza?	–Hokej? Piłką do kosza?
	–Well, it’s a combination on the two. We call it baskiceball.	– No cóż, to połączenie tych dwóch. Nazywamy to baskiceball.	– Cóż, to połączenie tych dwóch dyscyplin. Nazywamy to baskiceballem.	B: To połączenie obu sportów. Nazywamy to koszhokej.	B: Cóż, to połączenie tych dwóch. Nazywamy to Kosho–kej.	–To połączenie obydwu gier. Lodokoszka.
	–Baskiceball? Not Iceketball?	Baskiceball? nie Iceketball?	– Baskiceballem? A nie iceketballem?	A: Koszhokej? A nie hokeikosz?	A: Kosho–kej? A nie Hoko–sz?	–Lodokoszka? Nie lepiej lodokówka?
	–Iceketball? Just sounds weird.	– Iceketball? po prostu brzmi dziwnie.	Iceketball? Brzmi dziwnie.	B: Hokeikosz? Brzmi po prostu dziwnie.	B: Hoko–sz? To brzmi po prostu dziwacznie.	–Lodo...kówka? Jakoś nie brzmi.
30	The thanks–tini. A fun and delicious new novelty drink I invented. (...) If you wanna good holiday drink, try his Kwanza–politan.	Dzięki–tini. Fajny i pyszny nowy, nowatorski drink, który wynalazłem. (...) Jeśli chcesz dobrego świątecznego drinka, spróbuj jego Kwanza–politan.	Thanks–tini. Zabawny i pyszny nowy drink, który wymyśliłem. (...) Jeśli chcesz dobrego drinka na święta, spróbuj jego Kwanza–politan.	Thanks–tini. Świetny, zabawny i pyszny nowy drink, który wymyśliłem. (...) A jeśli chcesz świąteczny napój, spróbuj jego Kwanza–politan.	A: Andrzej–tini. Zabawny i pyszny nowy, wymyślony przeze mnie, drink z dowcipem. B: Jeśli chcesz dobrego drinka na święta, spróbuj jego Wigilio–politana.	Dziękcy–tini. Pyszny nowy drink mojego autorstwa. (...) Nie próbowałaś jego Gwiazdko–politana.

The professional translation creates analogous portmanteau words in Polish and successfully conveys the original meaning. As far as the NMT tools are concerned, in the majority of cases, the original English words have been maintained (“baskiceball”, iceketball, Kwanzapolitan”, Thankstini”). While DeepL uses Polish inflectional morphemes in the English words, Google maintains the nominative form. The word “Dziękitini” is the only case of translation of a portmanteau word into Polish in the analysed NMT translation. The LLM-based translation creates corresponding portmanteau words in Example 29. However, the spelling of the proposed neologisms is not fully adapted to the rules of the Polish language, e.g., “Koshokej” proposed by Gemini or “hokeikosz” proposed by ChatGPT. As a final remark, Gemini adapts the names in Example 30 to the Polish culture, since its translation uses equivalents of holidays rooted in the Polish tradition, instead of the original ones, while ChatGPT applies the original English lexemes.

5. Conclusions and discussion

The analysis has demonstrated that LLM-based tools (ChatGPT and Gemini) are able to recognise verbal humour mechanisms based on lexical ambiguity, such as homonymy, polysemy, and homophony. Both tools analyse the provided fragments with precision and propose various versions of explanatory translations. However, when prompted to choose one version, they are unable to provide translations that employ verbal humour mechanisms and achieve an analogous humorous effect based on lexical ambiguity in Polish.

The professional translator achieves the desired humorous effect, resorting to various verbal humour mechanisms, not necessarily identical to those used in the source text. Rather than applying the most obvious, literal equivalents of the original lexical items, the professional translation prioritises the humorous effect. Translations provided by AI-driven tools, on the other hand, tend to focus on the explicit meaning of the original fragments. Specifically, the two NMT-based tools (Google Translate and DeepL) and ChatGPT do not convey the double-meaning effect in any of the translations provided. Gemini's translation demonstrates an effort to capture the ambiguity in some cases; however, its translation tends to be flawed by calques from English, errors, or solutions that do not fit the context, which affects the communicative effect. The system does not seem to be able to deal with the complexity of the task of humour rendering, e.g., when additional constraints imposed by the visual dimension of the source text should be included in the translation.

All four tools recognise idioms and apply their Polish functional equivalents; however, they do not succeed in recreating lexical ambiguity through the modification of fixed phrases in order to achieve a comparable humorous effect. Moreover, the analysed NMT tools tend to keep names and less typical linguistic elements (such as neologisms and portmanteau words or childlike expressions, such as “doo-doo”) in English, which affects the communicative effect. LLMs more frequently attempt to create analogous portmanteau words in Polish and translate the atypical names, in order to convey the humorous effect; however, at times, they also employ original words (e.g., “Kwanzapolitan”, “Thankstini”, and “dudu”). What is more, the spelling of the proposed neologisms is not always adapted to the rules of the Polish language (e.g., “Koshokej” proposed by Gemini or “hokeikosz” proposed by ChatGPT). While NMT tools do not recreate rhymes, LLM tools reproduce them partially (ChatGPT creates a rhyme in one out of the three analysed examples, while Gemini recreates them in two examples). On the other hand, all of the analysed AI translation tools capture the style of the original and convey the formal and colloquial tone, which is why they seem to be able to convey humour based on blending of contrastive elements, although both LLM tools use atypical forms in Polish at times. Furthermore, they convey humour based on exaggeration. The hypothesis that models based on LLMs would produce more accurate translation in comparison with the tools based solely on NMT has not been confirmed.

All things considered, AI translation tools are currently incapable of translating verbal humour successfully without human intervention. While tools such as those based on LLMs might provide support to professional translators in analysing the source text, recognising cultural references, and identifying humour mechanisms, they cannot currently replace human professional translators as far as the task of effective humour translation is concerned. These findings are consistent with studies pointing to hybrid techniques, which combine human expertise with AI support, as the likely prevailing model in the future (e.g., Amini et al., 2014), rather than suggesting that translation will become an obsolete profession. The findings respond to the growing concern regarding the future of translation, described in Schilling (2018) Łukasik (2024), or Gutiérrez Rubio (2024).

The knowledge of new technologies in translation is essential for professional translators' career success. It might enhance their productivity and make their services more competitive, and crucially, it allows them to demonstrate their professional value by knowing where MT falls short. The analysis presented in the paper indicates that, at present, a successful translation of verbal humour remains a limitation for MT. These results are in line with the view of some scholars (e.g., Kirov, Malamin, 2022; Tavares et al., 2023) that creative texts are the least likely to be translated successfully by AI-powered tools. The conclusion is limited to English–Polish translation and further studies in different language pairs are encouraged.

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COMMITMENT AS ONE OF THE ELEMENTS OF THE QUALITY OF THE ORGANIZATION'S HUMAN CAPITAL IN THE AREA OF COMPETENCES

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Purpose: The purpose of the study arose from a research gap. The aim of the research undertaken in this article was to understand the conditions and dynamics of shaping engagement in the area of competencies as one of the dimensions of the quality of human capital in an organization.

Design/methodology/approach: An indirect survey method was used to collect data. Questions and answers were submitted in written form, without direct contact between the participant and the researcher. The research was conducted using a translational method; the classic questionnaire technique was digitized and transferred online. Data was collected via email survey. Empirical data was collected by a research services company between July and August 2022. The research was voluntary and anonymous. Completing the survey took 20-25 minutes. Data collection via a survey questionnaire via an application on the Ariadna Research Panel website complied with GDPR requirements. Participants responded sequentially, meaning they could move on to subsequent questions after answering previous ones. They were not able to review questions without answering them. The system only saved fully completed questionnaires. If participants opted out of further participation at any stage, their questionnaires were not saved. The aim of the study conducted on a group of 610 employees of Polish enterprises was to learn about the links between work commitment and the quality of human capital. Six cases were excluded from the analysis, as they had zero variance across all 60 Likert-scale survey questions. This meant that the individuals provided exactly the same answer to all questions. Therefore, the responses of 604 respondents were accepted for further analysis. The sampling was non-random, purposive, and non-random. Due to psychodemographic variables, the study group was structured as follows: 353 (58%) women, 250 (41%) men, and one person identified their gender as non-standard (0%). The factor connecting human capital with the process of organizational change is organizational commitment. It will decide what capital a changing organization will need and how it will change it. The research was conducted using the translational method, the classic survey technique was digitalized and transferred to the network. Data was collected using an e-mail survey technique. The surveyed employees of Polish enterprises update their competency resources at work with an average level of commitment.

Findings: The results obtained indicate that work commitment is one of the elements shaping the quality of the organization's human capital. The author also notes that in the future, the research should be expanded to include additional areas.

Research limitations/implications: Difficult access to relevant data.

Practical implications: The obtained results constitute a significant contribution to the approach to a different perspective on defining human capital and applying their solutions to management practice.

Originality/value: The obtained results constitute a significant contribution to the approach to a different perspective on defining human capital from the perspective of selecting appropriate research methods.

Keywords: commitment, human capital, competences.

Category of the paper: research paper.

1. Introduction

The factor that connects human capital with the process of organizational change is organizational commitment, which plays a key role in shaping the direction and dynamics of these changes (Meyer, Allen, 1997; Saks, 2006). It is the level and quality of employee commitment that will determine what kind of competencies and human resources will be necessary in the transformation process and how these resources will be used and developed (Becker, Huselid, Ulrich, 2001; Armstrong, 2012). People are one of the most valuable assets of every organization, and their knowledge, skills, abilities, and experience create human capital, which is of strategic importance for the functioning of the enterprise (Becker, 1993; Juchnowicz, Mazurek-Kucharska, Turek, 2013). In the era of growing competition and constant market changes, it is the ability to effectively manage this capital that allows organizations to gain a lasting competitive advantage and generate added value (Boxall, Purcell, 2011; Kotter, 1996). Therefore, understanding the mutual relationships between organizational commitment and human capital becomes the foundation for effective implementation of innovations and adaptation to the changing business environment (Ulrich et al., 2008; Saks, 2006).

2. Employee commitment

Employee commitment is a complex phenomenon that can be divided into two main streams: work commitment (e.g. commitment to a profession, position, career) and organizational commitment, i.e. the employee's relationship with the organization (Meyer, Allen, 1991). Research indicates that organizational commitment has a key impact on company results – it promotes efficiency, innovation, acceptance of change and learning. It increases satisfaction, loyalty, retention and reduces absenteeism. Organizational commitment: promotes achieving high quality and effectiveness of actions (Tolentino, 2013; Rafiei, Amini, Foroozandeh, 2014; Ogala, 2020; Armstrong, 2009), affects the increase in productivity and

work results (Wołowska, 2013; Ogala, 2020; Shaima, 2023; Oyeniya, Adeyemi, 2017; Abdelmoula, Boudabbous, 2021), on acceptance of changes (Yousef, 2017; Vveinhardt, Sedziuviene, 2022), on innovation, creativity and affects the learning process (Xanthopoulou, Bakker, Demerouti, Schaufeli, 2009; Serna, Martínez, Eternod, 2018; Hou, Gao, Li, Yu, 2011; Molino, Cortese, Ghislieri, 2020; Yang, 2024). In crises, engaged employees support the organization (Saks, 2006; Bakker, Demerouti, 2008). Commitment depends on both employee characteristics and organizational factors such as culture, management style, fair treatment, development opportunities, communication, relationships, sense of security, recognition, and pay conditions (Kahn, 1990; Robinson, Perryman, Hayday, 2004). Therefore, organizational commitment is a key element of an organization's human capital (HCC), influencing its functioning and success (Becker, Huselid, Ulrich, 2001).

3. Quality of human capital

Quality of human capital There is no clear definition of the quality of human capital in the literature. One of the models describing this aspect is the "4K" model by M. Juchnowicz, B. Mazurek-Kucharska and D. Turek (Juchnowicz, 2014), which includes: Competencies - knowledge, skills, personal characteristics and the employee's style of action, Organizational culture - informal patterns of thinking and action, Interpersonal contacts - relations and the communication system in the organization, Organizational climate - subjectively felt work atmosphere. Another approach is the KSA (Knowledge, Skills, Attitudes) model, which emphasizes the importance of attitudes (e.g. commitment) in the use of professional knowledge and skills (Juchnowicz, Mazurek-Kucharska, Turek, 2015). RA Daulay and DA Restu indicate key indicators of the quality of human capital, including: competences, experience, commitment, teamwork, creativity, professional knowledge and level of education (Daulay, Restu, 2023). The literature also emphasizes the complementarity of human capital with intangible capital, such as organizational and knowledge capital. Other researchers have indicated the measurement of the quality of human capital when constructing an indicator that is based on the complementarity of work skills and technology (Doms et al., 1997; Goldin, Katz, 1998; Krusell et al., 2000; Bresnahan et al., 2002). Work quality reflects the level of human capital, which should be adapted to investments in these areas (Peters, Taylor, 2017; Bae, Kang, 2023). To sum up, the quality of human capital is mainly based on the commitment, knowledge, experience, and competencies of employees.

4. Employee competencies

There is no single, universally accepted definition of competence in the literature. However, it is commonly accepted that competence is a set of knowledge, skills, attitudes, personality traits and experiences that enable effective performance of professional tasks. Their development is a continuous process. D. McClelland points to the connections between competence and knowledge, skills and personal traits. R. Boyatzis sees them as the potential leading to effective action in a specific work environment. S. Whiddett and S. Hollyforde emphasize the importance of an integrated set of knowledge, skills and attitudes (Whiddett, Hollyforde, 2003). According to M. Armstrong, competence is the ability to apply knowledge in professional practice (Armstrong, 2005). GO Klemp, D. Parkes and other researchers add that competence also includes independence of action, the ability to plan and monitor work effects (Parkes, 1993; Ljungquist, 2007; Parry, 2005; Armstrong, 2002; Dessler, 2009). In Polish literature, J. Skrzypczak associates competences with the ability to apply knowledge in practice, and H. Król and G. Filipowicz define them as predispositions that allow to perform tasks in accordance with the requirements of the organization (Skrzypczak, 1998; Nogalski, Śniadecki, 1998; Król, Ludwiczynski, 2007; Filipowicz, 2004; Walkowiak, 2004). A. Sajkiewicz extends the concept to include style of action, personality and principles that influence the achieved results (Sajkiewicz, 2002). Competencies are treated as a key element of human capital, influencing the quality of work and organizational effectiveness (Chłoń-Domińczak, Kamieniecka, Trawińska-Konador, Pawłowski, Rynko, 2015; Włodarkiewicz-Klimek, 2018). The literature review indicates that this concept consists of, among others, practical skills, attitudes, experience, values and personality traits. Their importance is confirmed by the fact that employers in Poland consider them to be one of the most important elements of employee resources.

5. Methodology

The research was conducted using the translation method, the classic survey technique was digitalized and transferred to the network. Data was collected using an e-mail survey technique. The surveyed employees of Polish enterprises update their competency resources at work with an average level of engagement. Two elements of work commitment were distinguished: work commitment and a sense of responsibility for work. The obtained results indicate that work commitment is one of the elements shaping the quality of the organization's human capital. The author also notes that in the future, research should be expanded to include additional areas.

6. Results

Individual statements regarding work commitment in the area of employee competencies were assessed by the respondents using a seven-point Likert scale. Before starting the analysis, the variables were ranked, where 1 meant "almost never", 7 - "almost always". The table below presents the statements to which the respondents responded.

Table 1.
Statements of the work commitment scale

Code	Content of the statement
PZ-1	Work evokes strong positive emotions in me.
PZ-2	Work evokes strong negative emotions in me.
PZ-3	I am fully committed to my work.
PZ-4	I am absorbed in my work.
PZ-5	Being involved in my work makes me discover more fully who I am.
PZ-6	I am committed to doing a good job every day for the benefit of my company.
PZ-7	I am committed to improving work methods.
PZ-8	I am committed to improving the results of my work.
PZ-9	I am fully committed to achieving the company's goals.
PZ-10	I am committed to maintaining or improving working conditions.
PZ-11	I try to obtain feedback on the results of my work.
PZ-12	I take full advantage of all opportunities for consulting in my professional work.
PZ-13	I am involved in obtaining current information about the work and the company in order to perform the assigned tasks as best as possible - I participate in meetings, browse intranet and internet resources
PZ-14	I willingly and frequently use the company's technical and organizational support (IT technologies, work cards, instructions, mini libraries, manuals, etc.)
PZ-15	I carry out professional tasks using my authority and taking responsibility for the manner in which they are performed.
PZ-16	Thanks to the autonomy in carrying out tasks and responsibilities, I can be more involved in achieving the company's goals.
PZ-17	I feel fully responsible for the results of my work.
PZ-18	I feel fully responsible for maintaining order in my workstation.
PZ-19	I feel responsible for maintaining good social relations in my work environment.

Source: own study based on empirical research.

Table 2 presents the basic results of descriptive statistics for the group of statements regarding involvement.

The correlation matrix for PZ statements is presented in Table 2.

Table 2.*Work commitment - correlation matrix for individual statements*

Theorem Code	PZ-1	PZ-2	PZ-3	PZ-4	PZ-5	PZ-6	PZ-7	PZ-8	PZ-9	PZ-10	PZ-11	PZ-12	PZ-13	PZ-14	PZ-15	PZ-16	PZ-17	PZ-18	PZ-19
PZ-1	1.0	-0.3	0.6	0.6	0.6	0.5	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.4	0.2	0.3
PZ-2	-0.3	1.0	-0.3	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.1	-0.2	-0.1	-0.2	-0.3	-0.3	-0.2	-0.2
PZ-3	0.6	-0.3	1.0	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.5	0.4	0.6	0.6	0.5	0.4	0.4
PZ-4	0.6	-0.2	0.8	1.0	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.5	0.6	0.4	0.6	0.6	0.5	0.4	0.4
PZ-5	0.6	-0.2	0.7	0.7	1.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.6	0.4	0.3	0.4
PZ-6	0.5	-0.3	0.7	0.7	0.6	1.0	0.8	0.7	0.7	0.7	0.6	0.5	0.5	0.4	0.6	0.6	0.7	0.6	0.5
PZ-7	0.5	-0.3	0.7	0.7	0.6	0.8	1.0	0.8	0.8	0.8	0.6	0.5	0.6	0.5	0.6	0.7	0.6	0.5	0.5
PZ-8	0.5	-0.3	0.7	0.7	0.6	0.7	0.8	1.0	0.8	0.8	0.6	0.6	0.6	0.5	0.6	0.7	0.6	0.5	0.5
PZ-9	0.6	-0.3	0.7	0.7	0.6	0.7	0.8	0.8	1.0	0.8	0.7	0.6	0.6	0.5	0.6	0.7	0.6	0.5	0.5
PZ-10	0.5	-0.3	0.7	0.7	0.6	0.7	0.8	0.8	0.8	1.0	0.7	0.6	0.6	0.5	0.6	0.7	0.6	0.5	0.5
PZ-11	0.5	-0.2	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	1.0	0.6	0.6	0.6	0.6	0.6	0.5	0.4	0.5
PZ-12	0.5	-0.1	0.6	0.5	0.6	0.5	0.5	0.6	0.6	0.6	0.6	1.0	0.7	0.6	0.5	0.5	0.3	0.3	0.3
PZ-13	0.5	-0.2	0.5	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.6	0.7	1.0	0.7	0.6	0.6	0.4	0.3	0.4
PZ-14	0.4	-0.1	0.4	0.4	0.5	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.7	1.0	0.6	0.5	0.4	0.3	0.3
PZ-15	0.5	-0.2	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.6	1.0	0.7	0.6	0.5	0.6
PZ-16	0.5	-0.3	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.6	0.5	0.6	0.5	0.7	1.0	0.6	0.5	0.5
PZ-17	0.4	-0.3	0.5	0.5	0.4	0.7	0.6	0.6	0.6	0.6	0.5	0.3	0.4	0.4	0.6	0.6	1.0	0.7	0.6
PZ-18	0.2	-0.2	0.4	0.4	0.3	0.6	0.5	0.5	0.5	0.5	0.4	0.3	0.3	0.3	0.5	0.5	0.7	1.0	0.7
PZ-19	0.3	-0.2	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.3	0.4	0.3	0.6	0.5	0.6	0.7	1.0

Source: own study based on empirical research.

Analyzing the correlation matrix for statements PZ-1 to PZ-19, it can be seen that the vast majority of statements are related to each other by correlations of at least 0.5. Statement PZ-2 stands out clearly, being weakly related to all the others. Statement PZ-18 has a slightly greater, but still weak, relationship with the others.

It can therefore be assumed that a deeper analysis will allow for the extraction of the components of the work commitment factor. Due to the fact that the PZ-2 statement is negatively correlated with all the others, it was reversed in order to calculate the reliability coefficient. The Cronbach's alpha coefficient value is 0.95, which indicates high reliability of the PZ statement block, and therefore their coherence, which allowed for their aggregation for PCA analysis. However, on the basis of factor analysis, two factors were extracted in the structure of work commitment.

Table 3.*Suggested division of PZ statements into two factors with proposed names*

Factor 1: Work Commitment		Factor 2: Sense of responsibility for work	
CONTENT OF THE STATEMENTS	CODE	CONTENT OF THE STATEMENTS	CODE
Work evokes strong positive emotions in me.	PZ-1	I feel fully responsible for the results of my work.	PZ-17
Work evokes strong negative emotions in me.	PZ-2	I feel fully responsible for maintaining order in my workstation.	PZ-18
I am fully committed to my work.	PZ-3	I feel responsible for maintaining good social relations in my work environment.	PZ-19
I am absorbed in my work.	PZ-4		
Being involved in my work makes me discover more fully who I am.	PZ-5		
I am committed to doing a good job every day for the benefit of my company.	PZ-6		
I am committed to improving work methods.	PZ-7		
I am committed to improving the results of my work.	PZ-8		

I am fully committed to achieving the company's goals.	PZ-9		
I am committed to maintaining or improving working conditions.	PZ-10		
I try to obtain feedback on the results of my work.	PZ-11		
I take full advantage of all opportunities for consulting in my professional work.	PZ-12		
I am involved in obtaining current information about the work and the company in order to perform the assigned tasks as best as possible - I participate in meetings, browse intranet resources and the Internet	PZ-13		
I willingly and frequently use the company's technical and organizational support (IT technologies, work cards, instructions, mini libraries, manuals, etc.)	PZ-14		
I carry out professional tasks using my authority and taking responsibility for the manner in which they are performed.	PZ-15		
Thanks to the autonomy in carrying out tasks and responsibilities, I can be more involved in achieving the company's goals.	PZ-16		

Source: own study based on empirical research.

The internal consistency of the factor: work commitment (Cronbach's alpha = 0.93) indicates high reliability of the conducted research. Tables 4 and 5 present the basic results of descriptive statistics for the factor: work commitment and for the individual statements included in it.

Table 4.

Descriptive statistics for work commitment as a KL content factor in the area of knowledge and competences (extracted after PCA analysis)

KL quality factor	N	Mean	SD	Min.	Max.	Skewness	Standard skewness error	Kurtosis	Standard error kurtosis	KS d
PZ _{PZ}	604	77.06	15.37	22	112	-0.58	0.10	1.42	0.20	0.4 for p<0.2

PZ_{PZ} – work engagement factor extracted after PCA analysis from work commitment as an element of the KL quality model.

Source: own study based on empirical research.

Based on the descriptive statistics of the PZ_{PZ} factor presented in Table 4, it can be seen that the work commitment variable has a normal distribution – the significance level for the Kolmogorov-Smirnov test is greater than 0.05. The distribution of this variable is left-skewed, therefore the Median value is higher than the mean; which means that for most respondents “sometimes” or “often” the competencies used in the implementation of tasks are related to the process of work commitment. In turn, the kurtosis value indicates a large differentiation of the respondents’ perceptions regarding the connection between the use of competencies at work and commitment.

Table 5.*Descriptive statistics for statements regarding work commitment PZ_{PZ}*

Theorem Code	N	Mean	Median	Fashion	Fashion N	Min	Max	SD
PZ-1	604	4.63	5	4	182	1	7	1,300
PZ-2	604	3.93	4	4	175	1	7	1,539
PZ-3	604	4.93	5	5	206	1	7	1,283
PZ-4	604	4.79	5	5	197	1	7	1,328
PZ-5	604	4.52	5	5	162	1	7	1,415
PZ-6	604	5.11	5	5	211	1	7	1,187
PZ-7	604	5.01	5	5	203	1	7	1,242
PZ-8	604	5.07	5	5	205	1	7	1,227
PZ-9	604	5.04	5	5	195	1	7	1,227
PZ-10	604	5.03	5	5	200	1	7	1,212
PZ-11	604	4.92	5	5	191	1	7	1,270
PZ-12	604	4.61	5	5	171	1	7	1,485
PZ-13	604	4.81	5	5	182	1	7	1,374
PZ-14	604	4.70	5	5	174	1	7	1,436
PZ-15	604	5.11	5	5	191	1	7	1,231
PZ-16	604	4.96	5	5	204	1	7	1,313

PZ_{PZ} – work commitment statement code.

SD – standard deviation.

Source: own study based on empirical research.

The obtained results indicate that the respondents often declared that the activation of their knowledge and competences in the implementation of professional tasks is closely related to their involvement in work (with the modal value for almost all statements making up the professional and organizational experience factor being 5.0 and the distribution skewness being -0.58; Table No. 4). Only experiencing strong emotions related to work sometimes happens (Fashion = 4).

The content analysis of the statements to which the respondents assigned the highest scale ratings indicates that using knowledge and competences at work is often associated with work commitment. (PZ-6: "I am committed to doing my daily work for my company well" – average 5.11; PZ-15: "I carry out professional tasks using my rights and taking responsibility for the way they are performed" – average 5.11; PZ-8: "I am committed to improving the results of my work" – 5.07).

7. Conclusions/Discussion of Results

It can be concluded that the block of statements regarding work commitment, due to the Cronbach's alpha value of 0.95, is characterized by high internal consistency and high reliability. However, based on factor analysis, two factors were distinguished in the structure of work commitment (according to the factor loadings of the analysis for two factors). Hence, the following division of statements was proposed.

Table 6.*Suggested division of PZ statements into two factors with proposed names*

Factor 1: Work Commitment		Factor 2: Sense of responsibility for work	
CONTENT OF THE STATEMENTS	CODE	CONTENT OF THE STATEMENTS	CODE
Work evokes strong positive emotions in me.	PZ-1	I feel fully responsible for the results of my work.	PZ-17
Work evokes strong negative emotions in me.	PZ-2	I feel fully responsible for maintaining order in my workstation.	PZ-18
I am fully committed to my work.	PZ-3	I feel responsible for maintaining good social relations in my work environment.	PZ-19
I am absorbed in my work.	PZ-4		
Being involved in my work makes me discover more fully who I am.	PZ-5		
I am committed to doing a good job every day for the benefit of my company.	PZ-6		
I am committed to improving work methods.	PZ-7		
I am committed to improving the results of my work.	PZ-8		
I am fully committed to achieving the company's goals.	PZ-9		
I am committed to maintaining or improving working conditions.	PZ-10		
I try to obtain feedback on the results of my work.	PZ-11		
I take full advantage of all opportunities for consulting in my professional work.	PZ-12		
I am involved in obtaining current information about the work and the company in order to perform the assigned tasks as best as possible - I participate in meetings, browse intranet resources and the Internet.	PZ-13		
I willingly and often use the technical and organizational support of the company's work (IT technologies, work cards, instructions, mini libraries, manuals, etc.)	PZ-14		
I carry out professional tasks using my authority and taking responsibility for the manner in which they are performed.	PZ-15		
Thanks to the autonomy in carrying out tasks and responsibilities, I can be more involved in achieving the company's goals.	PZ-16		

Source: own study based on empirical research.

8. Summary

The obtained results indicate that the level of involvement of employees of Polish enterprises in the use of professional competences is moderate, which is confirmed by the average sten score of 5.53. This indicates that employees are involved in the process of updating and using their competence resources to an average degree.

Analysis of the mean responses for selected items suggests that both positive and negative emotions play a role in shaping professional commitment. However, positive experiences (mean 4.63) seem to have a stronger impact compared to negative emotions (mean 3.93).

Relatively high mean values for statements related to self-discovery through work (mean 4.52) and the use of career counseling (mean 4.61) indicate the significant importance of developmental factors in building professional commitment. This may indicate that work is perceived not only as an obligation, but also as a space for personal development and reflection on one's professional identity.

The collected empirical data justify the need to continue research on the relationships between the level of work commitment and the use of competencies. Further analyses may contribute to deepening knowledge on the mechanisms supporting the development of human capital in Polish organizations.

The work engagement factor encompasses: dedication to work to perform assigned tasks to the best of one's ability, the emotional and personal aspects of work expressed through absorption and independent initiation of professional tasks. The sense of responsibility for work, in turn, encompasses responsibility for work results, maintaining order in the workplace, and good social relations with co-workers. The work engagement factor determines the level of activation of possessed knowledge and competencies in the implementation of professional tasks (the level of its "capitalization"), thus indicating the actual value of the KL quality indicator.

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TOWARDS A WORKFORCE WITH AI SKILLS? RESPONSES IN EDUCATION IN POLAND

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Purpose: The paper aims to review understanding of the terms “AI skills” and “AI literacy” in EU documents and educational frameworks, and the current state of these skills in the European workforce. To assess the present state of preparation in Poland, educational policies on and projects involving AI are analyzed.

Design/methodology/approach: Review of EU legislation, policy, and data from official sources on AI skills and AI literacy. Content analysis of educational policy documents, drafts and proposals. For Poland: diachronic content analysis of legislation on AI, changes in educational policy, responses in 2025 in education and projects. Summary and critical analysis of findings. Recommendations.

Findings: AI literacy is a complex conglomerate of skills. Education for AI literacy needs to combine knowledge, skills-getting and practical application in context. Educators need additional pedagogical skills to support this process. Poland is developing innovative localized responses to implement EU legislation which have potential for wider application.

Research limitations/implications: Framework documents related to both primary and secondary education, which may lead to lack of clear focus. Separate reviews of each educational level would be advised as more policy and framework documents become available. Tertiary level is omitted, although by implication many of the school-level suggestions could be adapted and applied.

Practical implications: Schools (and universities) are advised to establish clear policies on ethical AI use, curricula and materials for digital and AI skills training. Interdisciplinary discussion and cooperation are needed to determine responsibilities for conduct of training.

Social implications: Preparing young people for ethical use of AI is a requisite to maintain the analytic and critical thinking skills needed to identify bias, inaccuracy, false information and manipulation. Without such skills the pillars of democracy are endangered. Skills for working with AI are a necessity for employment.

Originality/value: Offers a concise, critical interdisciplinary review of AI literacy, and the training needs of young people in this area, from European and Polish perspectives, for policy makers and educators. The contents could also inform those in tertiary education responsible for liaising with businesses and industry, or researchers seeking clarification on AI literacy and training.

Keywords: AI literacy, AI skills training, European policy on AI, AI in Polish education.

Category of the paper: general review.

1. Introduction

According to the AI Continent Action Plan (European Commission, 2025a), the European Union (EU) aims to “become a global leader in Artificial Intelligence (AI), a leading AI continent” (p. 1). Drawing on its single market with an AI regulation policy (European Union, 2024) in place, a well-developed research context, with developing technologies and a buoyant number of AI startups, the continent offers strong potential. AI is understood here as “software developed with [machine learning, logic and knowledge based, or statistical approaches which] can for a given set of human-defined objectives, generate outputs such as content, predications, recommendations or decisions influencing the environment it interacts with” (European Commission, 2022, p. 10).

The Action Plan outlines five priority areas needed to ensure its successful implementation: an AI computing infrastructure; a source of quality data for innovation; strategic development of AI applications for use in the public sector, private enterprise and industry; monitoring to ensure ethical adherence to AI regulations and to build public confidence in AI safety; and strong, equitable human resources with the appropriate skills to support and promote these developments. To create this workforce ready to work with AI the EU aims to offer initial education and training, development and extension of skills of existing workers and also for the general populace. There is a clear need. A 2024 survey of working adults in the EU (Cedefop, 2025) showed 40-60% had low understanding of the functioning of AI, or of its possible impact.

The plans for development of AI specific skills should, however, be viewed in the context of the overall state of skills among the adult population of Europe. The latest State of the Digital Decade Report (European Commission, 2025b) reveals that 55.6% of adults have basic digital skills, considered to include daily use of online services, for example, to access public institutions, healthcare and shopping. Use of such skills is uneven across sections of societies, with lower uptake among older adults, and those who are out of work, leaving them vulnerable to exclusion. The level of skills falls well below the target of 80% by 2030.

Development will take the form of “upskilling and reskilling” (European Commission, 2025c, p. 9) with goals to encourage more adults to participate in further training. The target is that by 2030 this will encompass 60% of the adult population, while the current level (2024) stands at 39.5%. The aim is not only to build skills, but also to raise awareness, ensure AI literacy and understanding of the role of AI in society through interactive communication. Human capital is viewed as the strength of the EU and so education and training for a future workforce ready to work with AI is a priority.

2. Understanding the concepts of AI skills and AI literacy

Legally, AI skills are defined as “the skills, knowledge and understanding that allows providers, deployers and affected persons...to make informed deployment of AI systems, as well as gain awareness about the opportunities and risks of AI and possible harm it can cause” (EU, 2024, AI Act, Article 3(56)). The AI Act defines an AI system as “a machine-based system that is designed to operate with varying levels of autonomy and that may exhibit adaptiveness after deployment, and that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environment” (Article 3(1)). It is, however, difficult to regard AI skills in isolation, firstly, as they cannot be implemented without fluency in more general foundational skills, such as literacy, numeracy and problem-solving (OECD, 2025), where literacy refers to the ability to read and write with understanding, communicate proficiently and engage actively in society. Numeracy is viewed as having basic arithmetic skills, and problem-solving as being able to meet everyday challenges with adaptability and flexibility. Secondly, as declared during the 3rd Working Conference on Artificial Intelligence and Education (Council of Europe, 10 October, 2025), AI literacy leads on from existing work on digital, and media literacies. Indeed, the European Digital Competence Framework, DigComp 3.0 (Cosgrove, Caccia, 2025), the first version of which was published in 2013, has been expanded to include AI competence. Aimed at a range of users in work and educational contexts, it complies with policy documents such as the Digital Decade Policy Programme 2030 (European Union, 2022), the Union of Skills (European Commission, 2025c), and the AI Continent Action Plan (European Commission, 2025a).

2.1. Building on foundational skills

Traditional concepts of reading and writing are often associated with print and paper resources. However, digital media differ due to the more dynamic nature of the form. While a printed page may offer information in frames and illustrations to accompany the main text, these are static, and it is the reader who must adjust to view them, by moving closer, or turning the page to the light. By contrast, digital forms are more flexible and can be adjusted by the viewer to meet their needs. Yet making such adjustments requires knowledge, and learning how to do so requires skills, especially as different electronic devices operate in various ways. Thus, as shown in this simple example, digital literacy adds additional layers of knowledge and skills to basic literacy. Digital media, above all, increasingly adds voice and film elements as integral, or optional parts of a text. Accessible digital formats offer the individual reader/viewer the freedom to choose accommodations to meet specific learning needs, suit the context in which the text is being accessed, or simply match the recipient’s momentary desire.

In terms of support for understanding, while printed texts may offer glossaries or other explanatory notes, the target and content of these are determined by the creator or editor of the text. In contrast, digital texts, with associated computer and internet support, allow the reader agentically to select any word or fragment of text they choose, highlight it, copy and find relevant explanation instantaneously. With appropriate settings, this support may also be voice-operated. In the digital context, therefore, the reader needs to learn how to interact with a text, just as in the past the reader might have reached for a dictionary, thesaurus or encyclopedia for help, if they had been shown how these could augment their understanding. The DigComp 3.0 framework therefore addresses three aspects of digital competence: knowledge, skills and attitudes. Learning how to interact with digital media requires positive attitudes, such as having the will to do so, the curiosity to find answers to what is not clear, and perseverance to experiment and try different approaches until a solution is found. Each of these entails knowledge of what to look for, where, and the skills of how to search, select and evaluate the appropriateness of the possible outcomes. Digital literacy is consequently a conglomeration of competencies, enacted through different digital practices. Most often these are socially situated, as the individual reader chooses information with intent to meet a particular purpose (Darvin & Hefner, 2022).

2.2. Building on digital skills

The DigComp 3.0 framework (Cosgrove & Caccia, 2025) is divided into five themes with a total of 21 competencies, described at four levels of proficiency. The aim is to build digital competence, defined as “...the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society. It includes information and data literacy, communication and collaboration, media literacy, digital content creation (including programming), safety (including digital well-being and competences related to cybersecurity), intellectual property related questions, problem solving and critical thinking.” (European Commission, 2019, p.10). It is important to note that the framework assumes the learner already possesses the foundational skills needed to process written, audio and visual information, and in addition has access to digital devices, the internet and necessary applications and software. Thus, the digital competences build on general literacy. The five thematic areas covered in DigComp 3.0 are:

1. Information search, evaluation, management
2. Communication and collaboration
3. Content creation
4. Safety, well-being and responsible use
5. Problem identification and solving

(Cosgrove & Caccia, 2025, p.17)

The aim here is not to give a comprehensive introduction to DigComp 3.0, but to offer an insight into how AI competencies have been incorporated within the expanded framework. Care

has been taken to place AI literacy in a wider social context than the educational institution, given that AI is already infused in daily life and will become increasingly more present. Effective participation in society and economic activity depend on competent use of AI technologies (Holmes, 2025).

Within the DigComp 3.0 framework, the range of contexts of AI application is nuanced between competences that are AI explicit, e.g. “Competence 1.1 Browsing, searching and filtering information”) 1.1.02: Identify the main features of commonly-used AI-driven and traditional search tools.” (Cosgrove & Caccia, 2025, p. 29), (all of the examples given here and below are from the Basic level, lowest of four levels), or those that implicitly include AI. These AI-implicit competencies are subdivided into four types:

1. Where the user has to decide whether to use an AI system as opposed to another digital option (e.g. CS1.1.04: “Use digital search tools to implement, refine or update basic information searches” (Cosgrove & Caccia, 2025, p. 29).

2. Where the user makes a choice whether or not to make use of an AI function offered within a digital technology (e.g. Competence 2.4 Collaborating through digital technologies. CS2.4.01 “Participate in collaborative groups via digital collaboration tools, recognizing their benefits and limitations” (Cosgrove & Caccia, 2025, p.35) (e.g. When online conferencing the participant can elect to use an AI assistant to summarize the proceedings).

3. Entail insight into the functioning of an AI system (e.g. CS1.1.03: “Recognise that digital search results or outputs can contain information that may not be relevant, and that they depend on the digital search tool used and the way that an individual specifies the search” (Cosgrove & Caccia, 2025, p. 29).

4. Entail understanding of the possible impact of a given AI system on people, and the environment (e.g. Competence 1.2 Evaluating information. CS1. 2.06. “Make a basic assessment of the reliability and credibility of digital information sources and content” (Cosgrove & Caccia, 2025, p. 30).

It could also be argued that AI literacy competencies could be differently grouped, for example, as pertaining to technological aspects of the systems and tools, practical aspects of effective use, and human aspects, relating to the impact of AI on humanity and the functioning of democratic societies (Holmes, 2025). In short, it can be implied from DigComp 3.0 that AI competencies are complex and being able to make informed decisions about their use involves knowledge and other skills. This points to the need for documents dedicated exclusively to AI competencies with information about what they entail.

2.3. Frameworks for AI competencies

Recognizing the need for specific definition of AI competencies, guidance in their teaching, and insight into skills required by teachers, UNESCO published two separate AI competency frameworks for educators (2024a) and for students (2024b). For reasons of space, only the student framework will be analysed here. AI literacy is viewed as “the set of foundational

values, ethical principles, knowledge and understanding that can ensure the proper and effective use of AI by students” (UNESCO, 2024b, p. 4). Student here is understood as being of school age, from kindergarten to grade 12.

2.3.1. UNESCO AI Competency Framework for Students

The AI competency framework for students (UNESCO, 2024b) arranges competencies in four foundational areas: “Human-centred mindset, Ethics of AI, AI techniques and applications, and AI system design” (p. 4) (see Table 1). AI is therefore placed within a human context, focused on maintaining human rights and accountability, used for the common good (UNESCO, 2022, 2023).

Table 1.
AI Competency Framework for Students (UNESCO, 2025b): Areas

AI Competency Framework for Students: Areas
Human-centred mindset
Ethics of AI
AI techniques and application
AI system design

Source: Text: UNESCO, 2025b, p. 4. Table: own work.

For education, the emphasis is on ensuring human agency, respect, equity and inclusion, in sustainable ways. The importance of providing affordances for deep learning through human interaction, as opposed to rote, superficial tasks is highlighted, with implicit understanding that teaching and learning take place with AI support, but are not governed by it. In keeping with this, the framework aims to “help students acquire the values, knowledge and skills necessary to examine and understand AI critically from a holistic perspective, including its ethical, social and technical dimensions” (Giannini, 2024). The approach is that “AI competencies are ultimately a set of interdisciplinary, general abilities and value orientations that extend beyond particular AI domains or tools” (UNESCO 2024b, p. 18).

The document is presented as an international “reference framework” (UNESCO, 2024b, p. 12) targeted for those responsible for preparing policy, curricula, or programs for students, or to provide information for experienced educators. The AI Competency Framework for Students (AI CFS) (UNESCO, 2024b) aims to encourage critical considerations of the nature, use and impact of AI and so the purposes it could, should or should not be used for. Students become aware of the inherent risks or threats of AI in order to be able to make measured judgements in the future. Building on the four foundational areas described above, are twelve interconnected blocks of competences, developing through a progression of three levels: understand, apply and create, thus allowing the building of a spiral syllabus, where the same competency can be re-visited but with a new focus. This provides opportunities for review and consolidation before new aspects, which extend the level of skill and awareness, are added. For example, the aspect “Human-centred mindset” includes three blocks: “Human agency” (Understand), “Human Accountability” (Apply) and “Citizenship in the era of AI” (Create) (p. 19), (see Table 2). Each of these is fully described in the framework.

Table 2.
AI Competency Framework for Students (UNESCO, 2025b): Example of levels

Human-centred mindset	
Human agency	Understand
Human accountability	Apply
Citizenship in the era of AI	Create

Source: adapted from UNESCO, 2025b, Table 1, p. 19.

The authors acknowledge that not all students will reach the “Create” level at school for reasons of time, possibility, or interest, yet the Understand and Apply levels are proposed as mandatory. The way each of the competences are projected to develop is clearly explained in the document for each of the three levels (understand, apply, create). AI CFS offers a set of competency descriptors, a set of goals for the proposed curriculum, possible didactic approaches to implement the competencies and contexts in which the learning may take place. This allows for the framework to be used to create programs for formal education, but also for informal learning beyond school, in the home or community. To ensure inclusion, the learning environments include use of offline materials in paper form, or recordings, not only those needing internet and a digital device. The suggested outlines are designed to inspire educators to create varied, interesting content with clear pedagogical aims. Alternatively, it is proposed that the document could be used as a starting point for critical evaluation of existing policy, awareness-raising of the ethical issues underlying AI use, or development of understanding of AI competences. Companion documents (UNESCO, 2022b, 2024c) provide case studies showing how AI competencies could be taught in schools as a separate subject, across the curriculum through a number of subjects, added into associated subject programmes, such as ICT, or as an additional subject in extracurricular activities. Samples are also included in the AI CFS document.

Advice on curriculum design is offered, with specific examples. For implementation, the need for good internet access, digital devices, suitable software and appropriate applications is emphasized, in addition to provision of continuing support for teacher education on AI, including up-skilling, as needed. Guidelines for developing criterion-referenced descriptors for assessment are offered and suggestions made for scenarios and tasks for assessment purposes, with examples given for illustration. It is stressed that the AI CFS is envisaged as a flexible starting point on which policy makers and designers in many contexts can work to create curricula for their situations, reviewing and adapting them as AI technologies develop.

2.3.2. EU-OECD AI Literacy Framework

According to EU legislation, as of February 2025 enterprises producing, using or dealing with AI systems, were required to ensure access to training in necessary AI literacy skills to employees, together with all those in contact with the systems (EU, 2024, Article 4, AI Act), yet AI literacy is not clearly understood. Also unclear is how to educate for it and integrate it into existing school subject curricula. A 2022 UNESCO study reported that only 15 of 190 countries participating in a survey had produced, or were developing, curricula for AI skills

in schools. Young people are already engaging with AI tools and expressing concerns about equity of access, fairness and inclusion in education as a result of its use (Vodafone Foundation, 2024). The fact that AI is designed to interact in human-like ways is dangerously misleading and may mean that the actual capabilities of the systems may be misinterpreted by the unaware, necessitating awareness-raising in this respect (Holmes, 2025). Some AI literacy training available has been created by commercial entities seeking to promote specific AI systems or applications and is not without bias (UNESCO, 2024a). In response, the European Commission, in cooperation with the OECD, published a draft version of the AI Literacy Framework (AI Lit Framework) (May, 2025) for consultation and feedback. The document (OECD, 2025) is compatible with other EU policy, namely the Digital Education Action Plan 2012-2027 (European Commission, 2020), the Ethics Guidelines for Trustworthy AI (High-Level Expert Group on Artificial Intelligence, 2019), the Ethical guidelines on the use of Artificial intelligence and data for educators (European Commission, 2022) and the 2022 version of DigComp (2.2), recently succeeded by DigComp 3.0 (see above).

AI literacy in the Draft Framework is seen as “the technical knowledge, durable skills, and future-ready attitudes required to thrive in a world influenced by AI. It enables learners to engage, create with, manage, and design AI, while critically evaluating its benefits, risks, and ethical implications” (OECD, 2025, p. 6). Echoing concerns from the UNESCO AI CFS, the OECD document holds that “AI literacy must be grounded in trusted information, a focus on ethics, and a commitment to social good” (p. 6.). However, the onus in this framework appears to be placed on the teacher, who is expected to create the conditions for learning about AI, having first developed their own competencies, within their own subject, if that is appropriate. It is also acknowledged that learning about AI takes place across both primary and secondary education, as well as in informal contexts outside school. The AI Lit Framework is addressed in the first place to teachers, then to teacher educators, those in leadership positions, including policy makers, and designers of educational materials.

DigComp, the AI CFS and the AI Competency Framework for Teachers (UNESCO, 2024a), are acknowledged as providing important input for the AI Lit framework, as is work by Mills et al. (2024) and the AI4K12 Initiative (2022). Drawing on work that has gone before, the draft OECD AI Lit Framework draws out three themes underlying AI literacy: (1) Knowledge of the workings of AI and Machine Learning, (2) Key human skills needed for effective AI collaboration, and (3) Influences of AI at individual, societal and environmental levels. Much of what is used to justify these themes echoes the UNESCO framework (2024b), although some additional detail is offered. In theme (1), the data gathering processes used to train AI and possible biases caused by statistical modelling are highlighted. The body of work from computer science done on the “Big Five Ideas about AI” (Touretzky et al., 2019) is referenced, which proposes that children need to understand how AI works before being able to be aware of its inherent problems. Theme (2) draws on ideas from media literacy, computational thinking and algorithmic literacy. The rationale for Theme (3) cites the

UNESCO framework (2024b), DigComp 2.2 and EU policy documents discussed earlier in this paper. Concerns are raised about the negative environmental impact of AI, draining energy and water resources, and questions are asked about autonomy and ownership arising from the data gathering processes used to train the AI. Granted, this is a draft document, yet it appears to be strongly derivative, offering little beyond the UNESCO (2024b) framework.

The principles on which the OECD framework are based are stated as being “Interdisciplinary, Foundational, Illustrative, Global, Practical and Durable” (OECD, 2025, p. 12). “Illustrative” refers to the “scenarios and exemplars to be included” (p. 12), “global” refers to the reach of the views incorporated, which may possibly refer to opinions to be gathered from the feedback process, and “durable” refers to the claim that the framework highlights “knowledge and skills that will remain relevant as AI evolves” (p. 12) without further elaboration. Brief outlines of “Learning Personas” (p. 12) are offered, illustrating young people of 10, 13, 15 and 18 using AI in practical ways.

Competencies are arranged into four areas: “Engaging with AI, Creating with AI, Managing AI, and Designing AI” (OECD, 2025, p. 15). At the “Engaging” level, focus is on recognition of AI in use and evaluation of outputs with a view to developing critical awareness. At the “Creating” level the student interacts with AI to produce content and critically evaluate it. At the “Managing” level focus is on use of AI for enhancement of human functionality, exploring the various roles AI can take. The student is expected to evaluate not only the quality of the output, but also “whether AI’s role aligns with their goals and values” (p.15). At the “Designing” level learners do practical tasks “to examine how data, design choices, and model behavior influence the fairness, usefulness and impact of AI systems” (p. 15), apparently applying concepts from Design Thinking. Like DigComp 3.0, the framework builds competencies on knowledge, skills and attitudes, and ethics are also incorporated. “Knowledge” incorporates understanding the characteristics of AI, how it mirrors human decisions and views, its potential to change and enhance human activity, its scope and limitations, and how it can affect social and civic activity. “Skills” incorporate general soft skills of critical thinking, communication, collaboration, creativity and problem-solving, echoing the World Economic Forum Future of Jobs report (2025), but adds “computational thinking” (p. 18), which is viewed as the ability to analyse a problem to give instructions, and “self and social awareness” (p. 18). “Attitudes” include being responsible with empathy and demonstrating flexibility, curiosity and inventiveness.

The framework offers a total of 19 Knowledge statements for each of the thematic areas., e.g. “K1.4. AI systems operate differently depending on their purpose, whether to create, predict, recommend, or respond” (p. 19). “Competence” in this framework is defined as “a learning expectation that reflects technical knowledge, durable skills and future- ready attitudes” (p. 25), incidentally repeating its wording of the definition of AI literacy. The Skills are currently presented as imperatives, e.g. “Critical Thinking: Evaluate AI-generated content for accuracy, fairness and bias to make informed and ethical decisions” (p. 21) followed by

How can I / How do I...? questions addressed to the user. Some elaboration is offered but in extremely general terms. The Attitudes are amplified by descriptors, some of which are prescriptive, e.g. “They [i.e. students] believe everyone has the right to understand how AI affects them and to make informed decisions about its use” or “They consider learning to be an ongoing process and enjoy experimenting, believing that meaningful discoveries can happen through exploration” (p. 23). The “competences” are presented in the four areas (Engaging with AI etc.) and are also in the form of imperative statements (Recognise, Evaluate, Examine etc.), e.g. “Recognise AI’s roles and influence in different contexts” (p. 27(1)). Each has accompanying Knowledge statements and Attitudes given. The competence statement is followed by descriptors in the imperative form stating what learners do and two scenarios, one at the primary and the other at the secondary school level. Of concern is the suggestion of prescription, “although skills and attitudes have broad applicability, the framework highlights combinations that best support each competence” (p. 25). A possible explanation of this is that the (supposedly) secondary purpose of the framework (OECD, 2025, p. 2) is to “contribute to the PISA [Program for International Student Assessment] 2029 Media and Artificial Literacy Assessment” (p. 2). Schleicher (May 21, 2025), however, overtly states that the AI Lit Framework “will also provide the foundation for the first assessment of AI literacy” (section Integrating AI Literacy, para. 1). Indeed, the format of the Framework is more reminiscent of a test specifications document than a reference framework, deviating from the more usual operational aims in the form of “can do” statements for planned learner achievement and instead appearing to take an authoritarian, prescriptive stance, as shown, even towards what students are expected to believe. It is to be hoped that this changes in the final version.

The draft framework ends with an outline of the feedback and consultation process. The final version of the document, which will “reflect international input” (OECD, 2025, p. 39) is planned for 2026, together with a “limited set of AI literacy exemplars” (p. 39). The final section invites the reader to use a large language model chatbot (AI) by clicking a hyperlinked button which leads to an external (TeachAI) website. This gives a description of the prompts given to the bot. However, no information is overtly given about privacy or use of data. It is only returning to the main site, searching the page, finding and opening the Privacy Policy that it can be found that any data from interaction with the chatbot, “will be collected, processed and stored in the United States” (TeachAI 2025, About TeachAI para. 2). It could be claimed that there would appear to be a mismatch between claims about the importance of ethics in the Framework and this example of application, which is unfortunate for a document of this stature.

This section has aimed to provide an overview of EU legislation and policy on AI and to introduce two important frameworks proposed to support the work of policy makers, curriculum and program designers and educators in planning support for education and training in AI competencies. The following section turns to Poland, to provide a case study of policy and educational applications for support of AI competencies.

3. Policies and education for AI in practice: a case study of Poland

According to the Spotlight on Jobs and Skills Poland (Cedefop, 2025b), while the Polish workforce is in general well-educated and qualified (European Skills Index 2024 in Cedefop, 2025b) there is room for growth in activation and development of skills. By contrast, digital skills are below the EU average for the “above basic” level, and two thirds of young adults (aged 25-34) lack even basic digital skills. The goal is for basic digital skills to reach 70% by 2030. There is a low take up of training opportunities by those in the workforce (9% in 2023) with very low levels of women (1% in comparison to the EU, 17%) or those over 50 (6%, EU, 11%). ICT specialists comprise only 4.3% of the workforce, one of the lowest percentages in the EU (Cedefop, 2025).

The Policy for Development of Artificial Intelligence for Poland from 2020 (Polish Government, 2020), hereafter AI Policy 2020, acknowledged the need to raise digital competencies in Polish society and to create flexible forms of reskilling and upskilling to allow this to take place. The priority aims were to create a context for AI to support economic growth and social well-being, followed by having a populace with above basic skills in the use of AI for personal and professional purposes and a well-run state administration using AI.

In the priorities set within the Program for Development of Digital Competences (2023) (Program Rozwoju Kompetencji Cyfrowych) targets are that by 2030 Poland will achieve the EU target level for adult digital skills. Considerable investment has been made in improving overall access to fast digital infrastructure, and updating of hardware and internet access in schools. Children of school age from pre-school to the end of secondary education and young people in university are seen as a priority area for digital upskilling, which includes use of AI, (for more information, see Morańska, 2024). Compliant with this, priorities for educational policy for the academic years 2024-2025 and 2025-2026 included development of skills for safe use of the internet, critical analytical skills with regard to information from online sources and appropriate use of digital and AI technology by teachers (Polish Government, 21.05.2025).

3.1. Diachronic overview: Polish education policy and schools during 2025

In May 2025 the Digital Education Section of the Committee on Informatics (DESCI, 2025), Polish Academy of Sciences (PAN), published *AI in Polish Schools. White Book*, (hereafter the *White Book*) calling for deep-seated change in attitudes and approaches to AI in education, bringing it out of isolation as a sub-section of computer studies and the domain of ICT teachers into wide-scale practical application by all educators across the curriculum. Citing the necessity to acknowledge the major changes in society caused by rapid development of AI technologies and the need for constructive adaptation to its disruption, the group made a series of recommendations.

In July 2025 announcement was made by the Ministry of National Education of a planned curriculum change for schools (Polish government, 09.07.25), to be called “Reform26: Compass for tomorrow”, which (in the spirit of the *White Book* recommendations) included threading use of new technologies across all subjects, rather than limiting them to ICT. This initiative also included upskilling of educators and enhancement of school digital infrastructure. A new subject, Media Literacy, was planned to start in grade 4 primary from September 2026 (The proposed changes, part of a wider reform package, were vetoed by the Polish President on 18.12.2025, on the grounds of the proposed speed of implementation of the changes, and inadequate social consultation on the proposal. No overt objection was made, however, to the digital and AI skills concept).

NASK [Naukowa i Akademicka Sieć Komputerowa. Research and Academic Computer Network] is a national research institution under the jurisdiction of the Ministry for Digitalization, founded in 2023. Tasked with the development of digital infrastructure and telecommunications, it focuses on cybersecurity, AI development, and education for safe and responsible use of new technologies. In order to obtain empirical information about the school situation following the launch of ChatGPT (2022), a questionnaire study was carried out in December 2023 among a representative sample of 995 primary school teachers of grades 4-8 (learners aged between 9 and 15 years), and interviews with 20 teachers declared as active users of generative AI. Findings (Pyżalski ed., 2025), revealed considerable anxiety and doubt among teachers with regard to the impact of generative AI on teaching and learning in school. Issues such as cognitive debt (Kosmyrna et al., 2025) and classroom management challenges were among those most frequently raised. Responses overall were, however, extremely varied. Teachers underlined the need for clear policy on AI use in school and by learners to avoid reduction of critical thinking. Learner difficulty in recognizing online information as fake was also highlighted. The authors stress that practical and sensible application of generative AI can be constructive, provided it is accompanied by understanding of its capabilities and discernment of when and how it can or should not be used.

In September 2025 a new program, “Digital Student 2024-2029” (Cyfrowy uczeń), to give funding to local authorities to support development of digital skills for pre-school, primary and secondary schools, was announced (Polish government, 18.09.2025). This will include development of new technologies, including AI, in school; teaching approaches and use of digital resources; training and upskilling of teachers; new science and AI laboratories; and hardware for learners, teachers and schools. The program is open not only to schools but also to other institutions offering extra-curricular activities, care and psychological support for young people and those with special needs. In 2025 funding was open only at the pre-school level and focused on support for specific learning needs. Teaching materials offered within the program are designed, for example, for speech and language therapy, and early literacy training.

In November 2025 revision was made to the AI Policy 2020 in response to the rapid and dynamic development of AI, with a new document called the Policy for Development of Artificial Intelligence for Poland to 2030 (Polish Government, 17.11.2025). The emphasis is placed firmly on ensuring human-centred and trustworthy AI development in a cybersecure environment, which will benefit economic growth, but also support social well-being for all. Clear and concrete aims are laid out. Implementation of the EU policies Apply AI Strategy (2025), which highlights specific sectors of industry for AI application, and Apply AI in Science (2025), which promotes and supports research on AI and implementation of outcomes, are highlighted. In this context, attention is also given to the newly developed Polish Large Language Model (PLLuM), an initiative of the Human-centric Innovative Vision for European AI consortium (HIVE), which is currently being piloted in local administration offices (Polish, a highly inflected language, offers potential for greater precision in prompts to AI than English). As in the AI 2020 policy, the need for a highly skilled workforce is acknowledged, but this has now been brought to the fore as a fundamental requirement for AI development, alongside efficient infrastructure.

Relevant to skills-development among educators and young people, Projekt Zbadai (Explore AI), a 3-year educational project initiated by the Copernicus Science Centre (CSC), Warsaw and funded by the Ministry of National Education, launched in December 2025. It aims to support the Digital Student program, (which will initially focus on updating school digital infrastructure), by building teacher skills and curiosity about AI and confidence in its use. The plan is that teachers will then be able to enthuse their students (Copernicus Science Centre, 2025). One part of the project will comprise a 5-module e-learning course for educators which introduces the workings of AI systems, prompt design, use of AI in data analysis and production of multimedia content, practical application of AI in education, and associated legal and ethical aspects (based on Witczak, 2026, own translation).

A central part of the project Explore AI is to be experimental, with the cooperation of 100 primary and 100 secondary schools throughout Poland, 930 educators and 13, 000 students (Copernicus Science Centre, 2025). For one semester, in each of the schools, a group of 2 teachers and at least 15 students will carry out one of 8 interdisciplinary projects created by researchers and experts from the CSC, a choice of 4 projects at each level. Teachers and students together will formulate research questions and test them during the cross-curricular exploratory projects, using AI to support in developing their understanding of the world. In this way the project aims not only to build AI skills but also independence in critical and analytic thinking through teamwork. The experts will provide support at all stages. The project teams will collect, analyze, interpret and present data and produce reports. At the same time, materials produced and projects carried out are to be shared on a dedicated online platform. The final product is to be a publication with recommendations for conducting school-based research projects. This could be used to cascade the approach into a wider network of schools for further implementation (Copernicus Science Centre, 2025).

This overview is, for reasons of space, selective, but aims to capture the dynamism of the changes underway during this phase of the AI transformation.

4. Discussion

Poland has well-developed digital infrastructure and is investing substantially in modernizing schools. However, both in the workplace and in educational institutions it would seem that there is still much to do in order to meet EU digital and AI skill targets. There does not yet appear to be a widely-established culture of continuing and lifelong learning in the adult population and this is a major drawback at a time of rapid technological change. In contrast to a top-down approach, where central policy decides and promotes, sustained change in education across the world has been found to start with innovation from individual teachers, or small groups of enthusiasts (e.g. <https://superbelfrzy.edu.pl/>). Communities of practice may build through contact and cooperation in face-to-face development workshops, projects, teacher organizations, online networking and dedicated special interest groups on social media. Long-term change is maintained by a supportive climate and empathetic school leadership (e.g. Fullan, 2002). Indeed, change at the level of the school is recognized as supporting digitalization (see Petterson, 2021 for a review).

While centralized definitions, goals, and even legislation, can act as levers for change, guidelines and frameworks need to be carefully adapted to fit local contexts and participants. The brief description of AI-related events of 2025 in Poland, attempted to offer a glimpse of this localization process taking place. Teacher responses reported here, although from the end of 2023 and so in this time of rapid change perhaps already no longer representative, offer indicators for future research directions.

Of key importance is understanding the process of transition to incorporation of AI use in educational institutions and workplaces, and study of the factors which promote or inhibit safe and responsible AI adoption (Mustafa et al., 2024). Any change process is complex, and uptake of a new digital tool is characterized by early adopters, resisters and those challenged or rendered helpless by the situation. For this reason, education and training in AI literacy, digital skills and critical/analytic thinking needs to follow principles of universal design, allowing accessibility for all, regardless of their levels of knowledge, skill or attitude. This creates a challenge for course creators and educators. It is unlikely that transmission-focused courses, already frequently found online, will enable uptake and application of new skills. A different, interactive and supported approach is needed, which by design, includes practical application as part of its content. Hence, the Polish Project Zbadai (Explore AI) is of interest. Combining various approaches and bringing together researchers, methodology experts and practicing teachers in project-based learning in school, this provides affordances for uptake of skills at

many levels and in various modes, key characteristics of universal design. In addition, the teacher themselves is pushed into the role of reflective practitioner, observing and analyzing the process, while at the same time taking an active guiding role. This model framework can serve as a blueprint for parallel application in different contexts. It offers potential for local grassroots actions which can bring together different stakeholders and actors, engage industry and institutions working with a common purpose and for mutual benefit.

From a research perspective, the complex, layered nature of AI literacy, with many skills co-engaged simultaneously, makes operationalization of *responsible and aware AI use* challenging. It could well be that, as with digital skills, (see the International Computer Driving License) a form of “driving licence” is needed, entailing demonstration of both knowledge and evidence-based practice. Educators in turn not only need developed practical skills in AI application, but also pedagogical skills to support others in the skill-getting process. Here again the Zbadai (Explore AI) project is promising, potentially offering insights on the pedagogical competencies entailed in facilitating AI literacy. These are complex research studies, requiring interdisciplinary teams. To add another layer, AI itself, at least in the form of data mining, would facilitate analysis of the large quantities of data involved. However, the research design would clearly also need to include human verification processes to validate the results.

5. Conclusion

In conclusion, analysis of documents from different European bodies and world organizations on aspects of AI literacy, has helped provide a picture of the multifaceted nature of the competencies needed for the individual wishing to use AI constructively, sensibly and ethically. AI skills have been found to be the top level of a pyramid structure (see Figure 1). The base of the pyramid is made up of foundation skills of reading with understanding, writing, communicating, and basic numerical skills. On to this are laid the second level of digital skills, which involve being able to carry out the base level foundational skills with use of a computer and other digital devices, safely, ethically and responsibly. The top tier, AI skills, involves use of all the skills included in the lower layers, understanding how their application can be assisted by AI and how human skills may be augmented by AI use. A key requisite to application of AI is understanding how it works, the possible threats this may entail, and how these can be addressed in responsible use for the benefit of an inclusive human-centred society. All the layers of the pyramid together make up what is known as AI literacy (Figure 1).

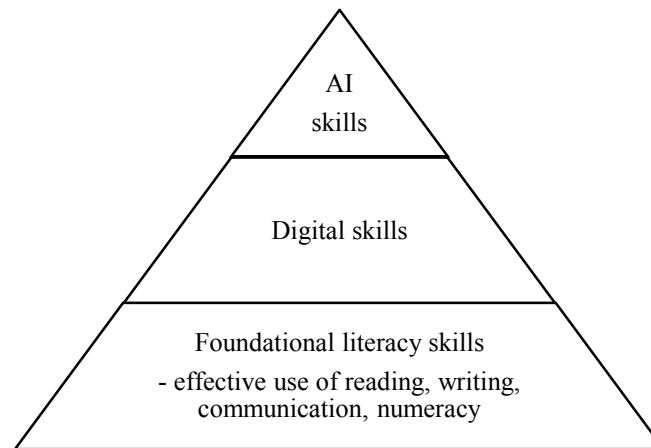


Figure 1. The AI literacy Pyramid.

Source: own work.

As a result, it is not surprising that employers have had difficulty offering the reskilling and upskilling courses required by the AI Act. The skills set is complex and extensive. Logically, for a workforce prepared to work with AI, this means that most of the skills needed in the workplace should already be in place by the end of compulsory education. As has been seen in the Poland case study, digital skills- the important second tier of the pyramid- are lacking in young adults. This points to the urgent need for provision of practical and relevant training, in areas outlined in DigComp 3.0, for secondary and university students. In addition, short courses, perhaps in the form of micro-credentials, are called for to upskill existing workers. In order to have the number of providers with the relevant knowledge, attitudes and skills and pedagogical expertise, given the shortage of ICT specialists, those with related expertise should be considered. Tertiary institutions have potential in these respects.

Providing an overview of legal, administrative and educational documents joined by a common theme has allowed a nuanced interpretation of the knowledge, skills and attitudes involved in AI literacy. Of these, perhaps the most important are self-knowledge, perseverance, curiosity and optimism. In the end, principled AI use is a question of personal integrity which involves understanding one's own beliefs and priorities. The process of learning in a rapidly changing world requires the courage and determination to continue, despite difficulty, uncertainty and moments of failure. Opening up to the change process is helped by being curious about what is happening and positive that ultimately there will be a satisfactory outcome, even if it is only momentary. In short, the process of exploring this plethora of information offers material for reflection, stimulus for further inquiry and, potentially, ideas for interdisciplinary projects.

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AI IN HIGHER EDUCATION: STUDENTS' VOICES IN THE ERA OF DIGITAL TRANSFORMATION

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Purpose: This paper examines how students of the Faculty of Organization and Management perceive and evaluate the implementation of artificial intelligence (AI) in the learning process, communication, and educational administration, as well as its role in the (re)shaping of university ethical standards.

Design/methodology/approach: The study is based on a survey conducted among 82 undergraduate students of the Department of Applied Linguistics. The questionnaire consisted predominantly of closed-ended (single and multiple choice) and semi-open questions. In several instances, a Likert scale was applied with a view to examining the intensity of respondents' attitudes and opinions. The research investigates the extent to which students use AI as a practical tool supporting language-related tasks and office management activities within the academic environment.

Findings: The results indicate that the increasing integration of AI into higher education significantly influences educational practices and institutional management. Students demonstrate a largely pragmatic engagement with AI technologies; however, their attitudes toward the ethical implications of AI remain ambivalent. In particular, students frequently negotiate the boundaries between assistance and authorship, as well as between automation and personal responsibility. The findings also reveal a strong awareness of issues related to reliability, accountability, and academic integrity.

Research limitations/implications: The study is limited to undergraduate students from a single department, which may restrict the generalizability of the findings to other academic disciplines or institutional contexts. Further research across different faculties and universities could provide a broader perspective on AI use in higher education.

Practical implications: The findings may inform universities and educators in developing guidelines and policies that support the responsible and ethical use of AI in teaching, learning, communication, and administrative practices.

Originality/value: The paper contributes to the growing discussion on Artificial Intelligence in Education (AIED) by offering empirical insights into students' perceptions of AI integration in both educational and organizational contexts, with particular attention to emerging ethical considerations in academic environments. The information obtained may be useful for universities in planning strategies to address the issues of privacy and data governance, access and distribution of AI tools, and institutional accountability.

Keywords: artificial intelligence (AI), artificial intelligence in education (AIED), higher education, educational technology, students' perceptions, digital transformation, organization and management, communication, academic integrity.

Category of the paper: Research paper.

1. Introduction

Artificial intelligence (AI) is rapidly revolutionizing the landscape of higher education, challenging the established modes of research, impacting teaching and learning processes, and transforming administrative operations at universities. In the sphere of teaching content, educators have found themselves at the crossroads, where they need to establish what is still worth teaching, how to successfully implement Artificial Intelligence in Education (AIED) to enhance the teaching process, and finally how to assess students' progress. They are grappling with the dilemma of what AI will mean to their students' future and how best to prepare them for an ever-changing workplace environment. OpenAI and other tech giants admit their strategy is to overhaul university education by reaching out and embracing every facet of student and campus life. Educational and institutional objectives aside, the ethical use of AI is key to ensuring transparency, integrity, accountability and personalization of teaching-learning dynamics.

Both educators and students are actively following advances in technology, as well as testing AI-powered tools and undeniable opportunities they present, often at lower financial costs and less time-consuming, while realizing the potential risks such as inaccurate or entirely false information and the loss of data privacy. It should be emphasized, though, that while AI enables university teachers to enrich their instruction, machine learning cannot and will not substitute humans, hence the highly favored idea to always center educators and advocate their agency to decide what content to choose and how to deliver it. Equally important is the recommendation to adopt a 'human-centered AI' perspective (Shneiderman, 4) with regard to learners at all levels of education. This approach has been implemented at the Silesian University of Technology University, where students from the Department of Applied Linguistics were invited to participate in a pilot study and report on the intervention of AI-driven technologies in everyday learning routine, highlighting their educational, social and ethical factors, as well as comment on institutional applications and evaluate their own level of trust in AI in Education (AIED).

Concurrently, the need to reexamine the purpose of higher education is vital in the era of ChatGPT, released by OpenAI in 2022, which can generate responses to a wide range of questions posed by students. ChatGPT draws on the datasets it has been trained on and produces answers based on predictable patterns, in most cases perceived by students as fully satisfactory solutions to academic requirements. Traditionally, before the introduction of AI tools in

universities, undergraduates facing a difficult academic task learned how to tackle it, made mistakes and corrected them, and usually appreciated the complexity of the learning process. Today, however, many students tend to bypass the more problematic aspects of academic work in order to accelerate the completion of assignments, often as a strategy to avoid frustration or anxiety, under the sometimes false impression that using AI tools reflects their participation in technological achievements. In May 2025, a new version of ChatGPT Edu, designed specifically to fully assist students with academic work, was announced, so the temptation to integrate this tool across educational and learning contexts is likely to become even harder to resist, promising hyper-efficiency while simultaneously reducing students' workload.

Finally, AI is increasingly applied to streamline university administration and management. It can automate routine procedures, such as enrolment or documentation processing, facilitate communication with students, support data-driven decision-making, e.g. by analysing institutional data related to students' progress, or optimize workflows and increase the efficiency and transparency of educational governance. While such systems are often promoted as key instruments for enhancing efficiency, transparency, and responsiveness, both students and academic staff must also consider the extent to which these technological advancements can be trusted and used responsibly.

2. Research Methodology

The pilot study conducted among a group of students aimed to collect the opinions of Applied Linguistics undergraduates at the Faculty of Organization and Management regarding the use of publicly available artificial intelligence (AI) tools in higher education (UNESCO, 2023). Above all, the paper focuses on the importance and implications of cutting-edge technological solutions in higher education management, presumed support of teaching-learning activities, and (re)shaping ethical attitudes in the era of digital transformation and AI-augmented world (European Commission, 2025).

To design and develop the authors' original research survey questionnaire, the Microsoft Forms application was used, which allowed for anonymous data collection and real-time recording of responses. The questionnaire was structured around five principal areas of investigation addressing:

1. respondents' demographic characteristics (age, gender, year of study),
2. respondents' everyday experiences in using next-generation applications,
3. the role of AI in learning process and university management,
4. the assessment of assets and liabilities (opportunities and risks) related to the implementation of digital solutions in teaching,
5. ethical reflections and recommendations for responsible application of AI.

The questions were predominantly closed-ended (single and multiple choice) and semi-open. In several instances, a Likert scale was applied with a view to examining the intensity of attitudes and opinions. The survey concluded with two open-ended questions.

The questionnaire was completed by 82 first-, second-, and third-year students of Applied Linguistics at the Faculty of Organization and Management of the Silesian University of Technology in Zabrze. They study two foreign languages simultaneously: English is their obligatory language B, taught from B2 level, while the secondary languages (language C) to choose from are French, German, Italian, or Spanish, taught from A1 level of the Common European Framework of Reference for Languages (CEFR). The sample was purposive, as the study targeted a specific academic group of undergraduates representing frequent and advanced users of digital innovations within a humanistic and linguistic context.

The study, based on the diagnostic survey method and a structured questionnaire, was conducted in October 2025. The questionnaire was anonymous and the participation entirely voluntary. Respondents were informed about the main objective of the study and ensured that the use of data would be exclusively for scientific purposes. Data collection was conducted online to ensure full accessibility and convenience when completing the survey across various devices, such as computers, tablets and smartphones.

Both quantitative and qualitative methods were employed to scrutinize the collected data. Quantitative data were processed using percentage distributions of responses and comparative analyses of selected variables. Subsequently, open-ended reports were subjected to content analysis to establish recurring themes, emotions, and attitudes toward AI. Additionally, visualizations of selected analyses in the form of graphical charts were prepared using ChatGPT-5, powered by the new GPT language model, the latest and the most useful for real-life problems and queries (GPT-5, OpenAI).

3. Results

The first area examined in the study concerned respondents' demographic characteristics. The results indicate that the majority of respondents were women (73%), which may reflect their greater inclination toward language learning and academic engagement. Male respondents constituted 25.6% of the sample, and two respondents (2.4%) declined to disclose their gender. This observation may suggest that the general tendency in the humanities, where female students have traditionally predominated, remains consistent.

The surveyed cohort comprised young adults, with the predominant age group being 20-22 years old, accounting for 81.7% of all respondents. Participants aged 23-25 constituted 14.6% of the sample, while 3.7% were older than 26. Since young people belong to the most enthusiastic users of modern technological tools, the selection of this target group was

a deliberate decision on the part of the authors of the questionnaire. The younger generation is typically characterized by both curiosity and openness to educational innovation, as well as high adaptability to technological changes. Young people eagerly embrace state of the art digital tools as part of the learning process and use them accordingly.

The vast majority of respondents (70%) were second-year students, while third-year students accounted for 30% of the sample. This choice was also intentional, targeted at capturing the perspectives of more advanced learners, for whom the role of AIED has become increasingly significant in academic research and independent scientific projects.

In the second section, respondents identified their skills, competences and hands-on experience with next-generation applications and systems. Participants demonstrated diverse levels of experience, with 57.3% declaring moderate competence, 37.8% rating their experience as good or very good, and 4.9% having no experience whatsoever. The large proportion with moderate to high competence may confirm that, indeed, young adults demonstrate the highest degree of technological expertise. Moreover, the survey revealed that the most frequently used applications include text generators, AI-based translators, and language correction programs.

The most popular and, consequently, most frequently used AI tool was ChatGPT, used by 90.2% of respondents, which attests to a dominant role of the generative language model among higher education students in linguistics-related fields. The second most popular tool was DeepL (78.0%), indicating that translation applications continue to play an important supportive role in foreign language acquisition. Grammarly (52.4%) ranked third, being primarily used for linguistic proofreading of academic texts and written assignments. Less popular tools included Google Bard / Gemini (23.2%) and other applications (12.2%), often chosen for graphic or study-planning purposes, e.g. creating timetables.

These data may indicate that the respondents express a strong preference for text- and language-based platforms, rather than analytical or visual systems, which is closely aligned with their field of study and the didactic needs of Applied Linguistics curricula. These further underscore a high level of students' awareness of digital tools that not only support and expedite language learning process and text preparation or edition, but also facilitate academic work and linguistic competence development.

The next query in the survey concerned the specific areas in which the use of digital innovations was justified. An overwhelming majority of respondents (85.4%) employed AIED tools in the area of language learning and translation, confirming a strong link between intelligent technologies, communication, and foreign language acquisition. 68.3% used AI to write and edit texts, whereas 56.1% utilized it to plan and manage their studies, indicating that these systems support not only the development of linguistic competences but also hone organizational skills. A relatively smaller group of respondents (39.0%) reported using digital assistants for project inspiration, while only 6.1% mentioned other, non-specified applications. To conclude, an overriding impression is that the predominant use of AIED among linguistics

students involves supporting cognitive and communicative processes, rather than altogether substituting individual academic effort.

The third aspect of the study pertained to AI in learning practices and higher education management. It began with questions focusing on the use of intelligent tools in two distinct areas: private and academic. The analysis of the collected data reveals that in both contexts the dominant frequency of use is several times per week (54.9% and 56.1%, respectively). Minor differences can be discerned among respondents who use these tools daily: 15.9% for academic purposes and 12.2% in private life. Conversely, occasional use is more frequent in private settings (14.6%) than in academic contexts (11%). However, these slight differences may indicate a high level of integration of digital infrastructure into students' daily lives and, as a consequence, suggest that the boundary between private and academic function is becoming increasingly blurred.

The survey also examined whether AI-based assistants influence respondents' learning styles and strategies. A total of 63.8% of respondents confirmed that using AI tools to some extent affected their learning approaches, attesting to the growing influence of digital culture on students' cognitive strategies. Only 9.8% stated that generative systems did not impact their learning, while for 22% it was 'hard to say,' possibly reflecting their ambivalent perception of the ongoing transformation of the learning process. Overall, the findings suggest that intelligent technologies have become an integral part of students' learning practices (Kukulska-Hulme, 2016), marking a shift from traditional education models toward a more personalized, technology-enhanced process of AI-assisted learning (Pham, Nguyen, Ha, & Nguyen Ngoc, 2023).

Subsequent questions addressed the use of AI in supporting learning practices and academic work. A detailed analysis revealed that respondents find these tools promising when planning, deepening their knowledge of particular subjects, and editing written assignments. More than two-thirds of respondents (68.3%) reported using digital tools to support more efficient self-regulated learning, while an even higher percentage (74.4%) resorted to AI systems to better understand complex course content and bridge knowledge gaps, thus confirming the role of AI in enhancing cognitive mechanisms. The use of new technologies also appears to be significant in editing academic written assignments (71.9%), mainly to improve language accuracy and the stylistic quality of texts. A smaller but nevertheless notable group (41.5%) reported using such tools for administrative writing, indicating an awareness of their potential not only in learning activities but also in organizational and bureaucratic contexts.

Most respondents also declared that they verify the accuracy and credibility of the answers and solutions generated by AI systems: nearly half (45.1%) do so 'regularly', and 26.8% 'always'. This high proportion reflects a strong level of cognitive awareness and critical engagement with AI-based tools. A vast majority of participants (84.2%) believed that the use of AI-assisted systems enhanced their learning efficiency: 36.6% 'strongly agreed', 47.6% 'rather agreed', about 11% adopted a neutral stance, and only 4.9% disagreed.

These results correspond with earlier observations regarding the type, frequency, and context of AI tools application: the more frequently they are employed, the more likely they are to be perceived as a factor increasing learning productivity and efficiency. Furthermore, 80.5% of respondents described AI systems as intuitive and user-friendly: 37.8% ‘strongly agreed’ and 42.7% ‘rather agreed.’ Only 6.1% reported difficulties in using such tools, whereas 13.4% adopted a neutral stance. These results may indicate a low-entry barrier and suggest that advanced technical expertise is not required to use AI-based systems effectively.

The fourth area of interest explored in the study concerned the assessment of assets and liabilities (opportunities and risks) associated with the use of digital environments in higher education. The analysis of the data confirms that respondents hold a highly positive view of AI’s capacity to promote equal education opportunities and enhance the learning process. More than three-quarters of respondents (75.6%) emphasized that learning-support innovations help equalize students’ opportunities (Holmes, Bialik, Fadel, 2019; OECD, 2023) by providing assistance to individuals with varying levels of linguistic and digital competence. The statement that universities should ensure access to basic digital tools was received an even higher level of acceptance (78.1%), indicating growing expectations among younger generations for institutional support and the integration of new interactive technologies into university infrastructure. A vast majority (81.7%) expressed interest in having a personalized, AI-based student assistant capable of reminding them about deadlines, due payments, and providing tailored, up-to-date information. Such generative systems, if properly implemented, may in the future become platforms that enhance both equity and efficiency, successfully reducing information access barriers. Respondents therefore advocated the introduction of well-designed solutions that could significantly upgrade the quality of higher education.

Another component of the survey sought to determine the potential of digital resources in administrative communication. A total of 78.1% of respondents believe that such tools could streamline and enhance interactions with university administrative units, particularly with the Dean’s Office or Student Services Office. The implementation of modern communication solutions would thus facilitate the automation of routine administrative mechanisms, which would, in effect, reduce bureaucracy, expedite the flow of information, and significantly improve the quality and accessibility of university services. For higher education management, these findings may indicate that respondents anticipate a modern, responsive, and digitally supported administrative system in which AI would play a key role. This tendency is aligned with the concept of the ‘Smart Campus’ (SURF, n.d.), where technologies support not only teaching activities but also administrative tasks and a steady flow of communication.

In contrast, respondents’ views were far more heterogeneous with regard to ethical considerations and perspectives. A total of 54.9% agreed that students should have the right to decline the use of next-generation technological tools during classes when such refusal is grounded in personal convictions or justified by well-founded ethical concerns. On the other hand, 26.8% expressed either neutral or opposing positions, indicating that the use of these tools

within the academic environment does not entail significant risks. Although AI-based technologies are widely employed and generally embraced as auxiliary instruments for teaching and learning, respondents strongly emphasized the importance of maintaining autonomy and freedom in their use. Consequently, the responsible implementation of digital tools in higher education requires not only advanced technological solutions but also, arguably of greater importance, clear and transparent institutional policies, systematic digital literacy training, and sustained, co-operative academic debate (European Commission, 2024; OECD, 2023).

The final part of the survey concerned ethical reflections and recommendations for further responsible and critical use of AI technologies in all spheres of academic life. This section opened with a statement expressing considerable misgivings about the use of generative tools at universities. A high proportion of respondents (75.6%) agreed that AI might foster plagiarism ('strongly agree' 30.5%, 'rather agree' 45.1%), whereas 17.1% remained neutral, and only 7.3% categorically disagreed. At the same time, a substantial majority of participants (78.1%) agreed that students should be officially required to disclose the use of digital assistants in the preparation of their theses, while 11% expressed a neutral stance, and a further 11% disagreed. This distribution of responses indicates that students are well aware of the relationship between the use of AI tools and the risk of academic misconduct, reflecting both a high level of ethical awareness and a certain degree of limited trust in the fair and accountable use of intelligent technologies within academic contexts. Respondents are highly committed to the principle of transparency and would appreciate institutional policies requiring the disclosure of the use of language models, especially in academic writing.

In response to the question examining respondents' awareness of the use of digital innovations, a total of 78% assessed their level as high, yet only 55% knew what was legally permitted. This discrepancy reveals a form of cognitive dissonance, where declared knowledge and confidence do not correspond to familiarity with the applicable rules and regulations. Such a gap underscores a rather superficial understanding of digital support mechanisms, shaped primarily by practical experience rather than ethical reflection.

The final set of ethics-related queries addressed the issue of regulating the use of AI at universities. A vast majority of respondents (81.7%) declared the necessity of establishing clear regulations regarding the use of intelligent technologies in academic life, while only 4.9% disagreed. This was one of the highest-rated items in the entire survey, demonstrating a strong demand for transparent rules concerning the ethical dimension of AI use. Similarly, 75.6% of respondents expected that the institutions themselves should use AI transparently, which may be perceived as an explicit call for partnership-based communication, with the university serving as a model of responsible and ethical innovation use.

The research group was unable to clearly determine, though, whether the academic community engaged in a broader debate on digital support mechanisms. Notably, 48.8% of respondents selected the response 'I do not know', while 26.8% indicated 'No', suggesting either limited or complete lack of institutional initiatives addressing ethical issues related to

digital technologies. Only approximately one-quarter of respondents confirmed that such discussions were currently taking place within the academic community.

The survey was concluded with two open-ended questions investigating assets and liabilities associated with the use of next-generation systems in academia. The most frequently mentioned benefit was ‘learning support’ (33.8%), followed by ‘information and organization’ (31.1%), ‘time saver’ (17.6%), and ‘idea or language generation’ (8.1%). The ‘unspecified’ category accounted for 31.1% of responses. The highest risk was attributed to ‘plagiarism and dishonesty’ (19.2%), followed by ‘decline in critical thinking or total dependency’ (11%). Among other liabilities were error making, AI hallucinations, lack of privacy, and the potential loss of image protection, each mentioned by fewer than 5% of respondents, while ‘other’ category accounted for as many as 60.3% of responses.

AI is thus perceived primarily as a supportive tutor and organizational coordinator, with operational and practical benefits occupying a central place in students’ agenda, while academic integrity emerges as the most significant concern, and plagiarism and misconduct as the most relatable risks. Respondents also expressed some reservations regarding the potential impact of AI use on cognitive competences. Finally, the relatively high proportion of responses categorized as ‘other’ indicates the need to refine coding categories in future analyses and suggests that many concerns and uncertainties surrounding AI remain rather nebulous.

4. Discussion

The survey conducted among 82 students of Applied Linguistics revealed a complex picture of versatile ways in which artificial intelligence is integrated into academic practices, and demonstrated generally favorable, yet diverse, attitudes toward its presence in learning, teaching and academic life in general. The quantitative and qualitative analysis of the 34 survey questions identified several key areas of interest: the frequency and context of AI use, the impact of digital tools on learning and communication, the ethical dimension of AI implementation, as well as the perceived assets and liabilities associated with its use.

The vast majority of respondents reported using AI-based modern solutions daily or several times per week and confirmed their primarily instrumental and auxiliary function. Most respondents also believe that supportive technologies make the learning process effective and more flexible (Holmes et al., 2019), at the same time reiterating that some behaviors may lead to misapplication or excessive reliance on ready-made solutions and result in cognitive autonomy failure. The analysis of responses further suggests that the research group perceives AI-powered tools not as a novelty, but as a useful and user-friendly digital partner supporting learning, planning, and communication. Their role centers around assisting rather than replacing human decision-making, facilitating and structuring the didactic process rather than substituting

it, which confirms the trend observed in literature toward the personalization of learning through modern technologies (Fazlagić, 2022). Meanwhile, respondents demonstrate a critical and reflective approach, acknowledging the imperfections or biases in generated output and remaining alert to the phenomenon of AI hallucinations (Ajuzieogu, 2024), or inaccurate and non-factual content generated by AI systems.

General feedback also acknowledged discrepancies between respondents' ethical awareness and the lack of clear formal regulations, which highlights a certain deficiency in institutional communication and limited visibility of ethical initiatives. These findings are further underscored by responses to the open-ended queries, which testify to the perennial clash between efficiency and academic integrity: while modern systems indeed streamline learning processes, they simultaneously challenge traditional notions of authorship and creative autonomy. The findings therefore contribute to the broader theoretical discussion on the role of artificial intelligence in higher education by illustrating how students negotiate the boundaries between technological assistance and academic autonomy in their everyday learning practices.

The survey conducted by the authors in October 2025 is part of a most recent trend in empirical research on generative artificial intelligence in higher education, with a particular focus on the student perspective and the field of applied linguistics. Previous research provides clear evidence that the rapid dissemination of AI-based tools in both the academic environment and the learning process has become increasingly prominent (Holmes et al., 2019; Zawacki-Richter et al., 2019). The present study confirms this observation, emphasizing the growing implementation of generative tools with a view of improving users' efficiency and supporting their participation in academic activities.

Moreover, previous studies have shown students' ability to adapt quickly to new digital solutions and to use information technologies as a neutral support for learning (Selwyn, 2016). The results obtained in the study are consistent with the approach presented. Respondents depict AI mainly as a tool that supports the completion of university assignments, but, similarly to the UNESCO report (2023), they also voice concerns about excessive trust in automatically generated content. Among other concerns expressed by the respondents were the potential impairment of critical thinking skills and risks to the integrity of academic practice.

A decidedly innovative contribution of the study lies in highlighting the need for institutional regulations - or rather the lack thereof - as a central factor underlying respondents' ambivalent attitudes toward generative tools. Previous research in this field has focused primarily on individual uncertainty or a lack of awareness regarding what is permitted and what is not (Akgun, Greenhow, 2022). The data obtained indicate that students do not lack ethical sensitivity; rather, what is missing are clear, formalized rules governing the acceptable use of AI tools within the university context. This conclusion is consistent with the findings of Williamson and Eynon (2020), who emphasize that ethical challenges in the era of digital education system are systemic rather than individual in nature.

The results of the study contradict some of the literature suggesting that laying down institutional regulation may be perceived by students as an attempt to curb their autonomy (Selwyn, 2016). Consequently, they indicate a lack of comprehensive, transparent guidelines, ethical standards, and formal and legal responsibility on the part of the university authorities, which further indicates a shift in the existing paradigm towards a co-decision-making and co-creative model of university management, where students submit a request for clarity and transparency rather than unlimited freedom. Similar trends have been noted in the latest European report on the concept of responsible artificial intelligence in education (European Commission, 2025).

Another point consistent with previous studies is the ambiguous perception of AI tools in education. According to the findings of Holmes et al. (2019) and the OECD report (2021), the available digital tools increase learning effectiveness, but at the same time can generate risks related to addiction and superficial information processing. The results obtained illustrate this ambivalence, revealing tensions between real productivity and concerns about independent critical thinking and academic integrity. This phenomenon is supported by the idea of transitioning from digital fluency to digital wisdom, understood as the ethical, reflective, and conscious use of new technologies (Floridi, 2019).

The results above have supported the authors' research hypotheses. The hypothesis of frequent and instrumental use of AI tools was fully confirmed and is consistent with the results of international studies. The assumption that the lack of formal and legal regulations may contribute to students' ethical uncertainty was also confirmed, which, in turn, correlates with current studies and reports analyzing gaps in the education management process (Zawacki-Richter et al., 2019; UNESCO, 2023). The only unconfirmed part of the study was the assumption that students considered all legal regulations to be too restrictive, whereas respondents clearly expressed the need for a specific ethical framework and open academic debate on the subject.

Further research in this area should extend the analyses presented in this study by increasing and diversifying the group of respondents and by introducing comparative perspectives across different academic disciplines and universities. The next stage of research could involve analysing the opinions of teaching and administrative staff regarding the integration of artificial intelligence into university management processes. Comparing the perspectives of students and academic staff may reveal important differences in the perception of the boundaries of responsibility and autonomy in the digital education ecosystem. This could be complemented by qualitative studies analyzing the impact of ethical regulations and transparent rules on the actual decisions made by students regarding the use of generative tools. Research of this kind could contribute to the development of a reflective culture of AI use in higher education, where new technologies become not only the objects of critical analysis, but also elements of a coherent ethical and regulatory framework.

5. Conclusion

Based on the analysis of the survey results, a number of practical recommendations can be formulated, with potentially serious implications for higher education management. It is imperative that a clear set of principles or a code of conduct regulating the use of ethical AI at the university (European Commission, 2024; UNESCO, 2023) is developed. Such a code should contain definitions and examples of acceptable and legal practices, as well as procedures for their verification. Additionally, it is indispensable to initiate an open debate concerning the disclosure of the use of generative tools use in the preparation of diploma theses and semester projects, along with easily accessible information on the implementation of such technologies by the university itself.

Secondly, in the field of education, training programs and workshops for both students and teaching staff, focusing on reflection, agency and accountability of generally available digital tools, should be implemented. Furthermore, reflective academic tasks, such as comparing texts written with and without digital assistance, need to be actively promoted. The curricula of academic courses that contain elements of communication or teach digital skills should be modernized to incorporate content related to AI ethics and transparency, e.g. through learning scenarios that would help students distinguish between legitimate assistance and sheer plagiarism in academic work.

In conclusion, the study demonstrates that artificial intelligence has already become an integral component of students' academic practices and learning strategies. While respondents generally perceive AI as a valuable tool that enhances efficiency, supports learning processes, and facilitates access to information, they simultaneously recognize the ethical challenges associated with its use. The findings highlight the importance of developing transparent institutional policies, strengthening digital literacy, and encouraging critical reflection on the role of AI in academic work. Ensuring a balanced integration of technological innovation with ethical awareness and institutional responsibility will therefore be crucial for shaping a sustainable and responsible model of higher education in the era of artificial intelligence.

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EXPECTATIONS TOWARD INTERPERSONAL INTERACTIONS IN RETAIL SETTINGS: THE PERSPECTIVE OF NEURODIVERGENT INDIVIDUALS

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Purpose: The aim of the article was to understand the expectations that neurodivergent individuals hold with regard to interpersonal interactions in retail settings. The authors also sought to identify factors that support or hinder the comfortable functioning of these individuals in their interactions with sales staff and other customers.

Design/methodology/approach: To achieve the stated objective, the authors conducted an empirical study among neurodivergent individuals using individual in-depth interviews. The research process adopted an approach grounded in the recognition of the importance of direct insight into the lived experiences of neurodivergent individuals, while data analysis was based on reflexive thematic analysis.

Findings: The exploration reveals a pronounced sense of overwhelm experienced by neurodivergent respondents, triggered by the presence of other shoppers in retail environments. Neurodivergent customers are characterized by an increased need to control interactions with sales staff, particularly with respect to autonomy in choosing the timing and manner of initiating such interactions. Moreover, they expect friendly and empathetic treatment from retail personnel.

Research limitations/implications: The study considered the perspectives of representatives of only selected manifestations of neurodiversity, which should be taken into account in future scholarly explorations by further diversifying the sample of respondents.

Practical implications: Recommendations were formulated concerning the creation of conditions conducive to positively perceived interactions between sales staff and neurodivergent customers in retail environments. These guidelines should be applied in the everyday practices of sales personnel and store managers.

Social implications: The findings are intended to contribute to increased awareness of the expectations of neurodivergent individuals regarding interpersonal interactions in retail settings. As a result, this may lead to an improvement in the quality of life of neurodivergent individuals.

Originality/value: The article contributes new insights to the academic discourse on the under-researched issue of creating neuroinclusive retail environments. The value of the paper lies particularly in identifying the expectations of neurodivergent customers toward interpersonal interactions accompanying the shopping process.

Keywords: interpersonal interactions, neuroatypical customers, customer service, stores.

Category of the paper: research paper.

1. Introduction

Retail spaces are designed as environments intended to generate maximum profits for store owners. Within these spaces, in addition to the physical environment (arranged in accordance with the principles of contemporary merchandising), the behavior of staff toward customers plays a crucial role in sales outcomes. Customer service can significantly enhance retail performance, but it can also discourage customers, leading them to refrain from making future purchases at a given store. In the context of effective communication between sales staff and customers, particular attention should be paid to neurodivergent individuals, whose perception of social interactions differs from prevailing and dominant social norms.

The purpose of this article is to understand the expectations that neuroatypical individuals hold with regard to interpersonal interactions in retail settings, as well as to identify the factors that support or hinder their comfortable functioning in interactions with sales staff and other customers. As previous research indicates, retail organizations barely acknowledge neurodiversity (Ali, Grabarski, Baker, 2004b). The authors adopted an approach that recognizes the importance of direct insight into the lived experiences of neuroatypical individuals, which is consistent with contemporary research directions in this field (Hens, Robeyns, Schaubroeck, 2019; Hens, 2021; Bernard et al., 2023; Bervoets, Hens, 2020). Qualitative data were collected through individual in-depth interviews, and the analysis of the empirical material was based on reflexive thematic analysis (Braun, Clarke, 2022; Ahmed et al., 2025).

The approach proposed in the article is original and constitutes a significant contribution to the advancement of research on the still insufficiently explored issue of designing neuroinclusive retail environments. The primary strength of the paper lies in the identification and systematization of neurodivergent customers' expectations regarding interpersonal interactions in shopping processes.

2. Literature review

The term neurodivergence is used to refer to the naturally occurring neurological diversity within the human population, described as neurodiversity (Jaarsma, Welin, 2012; Blackburn, 2023). Neurodivergence encompasses less common neurological profiles, such as autism spectrum disorder (ASD), attention deficit hyperactivity disorder (ADHD), attention deficit

disorder (ADD), Tourette syndrome, dyspraxia, and specific learning difficulties (Cruz et al., 2025; Baumer, Frueh, 2021). Notably, the term neurodivergence is most frequently associated with the first two of these conditions (Kamdar, Sabir, 2024).

The concept of neurodiversity was first introduced by the Australian sociologist J. Singer in correspondence with journalist H. Blume to describe the egalitarian dimension of the concept of neurological pluralism, promoted by online communities of individuals on the autism spectrum. According to the assumptions of the neurodiversity framework, the differences it encompasses should not be perceived as medical phenomena - deficits or dysfunctions - but rather as naturally occurring types of cognitive mechanisms characterized by specific strengths that contribute to technological and cultural development (Silberman, 2021, pp. 23, 441). The widespread prevalence of neurodiversity strongly supports the adoption of this perspective. It is estimated that neurodivergent individuals may constitute up to one-fifth of the global population (Doyle, 2020), and this proportion is increasing dynamically. Consequently, in virtually every domain of contemporary human functioning (e.g., professional contexts), there is a substantial likelihood of communication and cooperation with neurodivergent individuals (Dunne, 2024). In the context of retail, it can be assumed - on a global scale - that the population of neurodivergent individuals comprises approximately 1.85 billion customers. In addition, their families and acquaintances - potential customers familiar with neurodiversity - represent a further 3.3 billion individuals (Shin, Alexander, 2023).

Contemporary approaches to the study of neurodiversity emphasize the necessity of understanding the experiences of neurodivergent individuals through direct insight into their subjective perceptions (Hens, Robeyns, Schaubroeck, 2019; Hens, 2021; Bernard et al., 2023; Bervoets, Hens, 2020). In earlier explorations, researchers - drawing on neurocognitive theories (including theory of mind) - assumed that autistic individuals possess deficits that lead to difficulties in understanding the perspectives of others (Hens, Robeyns, Schaubroeck, 2019). Extending the theory of mind framework, some scholars argued that individuals with autism exhibit deficits in recognizing not only the mental states of others but also their own emotions (Baron-Cohen, Leslie, Frith, 1985; Frith, Happé, 1999), or are even devoid of emotions altogether (Mundy, 2009). These assumptions resulted in researchers focusing on the experiences of observers of disabilities/differences (Santuzzi, Waltz, 2016), while neglecting the self-perspectives of neurodivergent individuals. These premises were challenged only when neurodivergent individuals were granted the opportunity to speak on their own behalf and when their fundamental rights to autonomy, dignity, and respect were acknowledged (Pellicano, Heyworth, 2023).

At the same time, it should be noted that impairments in social communication and interpersonal interaction remain core diagnostic criteria for autism spectrum disorders, both in the DSM-5 classification of the American Psychiatric Association and in the ICD-11 classification of the World Health Organization (WHO). In this context, psychologists point to the double empathy problem, which refers to a bidirectional mismatch between autistic and

non-autistic individuals at both cognitive and communicative levels. This results in a partial or complete lack of mutual understanding (Milton, 2012). To mitigate this barrier, scholars advocate promoting open communication within neurodiverse environments that fosters mutual understanding and acceptance of “alterity” (Cruz et al., 2025).

Within the management literature, a clear shortage of research devoted to this issue can be observed (Doyle, McDowall, 2021). Existing studies on autism spectrum conditions have largely focused on the sensory challenges experienced by neurodivergent individuals, as well as on the specificities of their everyday functioning, most often in relation to public spaces (Manning, Williams, MacLennan, 2023; MacLennan et al., 2023; Crompton et al., 2024). Only a limited number of publications have explicitly addressed retail spaces (Bellamy et al., 2021). Based on these analyses, general recommendations have been formulated concerning merchandising practices, inclusive retailing, and supportive shopping environments (Taylor et al., 2019; De, Basu, Saraiwala, 2021; Iucolano et al., 2024).

Evidence suggests that people with complex communication needs may experience social exclusion in the retail environment (Taylor et al., 2022). With regard to the social dimension of neurodivergent individuals, the limited number of available studies has examined the potential use of digital technologies to provide support for individuals experiencing difficulties in interpersonal interactions (Walkowiak, 2021), including during shopping activities (Xia et al., 2021). It has been shown that, for many respondents, the mere necessity of engaging in interactions with other people is extremely exhausting, regardless of the specific manifestation of neurodiversity (Cruz et al., 2025, p. 3). Researchers have observed that the retail environment creates particular barriers that hinder the integration of individuals with complex communication needs. These barriers are primarily related to low levels of awareness and understanding of specific communication needs among retail participants, including store personnel (Taylor et al., 2020). In this context, it should be emphasized that shopping serves not only to satisfy basic needs but also includes maintaining one’s personal identity and self-image, and living a meaningful life (Sirgy, 1982). The importance of awareness of neurodiversity in the retail industry has been clearly demonstrated. At the same time, it has been observed that the frequency and intensity of interpersonal interactions, as well as sales staff attitudes toward customer neurodiversity, are influenced by the size of the store in which they are employed (Voelpel, Eckhoff, Förster, 2008; Ali, Grabarski, Baker, 2024a).

The considerations outlined above justify the need for scholarly exploration aimed at gaining insight into the perspectives and experiences of neuroatypical individuals - particularly in domains where solutions are designed by and for the neurotypical (dominant) majority (Cruz et al., 2025). Failure to conduct research in this area may lead to the social exclusion of individuals experiencing difficulties in social communication. Retail spaces should therefore be regarded as key areas of analysis (Taylor et al., 2021). Importantly, research should address not only the physical environments in which neurodivergent customers shop, but also the interactions they engage in with sales staff and other individuals present in retail settings.

A review of the existing body of literature indicates the presence of a research gap. There are no comprehensive studies focusing on the issues addressed in this article. To date, scholars have not published findings that examine the functioning of neurodivergent individuals in real retail environments through the lens of interpersonal interactions. The present publication seeks to contribute to partially filling this gap and to encourage scholars to undertake further research within this area of inquiry.

3. Research methodology

The authors of the present study collected empirical data using individual in-depth interviews (semi-structured interviews). The interviews were conducted on the basis of an interview guide containing questions directly related to the research problem, formulated as follows: Which aspects of the behavior of store personnel and other customers influence the perception of interpersonal interactions among neurodivergent individuals in retail settings? It was assumed that conducting an exploration focused on this research problem would make it possible to identify the expectations of neurodivergent individuals with regard to a selected - researcher-relevant - dimension of the shopping environment, as well as to formulate recommendations for sales staff concerning the accommodation of the needs of this customer group.

The interviews were conducted in accordance with the methodological rigor required for the selected research method. Data analysis was based on reflexive thematic analysis (Braun, Clarke, 2022). The empirical material was collected in May 2024. With the respondents' consent, the interviews were audio-recorded and subsequently transcribed. The interview data were analyzed using CAQDAS software (Computer-Assisted Qualitative Data Analysis Software).

Participant selection followed a purposive sampling strategy. The study involved five respondents whose characteristics met the criteria of a neurodivergent profile. Interviews were conducted with individuals holding medical diagnoses confirming attention deficit hyperactivity disorder (ADHD), dyslexia, autism spectrum disorder (ASD), and post-traumatic stress disorder (PTSD). The characteristics of the respondents are presented in Table 1.

Table 1.
Profile of the study participants

Respondent (code)	Gender	Age	Type of condition
Respondent 1 (R1)	Female	23	Dyslexia, migraines
Respondent 2 (R2)	Female	35	Migraine with aura, anxiety disorder
Respondent 3 (R3)	Male	31	Attention Deficit Hyperactivity Disorder (ADHD)
Respondent 4 (R4)	Female	19	Autism spectrum disorder (ASD)
Respondent 5 (R5)	Female	25	Post-traumatic stress disorder (PTSD), dyslexia

Source: authors' own elaboration.

The participants declared that they regularly engage in independent shopping. Given the specific characteristics of the respondents resulting from their neurodivergence, the researcher conducting the interviews demonstrated particular empathy and sensitivity toward the interlocutors. The interviews were adapted to the individual needs of the participants in order to ensure a sense of safety and to facilitate the free expression of their views. All respondents were adults and provided informed consent to participate in the study.

4. Results

The examination of the empirical material, conducted in accordance with the assumptions of reflexive thematic analysis, made it possible to identify three main themes (categories) relating to the experiences and expectations of neurodivergent individuals regarding interpersonal interactions in retail settings. The distinguished categories include: (1) social overload (excessive numbers of people in retail spaces); (2) intrusiveness on the part of sales staff and the feeling of being constantly observed; and (3) the need for friendly and empathetic customer service. Below, when presenting the interview findings, statements made by individual respondents are cited and labeled as R1 - R5 (in line with the symbols presented in Table 1).

With regard to the first identified theme, respondents emphasized the difficulty of shopping in stores characterized by high customer density. They pointed to feelings of being overwhelmed, frustration, and disorientation. Crowded environments hinder concentration among neurodivergent individuals. Moreover, according to the respondents, such conditions limit freedom of movement and evoke a sense of physical boundary violation through unwanted bodily contact.

“In stores, what irritates me is that people keep getting in my way - to the point that I can’t find anything; I get annoyed when this prolongs my shopping time. In shopping malls, instead of quickly buying what I need and leaving, frustration emerges because I find myself in a crowd. I then feel uncertainty and shame” (R1).

“I hate places with a lot of people; I avoid crowded stores. I much prefer shopping online or, alternatively, in smaller venues. I dislike stores where I feel the space shrinking - when people push past me, brush against me, bump into me, or touch me” (R2).

“I try to approach products in such a way that I don’t have to push through crowds. It takes a long time because I walk around the long way. This only makes me more agitated, and I immediately want to leave the store” (R3).

“I feel reluctant to visit shopping malls because they are usually overcrowded with people who make noise and cause discomfort for me” (R4).

“The sheer number of people is very exhausting for me; when too much is happening around me, it’s hard to focus. During my last shopping trip, I repeatedly walked from the end of the store back to the entrance instead of moving sequentially. The presence of many people didn’t help - I got distracted quickly, for example when someone wanted to take an item from a shelf where I was standing” (R5).

The second theme that emerged from the analysis of the empirical material concerned the need for autonomy during shopping and control over interactions with sales staff among neurodivergent individuals. Respondents acknowledged that the presence of other shoppers and store personnel is inevitable; however, they pointed to excessive noise generated by other customers and intrusive behaviors on the part of sales employees. Negative emotions were evoked particularly when sales staff failed to respect customers’ freedom to choose the timing and manner of initiating interaction.

“I’m bothered by store or brand representatives offering samples. I really dislike being pulled out of my shopping rhythm or having contact forced on me - it frustrates me. I perceive it as a lack of respect for my personal space” (R1).

“I don’t like being approached by staff. It may not be irritating because I know it’s their job, but it is distracting” (R2).

“Other people bother me - that’s something that can’t really be changed in stores. But customers could at least be a bit quieter, if not in shopping mall corridors, then inside the stores themselves” (R3).

“When I’m looking for something, I usually ask on my own where a product is located. I don’t need staff jumping on me before I’ve even properly entered the store. Generally speaking, I don’t have a problem with shopping itself; the issue arises in stores where the number of people and the layout of aisles create a constant feeling of being observed - both by other customers and by sales staff” (R4).

“I don’t like it when staff approach me - it really bothers me. I feel as though they’ll try to persuade me to buy more than I intend to, and in the worst case, they might succeed” (R5).

The third identified theme revealed specific expectations of neurodivergent individuals regarding friendly and empathetic customer service. In this context, respondents highlighted a contrast between negative experiences in shopping malls and positive experiences in smaller retail outlets, where contact with sales staff is voluntary, personalized, well-balanced, and empathetic. For some respondents, positive signals sent by store personnel - such as kindness, smiling, and genuine engagement - were particularly important.

“I experience pleasant shopping in one small store. When I go there, I don’t feel attacked; no one forces anything on me, and at the same time I feel taken care of. They ask whether I need help - if I say no, they leave me alone; if I say yes, I can ask questions. There’s a kind of comfortable cooperation between me and the staff” (R1).

“During one vacation, I entered a small shop full of figurines. There were so many of them, and I picked a few. There were no other customers, and I could look at and touch everything. There was also a very kind woman who made the figurines by hand and happily talked about them - she was open and non-intrusive, capable of having a pleasant conversation. I liked it so much that I left smiling; the saleswoman also seemed happy” (R2).

“Customer service in stores can be terrible. I see situations where none of the employees smile; sometimes they mutter ‘hello’ or don’t say it at all. Some stores feel so depressing that I stop going there. A positive example is a small greengrocer near my apartment - it’s expensive, so I don’t really like shopping there, but it has a pleasant atmosphere. There’s a wonderful, extremely kind woman working there” (R3).

“I don’t like it when aggressive sales assistants approach me and ask, ‘How can I help you?’ - I then feel obliged to continue the interaction. However, when they phrase it differently - politely informing me that they are available and that I can approach them if needed - I perceive it completely differently. Sometimes, I do need such help” (R5).

In summary, the analysis of interview content reveals a clear picture of the core expectations neurodivergent individuals hold toward interpersonal interactions in retail environments. These expectations include: (1) the desire for a safe space free from excessive social stimuli; (2) a non-intrusive presence of store employees and unobtrusive observation of customers; and (3) the creation of a friendly and empathetic atmosphere conducive to customer - employee interactions.

5. Discussion

The statements quoted from the interview participants are consistent with the findings reported by the few scholars who have based their conclusions on first-hand accounts provided by neurodivergent individuals. Examples of neurodivergent customers’ statements drawn from the literature include the following: “the visual and audible cacophonies of thousands of gesticulating people engaging in conversation at varying volumes reverberate through the stands, spiking my stress and amplifying my already urgent need to move”; “perhaps the lack of ‘collegiality’ among sales staff stems not from maliciousness, but results from the frustration of their need for clear, direct communication, or the need for consistent application of processes” (Cruz et al., 2025, pp. 5-6).

As already noted, only a limited number of studies have addressed the issue of how neurodiversity conditions interactions between customers and sales staff. The findings obtained so far are consistent with the results of the interviews conducted by the authors of the present study (although the interview excerpts presented here allowed for a more in-depth exploration of the phenomenon under investigation). In particular, convergent conclusions indicate that

people with complex communication needs experience barriers when interacting with sales staff (Taylor et al., 2022). For diagnosed individuals, shopping constitutes a challenging daily living skill. When confronted with unfamiliar environments, such as supermarkets, such individuals have been shown to exhibit altered behaviors and affective responses (Adjorlu et al., 2017; Robles et al., 2022).

Given the significant social relevance of the issue under study, the practical implications derived from the interviews are of importance alongside their academic contribution. In light of the results obtained in the present study, as well as findings reported by other scholars, a practical recommendation emerges highlighting the need to formulate policies and guidelines supporting neurodivergent individuals in navigating a social world. Neurodivergent retail customers have indicated that they struggle to understand rules “if they are unspoken, ill-defined, changed mid-game, or even routinely ignored by others” (Cruz et al., 2025, p. 4). It therefore appears justified to propose the development - at a concise and synthetic level - of clear service guidelines for interactions with neurodivergent customers. Such a document should take into account situations that require support from sales staff as well as those in which assistance is unnecessary or undesired. It should also serve as a training resource for retail employees, as training is crucial given that sales associates can reduce customers’ levels of stress in crowded situations by employing their task and interaction competences (Lucia-Palacios, Pérez-López, Polo-Redondo, 2018). Retail companies’ policies in this area should be made visible within stores (e.g., in the form of posters or notices), thereby helping neurodivergent customers orient themselves with regard to the rules applicable in a given retail setting. It is recommended that such guidelines be supplemented with graphic elements to facilitate comprehension. When designing retail spaces, it is essential to consider that many neurodivergent individuals prefer limited social interaction and may display heightened sensitivity to sudden loud sounds. These sensitivities may contribute to impairments in language comprehension (e.g., understanding sales staff communication) and to a reduced ability to distinguish relevant sounds from background noise. The importance of this aspect of in-store functioning has been emphasized both in the scientific literature (Rotschafer, 2021; Perkowski et al., 2024; Cruz et al., 2025) and in the interviews conducted by the authors. Consequently, it is advisable to design “quiet zones” within stores or to introduce “quiet hours” - areas or time periods during which customer conversations are minimized. The interview findings further indicate that sales staff training programs should place greater emphasis on neuroinclusivity and non-intrusive customer service.

It should also be noted that, in addition to promoting attitudes of openness among sales staff, it is important to undertake initiatives aimed at preparing neurodivergent individuals to function as independent customers. This may be achieved through personalized training programs (including, for example, serious games or virtual reality - VR - solutions), which allow individuals with ASD to practice shopping-related activities in a controlled and supportive environment (Adjorlu et al., 2017; Bhatla, Shankar, Jalal, 2022; Vallefucio et al., 2022).

6. Summary

The conducted interviews provided valuable insights. However, as a pioneering study, it has certain limitations - primarily with regard to the representativeness and size of the interview sample, as well as the absence of methodological triangulation through the combination of multiple research methods. The further research should include respondents representing a broader range of neurological differences than those characterizing the participants of the present study (ASD, ADHD, dyslexia, migraines, anxiety disorders). Moreover, future studies should involve larger samples. To achieve a broader and more nuanced understanding of the phenomenon under investigation, it would be beneficial to apply additional research methods within a triangulation framework, including both qualitative approaches (in particular focus group interviews) and quantitative methods (such as surveys conducted among neurodivergent individuals). It would also be worthwhile for future studies to incorporate the perspective of the other party to the interaction, namely sales personnel.

The conclusions presented in this study - by identifying key themes related to neurodivergent individuals' expectations regarding interpersonal interactions in retail settings - contribute to the development of knowledge on the creation of inclusive retail environments. In doing so, the study constitutes an initial step toward addressing the identified research gap. Furthermore, it outlines directions for future research for scholars interested in the social dimensions of neurodivergent individuals' functioning (e.g., the need to further examine social overload in retail spaces). Importantly, the findings also provide practical guidance for sales staff and store managers.

Finally, it should be emphasized that the findings of the conducted interviews constitute new and broadly applicable knowledge, extending beyond the retail context. They may be used both in academic research and in practice with regard to all shared spaces in which interactions with neurodivergent individuals take place (including, among others, public offices, railway stations, airports, educational institutions, places of worship, and cultural institutions).

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ANTECEDENTS OF CONSUMER ENGAGEMENT IN CO-CREATION OF INNOVATION – LITERATURE REVIEW

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Purpose: Taking into consideration an important role of consumer participation in co-creation of innovation as well as the emergence of many virtual spaces for this process, present paper aims to answer the question what drives a consumer value co-creation of innovation in the context of virtual environment.

Methodology: The author conducted a systematic literature review covering research papers from period 2015-2025. For searching reviewed articles the Scopus database was used. Only top tier journal from AJG 2020 list was included into analysis.

Findings: Antecedents of co-creation of innovation can be associated with extrinsic motivations and intrinsic motivations. Extrinsic motivations are monetary oriented whereas intrinsic motivations include: enjoyment of contributing, need of social interactions (contact with people, social recognition), desire to make contribution (or empowerment), learning (acquiring knowledge), ability to co-create (customer knowledge and skills), and perceived risk of co-creation.

Research limitations/implications: The publication search procedure presented in this paper uses only the Scopus database. The use of ABS list as criterion could cause that some publication in journals were omitted.

Practical implications: Collaboration between companies and consumers in co-creating innovation brings many benefits, including generating new ideas, product development and reducing financial costs of market research. Understanding an individual motivations of consumers will allow companies to better design activities that maintain and encourage future cooperation.

Originality/value: The presented results allow us to establish the state of knowledge regarding the motivation why consumers engage in co-creating innovation. The context of the virtual environment as a space for collaboration is particularly important here.

Keywords: co-creation, innovation, user participation, consumer engagement.

Category of the paper: research paper.

1. Introduction

Nowadays, rapid technological progress is causing changes in consumers' preferences and lifestyles (Rubio, Villaseñor, Yagüe, 2021). The wide availability of the Internet in the last decade has changed the way of communication and information flow (Burri, 2010). At the same time, we can observe a growing trend of reluctance to purchase ready-made products and services from the company's existing offer (Bednarz, 2017). The DIY trend, namely "do it yourself", has gained popularity. People intentionally undertake activities, despite the awareness that the whole production process can be outsourced to external entities (Trivedi, Pandey, Trivedi, 2022). Customization and personalization of consumer products requires significant input from the consumer already at the design and production stage (Bruns, 2016).

Many online platforms are heavily used by producing consumers (Fuchs, 2014). For example Wikipedia, where users are constantly adding and editing content (Ritzer, 2010). Social media (e.g. Facebook, MySpace), where profiles are created with photos and videos, contacts are established and communities are formed, enable consumers to participate in new type activities and provide a new dimension of customers' empowerment. Companies have an opportunity to interact with customers more broadly and more richly in relatively short time. The virtual world constitute a space for communication between companies as well as consumers. Different brand strategies can be implemented with use of electronic discussion forums, chat rooms, or online communities. Despite many company initiative, online consumers' community can also get involved in building brand message. New forms of cooperation allow strengthen consumer and brand relationships and engagement (Fernandes, Remelhe, 2016; Ritzer, 2010). Internet users create a market on auction portals such as eBay and share own amateur movies on YouTube. Inside a computer games players introduce changes into character image and whole virtual environment (Ritzer, 2010). Producing unofficial game content (*game modding*) represents a significant source of innovation for game developers. Firms noticed potential in work of amateur creators and began to stimulate player creativity. They encourage modders to cooperation by providing wide range of tools dedicated to modders' community (Burger-Helmchen, Cohendet, 2011; Prügl, Schreier, 2006). It became very valuable asset for developers because modding reduce a significant part of costs associated with gathering and sharing knowledge, and product development in general (Burger-Helmchen, Cohendet, 2011).

When the customer takes an active role in preparing the composition and the delivery of company's offering the value is created (Solakis, Katsoni, Mahmoud, Grigoriou, 2024). Value co-creation is an interactive process that integrates parties with particular knowledge and skills for a mutually beneficial collaboration (Solakis, Peña-Vinces, Lopez-Bonilla, 2022). The partnership between a company and experienced consumers enables the development of systems, products or services, which is crucial to creating innovation. The success of many

companies is based on innovation (Seran, Izvercian, 2014). After worldwide economic crisis in 2007-2010 years, the old approach to consumption has been replaced by collaborative open innovation model. Smart and creative organizations are developing new open innovation strategies in collaboration with external partners. This allows for greater freedom of idea flow and faster product innovation. The trend towards creative collaboration among consumers, which is spreading in the virtual world, enable companies to co-create products or services with their own customers, in a relatively short time, with good management of goods and costs. This leads to increased customer engagement and satisfaction (Izvercianu, Seran, Buciuman, 2012).

Marketing scholars as well as practitioners recognized the significant role of customer participation in the process of building companies' competitive advantage (Cui, Wu, 2016). In current literature scholars emphasize a significant role of consumers in developing company's offer. It can be rank from valuable product improvement suggestions to technical knowledge of customers to generate numerous innovative ideas (Nambisan, Baron, 2009). It allows to bring customers closer to the brand. People feel more empowered and appreciated because they have sense of influence on shaping the company's future offer. Virtual customer environments constitutes services, that can be ranked from online discussion forums to virtual design and prototyping platforms. Virtual environment offer firms an opportunity to involve consumers in product design, testing, and product support activities (Auh, Menguc, Katsikeas, Jung, 2019).

Taking into consideration an important role of consumer participation, present paper aims to answering a question what drives a consumer value co-creation of innovation in the context of virtual environment. To meet the assumed goal the author conducted a systematic review of current literature.

2. Value co-creation

Co-creation is developing paradigm in the current management literature. The concept assume that suppliers and customers are no longer on the opposite sides but collaborate in order to achieve new business opportunities (Galvagno, Dalli, 2014). The value is created not inside the organization but through relationships outside the formal boundaries of company.

Value co-creation can be defined as a joint collaborative activity by parties involved in direct interactions, aiming to contribute to the value that emerges for one or both parties (Grönroos, 2012; Grönroos, Voima, 2013). The process contains an elements such as knowledge enhancement and exchange, skills acquisition, as well as organizational learning. It arise a sense of ownership to consumers as a result of their contribution to the value development (Solakis, Peña-Vinces, Lopez-Bonilla, 2022). The collaboration between

a company and experienced consumers contribute to the development of systems, products or services (Seran, Izvercian, 2014). The quality of interaction depends on the created unique experience that led to induce emotional attachments with company's offerings. Consumer sense of being part of its product development process help a to gain a competitive advantage to the organization (Solakis, Peña-Vinces, Lopez-Bonilla, 2022).

The service science approach proposed by Vargo and Lusch (2004) assumed that companies should not consider products that they sell as physical goods but from the point of view of the services associated with company's offer (Galvagno, Dalli, 2014). This assumption underlies the Service-dominant logic theory (S-DL) that is helpful in explanation consumers' behavior, especially answering a question how they engage with and assess services or products. In this context, individual's behavior is influenced by the factors such as customer experiences, interactions and perceived value co-created with service providers (Chandra, Rahman, 2024). Partnership with customers give an organization opportunity to learn from customers and prepare its offering according to their perceived value (Solakis, Peña-Vinces, Lopez-Bonilla, 2022).

3. Systematic literature review procedure

In order to meet the assumed goal, the author employed a systematic literature review covering the last 10 years of research. Systematic literature review is based on replicable and transparent steps. Before starting the search, several criteria for the inclusion of publications were established. At first, the papers should focus on cooperation between consumers and company and the value that they co-create together in terms of innovation. Articles need to consider antecedents of consumers' involvement in co-creation of innovation. Second, only empirical studies are eligible. The author included all types of research conducted in the investigated field, quantitative as well as qualitative. Third, only English written papers were selected. The choice of the English language allowed for the inclusion in the analysis of works that have been internationally assessed and function in the international scientific circulation. The result was limited to articles in peer-reviewed top tier journals from AJG 2020 list.

Utilizing Scopus database, the author has searched for all scientific papers published in the period from January 2015 to April 2025. With use of the "co-creation" and "innovation" key words, 1184 scientific papers in English language were found. Figure 1 presents a number of publications in different subject area.

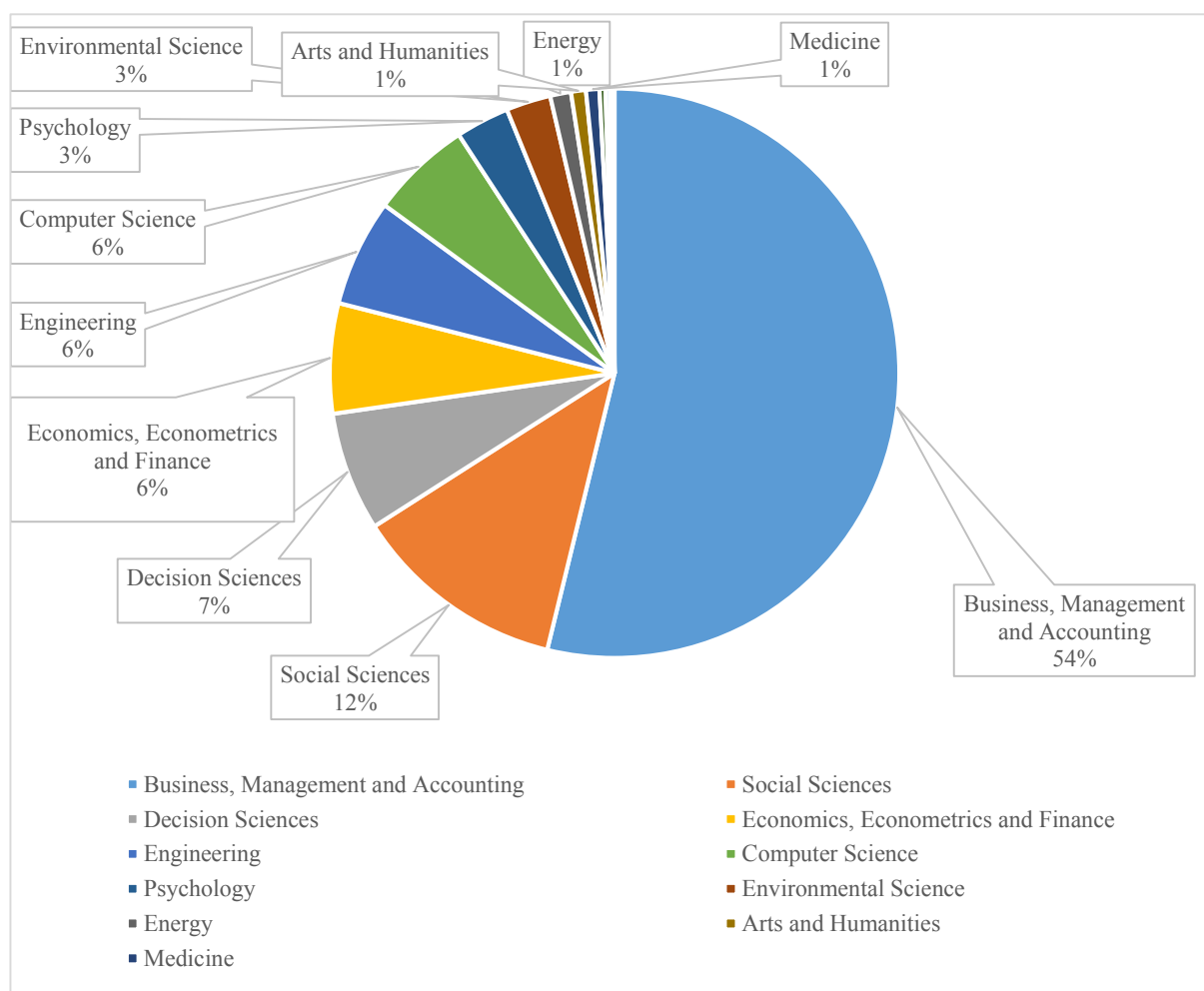


Figure 1. Number of articles published in journals across subject area.

Then, the results were limited to the field of business and accounting. In this area the author obtained 637 papers. Figure 2 shows the number of publications in the 10 years period. The growing trend, especially in 2024, indicate the increasing interest of scholars in customer co-creation of innovation.

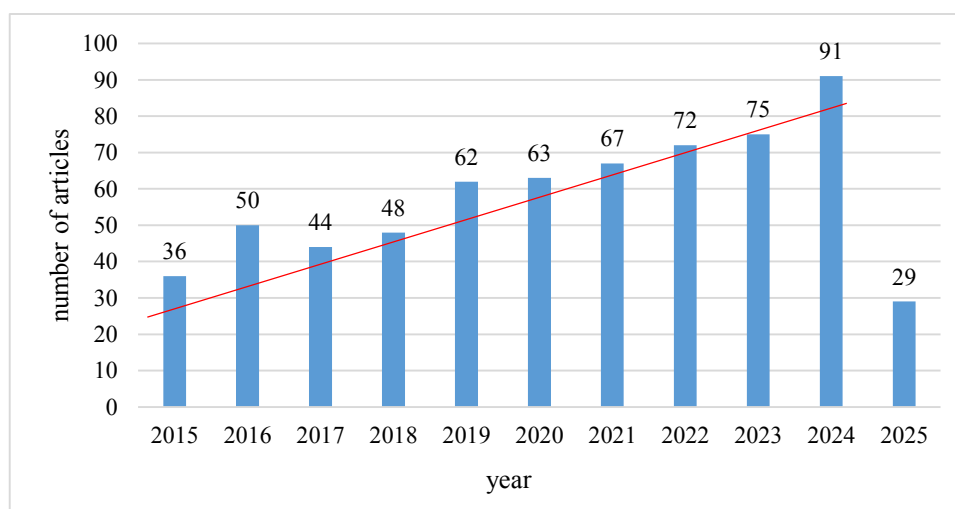


Figure 2. Number of articles published in journals and trend line.

Next, the search was limited to quality journals within the business and managerial literature fields by use the Chartered Association of Business Schools Academic Journal Guide (ABS 2020) (Akter et al., 2021; Leonidou et al., 2020; Mitrega et al., 2022; Pereira et al., 2021). In order to find scientific paper related to posed research questions, the author include to the further analysis only papers that contained key words: “antecedents”, “motive” or “motivation”. It allows to receive 40 papers. After that, the author analyzed abstracts of gathered articles. Papers that were not based on empirical research were also removed. The screening of all articles allows to receive 10 papers (appendix 1).

4. Results of the systematic literature review

In the context of innovation, consumers take on different roles in the value co-creation process and are involved to varying degrees. They can be divided into three types: informed, involved, and innovative. Informed consumers actively seek information and use it to meet their needs. Involved users participate in creation of innovation process. Innovative individuals provide innovation according to their own ideas (Huang, Iakovleva, Bessant, 2024). Similarly Nyström, Leminen, Westerlund and Kortelainen (2014) proposed four types of innovative consumers: the informant, the tester, the contributor, and the co-creator. They considered the levels of collaboration from passive to proactive participants, analyzing co-creation at different levels of consumer engagement.

Cui and Wu (2016) distinguished three forms of customer involvement in innovation: customer involvement as an information source, customer involvement as co-developers, customer involvement as innovators. They assumed that different customer involvement are driven by different factors. The results show that three types of customer involvement on new product performance are influenced differently by the nature of customer knowledge, the firm’s knowledge management strategy, and organizational support for knowledge management implementation (Cui, Wu, 2016).

The results of conducted research by Huang, Iakovleva and Bessant (2024) allows to-developed a framework and identified four interdependent phases of consumer involvement in innovation: recruitment, motivation, co-creation, and relations. Not every consumer is involved in all four stages equally and different phases can consist of different participants. Because the company goal is to enhance consumer involvement in long term, the vital phase is motivation stage.

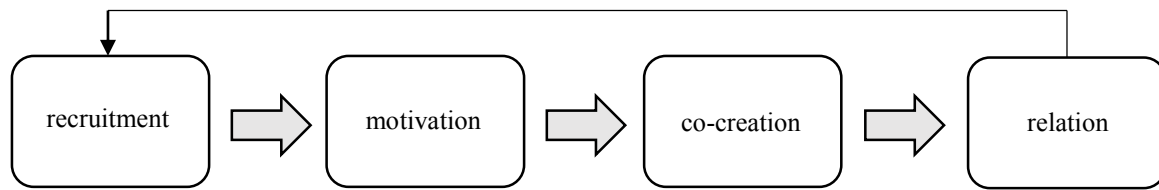


Figure 1. Framework for user involvement in innovation.

Source: Huang, Iakovleva, Bessant (2024).

According to authors, consumers are motivated to participate in co-creation activities because they want to meet following needs: social interactions, learning and contributing, empowerment, and compensation. The possibility of social interactions encourage consumers to contribute because of possibility to meet new people, exchange experiences with them, and engage in collaborative work. It increase a sense of belonging. Co-creation of innovation also allow to develop new skills and gain new knowledge. Consumers feel fulfilled when their contributions influence societal or technological progress. They are motivated by intrinsic factors like altruism. They create solutions that adapt to the broader needs of the community. Empowerment is related to consumer need of seeing their own ideas integrated into company's project and being proud of their contribution to innovation. Compensation include extrinsic factors such as monetary and alternative means. An example can be free meals, coupons, goodie bags, and gift cards. Sometimes, compensation can takes direct form of reimbursement for consumer's expenses (Huang, Iakovleva, Bessant, 2024).

Taking into consideration an important role of consumers in co-creation of innovation, it is worth to answer a questions, why people engage in this process. Research regarding customer co-creation in web-based multisided platforms suggest the following antecedents: culture, technology, intellectual property rights, and diverging interests.

Culture refers to the organizational culture and co-creation mechanism provided by company. Culture should also be considered as the cultural background of the society in general and participants of co-creation process. Technology can be indicated as an important driver as well as barrier of co-creation. If consumers are able to used technology, it can facilitate an interaction. But if the technology is difficult or complicated to use or has not been widely diffused, it can be a real barrier. Company's approach to intellectual property play an important role for co-creation activities. Participants involved in co-creation should be convinced about a fair and transparent rules related to benefits, economic or not economic (e.g., share of the profits, royalties, peer recognition). They should feel safe when they share their resources and experiences and get appropriate remuneration (de Oliveira, Cortimiglia, 2017).

Rubio, Villaseñor and Yagüe (2021) investigated co-creation behavior in the retail context. They distinguish two levels of involvement: a basic level related to feedback or communication of service errors and a higher level related to the consumer's participation in service innovation. More engage consumers share their own ideas and suggestions for preparing new company's offer, describe current trends in the services, suggest new modes of service, etc. The authors

indicated trust and perceived support as antecedents of co-creation of innovation. Trust can be defined as “the belief that the intentional action of one party is appropriate for the other party”. It is based on belief about the someone’s good intentions, competence, capability and reliability. Perceived support is the extent to which the communicator and the audience (company and consumer) are willing to improve communication between themselves. The company must supports consumers to encourage them to participate in co-creatin. According to results, trust and perceived support are equally important for encouraging the basic level of engagement, communication of service errors. In terms of more advanced level of co-creation perceived support is the most important driver to co-create. Trust also influence consumer engagement but significantly less than perceived support (Rubio, Villaseñor, Yagüe, 2021).

Engström and Elg (2015) investigated what drives patients to take part in service development. They indicated a number of motives: non-interest in participating, restitution after poor treatment, desire for contact with others, volunteerism, desire to make a contribution and the enjoyment of having a task to complete. The non-participatory approach is related to people who refused to participate in service co-creation. Some patients engage in service co-creation to find restitution from a service failure. Other consumers are drive by desire for contact with community. Participation in service co-creation is an opportunity to gather information’s and gain social support of care providers and others. The volunteerism is based on consumers’ sense of citizenship. Vast par of consumers are focused on being productive and feel a need to make a contribution to service. These patients have a strong sense of competency and self-assurance. Sometimes patients engage in service development because the need of enjoyment from completing the tasks. They are not guided by a need to accomplish an external goal (Engström, Elg, 2015).

Fernandes and Remelhe (2016) carried out a research aimed identifying customers’ motivations to engage in co-creation of innovation in virtual environment. The authors distinguished intrinsic and extrinsic motivations. Intrinsic motivations include a sense of self-expression and the pure enjoyment of contributing in terms of creativity. According to authors extrinsic benefits consist of social aspects, enhanced knowledge and economic benefits.

Conducted study gave prove that the greatest influence on customer engagement is exerted by the group of intrinsic motivations and knowledge acquisition. Significant role can be also assigned to socialization with others with similar interests. The prospect of remuneration for engagement in co-creation was not among the most important drivers in this case. The possibilities of receiving financial benefits do not has an influence on participation in collaborative innovation practices (Fernandes, Remelhe, 2016).

Lee, Lee and Tussyadiah (2017) applied Theory of planned behavior. The authors investigated factors that can motivate tourists to participate in co-creation of innovative tourism products. They proposed following antecedents: perceived benefits, perceived costs, subjective norms, and ability to co-create tourism innovations. Conducted research indicated that perceived benefits, subjective norms, and ability to co-create increase intention to co-create.

Perceived costs were found not to have a significant impact on intention to co-create. Tourists engage in innovation co-creation activities because they consider new product development to be beneficial for them (e.g. opportunity for social interactions, new knowledge acquisition). Moreover, consumers are more willing to contribute when they feel that their work is appreciated and supported by close friends or family. The key drivers is also possessing the necessary abilities and skills to co-create the innovation (e.g. rich experience in new product and service development, rich knowledge, creativity). The research confirmed that tourists participated in co-creation of innovation are not afraid of internal costs (e.g. the possible conflict with other people, the sacrifice of their own free time, disappointment from failure) and external costs (financial expenses). Consumers perceive their work as voluntary and do not expect any external benefits (e.g. financial bonuses) (Lee, Lee, Tussyadiah, 2017).

The issue of social support also appears in the case of other research on brand engagement in co-creation of innovation in social commerce. Social commerce is referred to a variety of commercial activities in social media platform. In social media consumers offer product assessment, exchange product's recommendation, and share their own experience. In this context, customers co-create value of particular brands. Bazi, Hajli, Hajli, Shanmugam and Lin (2020) established following antecedents of customer participation: social support, social commerce value and social commerce information. Social support is defined as perceived social resources that are actually provided to social media users by non-professionals from formal and informal support groups. In social media, customers can received two main forms of support, informational and emotional. Informational support refers to providing commercial information about the brand or product, such as product reviews, product recommendation and sharing shopping experience. Emotional support refers to offering other consumers mutual psychosocial support based on exchanging care, comforting each other in supporting purchase decision making process (Bazi, Hajli, Hajli, Shanmugam, Lin, 2020).

In 2015, Zhang, Kandampully and Bilgihan proposed a research model that show consumers' motivation to participate in co-creation of innovation in the hospitality industry. They include in the model three motivations: brand equity, sense of community and monetary incentive. A sense of community is a feeling of belonging to specific group of customers and can be explained by the theory of subjective norms. Subjective norms are personal feelings about other people's expectations towards us and the extent to which these feelings influence our behavior. In this case our actions depends mostly on a need for approval. Consumers voluntarily engage with the community because they are interested in helping others and participating in various activities. Belonging to community endorses consumer's value for themselves and for others people. A sense of community enhance consumer's involvement in the community.

Monetary incentive include direct benefits such as profit sharing to various form of indirect incentives like samples, beta products or receiving intellectual property rights. It was suggested that monetary incentives enhance consumers' positive attitude toward engagement

in co-innovation. The authors also imply that customers' prior experience with cooperation with innovation projects can moderate the effects of the abovementioned motivations on consumers' attitude towards engagement in co-creation of innovations (Zhang, Kandampully, Bilgihan, 2015).

Research in the context of a shared healthcare platform allowed to infer that consumers need to gather more information about the risk of consuming, delivering, and producing particular services or products. Because it is companies' responsibility to take care of customer safety, it can be inferred that a firm is obligated to inform customer about potential risk of involving a particular service or product. Managers should be aware that risk perceived by customer plays a crucial role in the value co-creation process (Akter, Babu, Hossain, Hani, 2022).

More recent study investigated the motivation of consumers to engage in new product co-creation according to different stages of participation, namely recruitment before, retention during and finalizing of a co-creation project. The authors considered following motivation factors: intrinsic, knowledge, empowerment, altruistic, social and reward-oriented motives. The results showed that consumers make a decision about joining the project because of curiosity and desire to meet new people. They continue the creative tasks after positive anticipation and enjoyment of new tasks and positive feedback received. When the project is in the final stage, the motives such as the usefulness of outcomes, the received recognition and perceived creative self-efficacy of consumers gain importance (Klincewicz, Jacobsen, Dębska, Gazdecki, Goryńska-Goldmann, Król, ... Zatorska, 2024).

5. Conclusions

The spread of new technologies in consumer and company interactions has changed the roles of customers in innovation and value creation (Nambisan, Baron, 2009). The benefits of consumer participation are undeniable thus present paper aims to answer the question what drives a consumer value co-creation of innovation in the context of virtual environment. Previous research allows to draw some conclusions. In general, antecedents of co-creation of innovation can be associated with extrinsic motivations and intrinsic motivations. Extrinsic motivations are monetary oriented whereas intrinsic motivations include: enjoyment of contributing, need of social interactions (contact with people, social recognition), desire to make contribution (or empowerment), learning (acquiring knowledge), ability to co-create (customer knowledge and skills), and perceived risk of co-creation. The research predominantly encounters different online co-creation platforms (e.g. Huang, Iakovleva, Bessant, 2024; Shin, Perdue, 2022) frequently created on the purpose of the innovative project (e.g. Lee, Lee, Tussyadiah, 2017). It is worth to pay attention that part of studies consider co-creation behavior while meaningful number of articles focus only on intention to co-create value.

Presented literature research have also a few limitations. The publication search procedure presented in this paper uses only the Scopus database. The Scopus database allows for reliable identification of publications that meet the established requirements. In the future, the literature review could be expanded on additional databases. Second, the use of ABS list as criterion could cause that some publication in journals were omitted. Future research can be expanded with other journals.

Taking into account growing body of content created by consumers in virtual environment (e.g. Hutzinger, Weitzl, 2021; Pentina, Guilloux, Micu, 2018) and digitalization of companies' activities (e.g. Ribeiro-Navarrete, Botella-Carrubi, Palacios-Marqués, Orero-Blat, 2021; Zeng, Ran, Zhou, Jin, Cheng, 2022) there is relatively low progress in research made. In the analyzed publications, the authors indicate numerous opportunities for future research. Future research should explore how user involvement evolves over time and how particular co-creation stages impact innovation outcomes and long-term cooperation (Huang, Iakovleva, Bessant, 2024; Klincewicz et al., 2024; Shin, Perdue, 2022). Some researcher encourage to investigate whether customer motivations and participation in collaborative innovation vary depending on type of industry (Lee, Lee, Tussyadiah, 2017; Rubio, Villaseñor, Yagüe, 2021). Gathered knowledge is limited to industries such as health care and hospitality services. It is also recommended to analyze different cultural and geographic contexts (Fernandes, Remelhe, 2016; Rubio, Villaseñor, Yagüe, 2021). Future research should also focus on different types of co-creation platforms, e.g., sharing economy platforms, marketplaces, innovation platforms to better understand how value co-creation process differ across them (Lee, Lee, Tussyadiah, 2017; de Oliveira, Cortimiglia, 2017). Future research should consider other media for example social networking sites and computer games.

Some authors indicated an importance of development and testing of digital tools supporting co-creation (Huang, Iakovleva, Bessant, 2024), thus future research should examine how emerging digital technologies such as artificial intelligence, Internet of Things, and advanced data analytics can support and transform co-creation processes in innovation ecosystems.

According to several authors, in the future scholars should conduct longitudinal studies on user involvement in innovation processes (e.g. Engström, Elg, 2015; Fernandes, Remelhe, 2016; Huang, Iakovleva, Bessant, 2024; Klincewicz 2024; Lee, Lee, Tussyadiah, 2017). The authors suggest using different methodologies such as case studies, experimental research (Cui, Wu, 2016; Fernandes, Remelhe, 2016) and mixed-method research designs combining qualitative and quantitative methods to better understand the dynamics of customer participation over time (Engström, Elg, 2015) and explain how value co-creation processes influence service innovation, perceived value, and patient welfare over time (Rubio, Villaseñor, Yagüe, 2021).

According to the authors' knowledge, the aspect of co-creation of brand innovation is essentially omitted. Widespread new media allow consumer to participate in creating brand communication and brand image. Fernandes and Remelhe (2016) also suggest to examine

co-creation activities across community types, e.g., online communities, brand communities, to understand how participation dynamics vary. It is worth to investigate how people engage in branded innovations, what are their motivations and how companies can manage this phenomenon.

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Appendix

Research paper related to antecedents of co-creation of innovations

Authors, Year	Journal	Motives / Antecedents	Media type	Method
Huang J.H.; Iakovleva T.A.; Bessant J. (2024)	International Journal of Innovation Management	social interactions, learning and contributing, empowerment, compensation	living labs (collaborative innovation spaces)	Interviews <i>behavioral results</i>
Klincewicz K.; Jacobsen L.F.; Dębska K.; Gazdecki M.; Goryńska- Goldmann E.; Król K.; Lähteenmäki L.; Wielicka-Regulska A.; Zatorska M. (2024)	Creativity and Innovation Management	intrinsic, knowledge, empowerment, altruistic, social, reward-oriented motives	offline co- creation project	Interviews <i>behavioral results</i>
Shin H.; Perdue R.R. (2022)	International Journal of Hospitality Management	customer empowerment, social recognition rewards	online hospitality platforms	experimental studies, survey <i>intentions</i>
Akter S.; Babu M.M.; Hossain M.A.; Hani U. (2022)	Journal of Business Research	dialogue (continuous interactions between the consumer and service providers), access to the customers' preferences, risk (of consuming, delivering, and producing particular services or products), transparency (equity while discussing value co-creation) <i>sharing economy approach</i>	a shared healthcare platform	survey <i>behavioral results</i>
Rubio N.; Villaseñor N.; Yagüe M.J. (2021)	International Journal of Retail and Distribution Management	trust, perceived support <i>service-dominant logic</i>	offline co- creation project	survey <i>behavioral results</i>
Lee G.; Lee J.; Tussyadiah I.P. (2017)	Asia Pacific Journal of Tourism Research	perceived benefits, perceived costs, subjective norms, ability to co-create <i>theory of planned behavior, self- determination theory</i>	innovation co- creation platforms, co- creation of tourist destinations	survey <i>intentions</i>
de Oliveira D.T.; Cortimiglia M.N. (2017)	Business Horizons	culture, technology, intellectual property rights, diverging interests <i>service-dominant logic</i>	web-based multisided platforms	systematic literature review, interviews, an analysis of secondary data on representative cases <i>behavioral results</i>

Cont. table

Cui A.S.; Wu F. (2016)	Journal of the Academy of Marketing Science	the nature of customer knowledge, the firm's knowledge management strategy, organizational support for knowledge management implementation	offline co-creation project	survey <i>behavioral results</i>
Fernandes T.; Remelhe P. (2016)	Journal of Strategic Marketing	intrinsic motivation (a sense of self-expression, enjoyment of contributing), extrinsic benefits (social benefits, enhanced knowledge, economic benefits)	FS (Android) collaborative platforms	survey <i>behavioral results / intentions</i>
Engström J.; Elg M. (2015)	Journal of Services Marketing	restitution after poor treatment, desire for contact with others, volunteerism, desire to make a contribution, the enjoyment of having a task to complete <i>self-determination theory</i>	health-care service development, offline	solicited diaries, in-depth interviews <i>behavioral results</i>

Source: own elaboration.

IMPLEMENTATION OF LEAN MANAGEMENT CULTURE ELEMENTS IN UNIVERSITY MANAGEMENT

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Purpose: The aim of the article was to analyze the implementation of Lean Management culture elements and to assess the degree of this implementation by public academic universities in Poland.

Design/methodology/approach: The research results presented in this article cover the period 2021-2025. The study was conducted at public academic universities in Poland, and the analysis of Lean Management culture elements was one of many topics addressed in the study. The study was conducted using a survey method.

Findings: Twenty elements of Lean Management culture were examined, grouped into four areas: strategic perspective, eliminating waste, human capital management, problem identification and solving. The varying degrees of implementation of individual elements of Lean culture were indicated.

Research limitations/implications: Limitations in the empirical part of the article may result from the number and content of Lean Management culture elements used in the analysis, as well as the scale of assessing their implementation. Every scientific study is burdened with researcher subjectivity, which, despite limitations, leads to research results and conclusions.

Practical implications: The key findings of this study are the elements of Lean Management culture that achieved the highest and lowest levels of implementation. The highest-rated elements included: university's openness to organizational, social, and technical changes, the freedom within the university and the space for discussion and individual opinions, and the appreciation of the role of partners and collaborators, which should translate into their broader involvement in university processes. The lowest levels of implementation were related to: employees are not integrated (loyal) with the university's vision, mission, and strategy, poor internal communication system and employees are not committed to the continuous improvement of the university.

Originality/value: The topic of implementing Lean Management culture elements at universities is still rarely addressed in research and academic publications. This article is another scholarly publication the author has undertaken on this topic. Universities, as organizations, should be focused on implementing modern improvement concepts, including Lean Management.

Keywords: Lean Management, university, organizational culture.

Category of the paper: Research paper.

1. Introduction

Lean management is a business strategy and not a toolset. Lean is the willingness on each hierarchical level to question one's own behavior, to learn from mistakes and to continuously develop new solutions towards waste-free processes. Lean stands for permanent customer-focused and value-adding thinking and acting (Höfer, Naeve, 2017, p. 64; Balzer, 2010; Sunder, 2016, pp. 159-178; Teichler, 2016, pp. 13-51).

All lean activities require high lean awareness of all participants (in the case of institutions of higher education: students, staff, professors, companies, and partners) as well as lean leadership (Liker, Convis, 2012, p. 13). Based on this, five factors for an organization to apply lean thinking in this environment can be defined: leadership and vision, management commitment and resources, linking lean to universities strategy, customer focus and selecting the right people. This list can be supplemented by lean culture and lean instruments. Lean culture is one of the key messages of the lean strategy. But this requires that individuals are able to recognize their own failures, to admit them, and to identify them as a potential area for improvement. To facilitate this, an essential task of lean leadership is to convince staff members that problems and mistakes are not considered as threats or as bad in general. Mistakes are chances to improve if we analyze their causes without blaming anybody, search for solutions, and implement them together (Höfer, Naeve, 2017, p. 76; Altbach, 2002, pp. 153-168; Carvalho, 2020; Thomas, Antony, Francis, Fisher, 2015, pp. 982-996; Tight, 2012; Yorkstone, 2016). The catalog of Lean instruments is very broad and encompasses concepts, systems, methods, techniques, and tools for quality management and improvement. The vast majority of Lean instruments used in enterprises can be applied to university projects, such as auditing, brainstorming, flowcharts, FMEA and QFD methods, value stream mapping, benchmarking, SWOT analysis, and 5Why. The catalog of Lean instruments is open and flexible. Individual instruments can be modified and adapted to the specific needs of the university. It is important that the use of instruments brings specific benefits to the university, whether in the form of identified causes of problems or solutions to a given issue. An important issue that should be clearly emphasized is the knowledge of Lean instruments among university management staff. Education, training, and the transfer of relevant knowledge are crucial in this regard (Jakubiec, 2017, 2021, pp. 115-116; Klochkov, Gazizulina, Ostapenko, 2020, pp. 445-460).

This article is a theoretical and empirical study of the topic. The successful implementation and functioning of the Lean Management concept depends on the degree of implementation of Lean culture elements at a university. Generally, Lean Management culture refers to the concept's assumptions, such as waste elimination and continuous improvement. However, it is important to note the connection between organizational culture, university organizational culture, and Lean Management culture. Analysis of this connection and characterization of the

above issues complete the theoretical aspect of the article. The empirical section includes a presentation of selected results of a broader study conducted by the author between 2021 and 2025 at public academic universities in Poland. This presentation assesses the degree of implementation of Lean culture elements at the universities studied.

2. Organizational culture and Lean Management culture – theoretical background

The concept of organizational culture stems from two perspectives in organizational and management theory (currently management and quality sciences). The first refers to the organizational environment and stems from an analysis of the influence of the national culture of specific communities on management. National culture is one of the determinants of an organization's specificity. In this sense, it defines general expectations for employees, for example, regarding loyalty. The second perspective refers to the behavioral school, which focuses on interpersonal processes and group dynamics within an organization. Organizational culture is treated as an internal factor of the organization (Aniszewska, 2003, pp. 17-20; Mann, 2015, pp. 3-5).

The above definitions of organizational culture provide a basis for defining the organizational culture of universities. Ł. Sułkowski attempted such a definition in his monograph entitled "Fuzje uczelni: Czy w szaleństwie jest metoda?". The following can be identified as components of the university's organizational culture (Sułkowski, 2017; Emiliani, 2015):

1. Cultural values, such as assumptions and social and organizational norms, constitute the core of culture, defining the university's identity, individual roles, and relationships with the environment. These components largely underpin the social norms that guide the behavior of university members.
2. Communication constitutes a crucial element in creating a university's organizational culture. Examples include verbal, informal descriptions of real or imaginative events from the university's history shared by employees.
3. University symbols constitute crucial cultural values, such as the university's name, logo, brand, authority insignia, banners, etc.
4. Metaphors, as another element in creating a university's organizational culture, define the university's essence and demonstrate how it is perceived by stakeholders (employees, students, doctoral candidates, and external entities).
5. Rituals and routines refer to established ways of operating within the university.
6. Customs are recurring social practices at a university.

7. Artifacts are manifestations of the functioning of organizational culture. These include: physical artifacts (space, infrastructure), behavioral artifacts (gestures, greetings, nonverbal communication), and linguistic artifacts (linguistic conventions, addressing in statements).
8. Subcultures are found within organizational culture. These are social groups with values that emerge that are inconsistent with the culture of the entire organization (often serving to meet individual needs).
9. Stereotypes refer to knowledge derived from experience and its application in similar situations related to identity, employee relationships, relationships with students or relationships with the environment.
10. Heroes are defined as important figures who have had a significant impact on the university and its culture, such as founders, rectors, and distinguished employees.
11. Taboos are topics or social activities that are hidden and not discussed, but are important to the university and are time-honored by tradition.

A university's organizational culture defines its functioning in scientific, educational, and administrative-organizational aspects. The literature on the subject and the practical operation of universities allow for the identification of model approaches in this regard. It is worth noting the models of university organizational culture developed by I. McNay and further developed by J. Jameson (Lacatus, 2013, p. 424; McNay, 1995; Jameson, 2011; Krdžalicia, Brguljab, Duraković, 2020, pp. 567-577.). These models include:

- the collegial model, which assumes, among other things, freedom and consensus in action,
- the bureaucratic model based on equality and a formal-rational management style,
- the corporate model based on loyalty and a political-tactical management style and
- the entrepreneurial model based on competencies and decentralized leadership.

The development of these models was based on various criteria, such as the role of university authorities, decision-making centers, management styles, adaptation to the environment, student/doctoral student status, and administrative subservience. This definition of university organizational culture undoubtedly contributes to the research and development of a Lean Management culture within university structures.

The issue of examining Lean Management culture as an organizational culture is multidimensional. This stems, among other things, from the essence of the Lean Management concept and the shift in thinking about university management. Lean Management establishes organizational culture as a concept that can be implemented at universities, following the adoption of a process orientation in which university employees play a central role, and as a concept in which the primary goals are quality, efficiency, and flexibility. It should be added that the factors determining the success or failure of implementing the concept are the culture of the organization – the university – and the culture of the community in which the university

operates (Parkes, 2014, pp. 123-124; Meek, Teichler, Kearney, 2009; Puvanasvaran, Megat, Tang, Muhamad, Hamouda, 2009, pp. 930-943).

J. Maciąg in the publication "Kultura Lean Management w polskich szkołach wyższych (wyniki badań pilotażowych)" attempted to define the Lean Management culture as a type of organizational culture, indicating the following approaches in this respect:

1. Philosophical approach. It is based on the essence of the concept that postulates lean operation, that is, improving operational efficiency by eliminating waste, minimizing it, and controlling the flow of added value. According to this approach, Lean Management culture can be defined as an applied philosophy of action, the essence of which is the quality of relationships between people, shared behaviors, and work culture.
2. Approach based on the components of Lean Management culture. According to this approach, the culture in question can be defined on several levels. These are: basic assumptions, values, and artifacts. Basic assumptions refer to the norms and principles as well as the methods, techniques, and tools for implementing Lean Management. Values derive from the Lean Management philosophy and include attitudes, beliefs, and thinking focused on value creation and waste elimination. Artifacts are defined as linguistic, behavioral, and physical artifacts, which may originate from national culture.
3. Normative approach. This approach constructs principles and norms of behavior of organization members, as well as techniques and tools for their implementation. An example are J.K. Liker's principles, presented in the work entitled "The Toyota Way: 14 Management Principles of the World's Leading Manufacturing Company" (Liker, 2005).
4. Psychological approach. In this approach, the central role is played by the individual – the university employee. The employee's attitude toward change and the need to eliminate/change employee habits and customs are emphasized. Motivation is also important.

The theoretical characterization and empirical analysis of the culture of this concept were based on the model of Lean Management culture dimensions described by J.K. Liker in his publication "The Toyota Way: 14 Management Principles of the World's Leading Manufacturing Company" (Liker, 2005). The dimensions of Lean Management culture include (Liker, 2005, pp. 29-34; Aguirre, Pérez-Domínguez, Luviano-Cruz, Noriega, Gómez, Callejas-Cuervo, 2020, pp. 2-12):

1. Overall concept (long-range thinking). Basing management decisions on a long-range concept, even at the expense of short-term financial results.
2. Process (eliminating waste). This dimension emphasizes the principles of:
 - creating a continuous and seamless problem-revealing system,
 - utilizing pull systems to avoid waste,

- balancing the workload,
 - stopping work when a quality issue occurs,
 - standardizing tasks to ensure continuous improvement,
 - using reliable, proven technology,
 - using visual control to ensure no problems remain hidden.
3. People and partners (respect, challenging, nurturing). In this dimension, the principles are:
- nurturing leaders,
 - respecting people, nurturing their development, and challenging them,
 - respecting partners, challenging them, and helping them.
4. Problem-solving (continuous improvement and learning), which is based on the principles of:
- continuous learning through Kaizen,
 - personal commitment to improvement,
 - decision-making through consensus and careful consideration of all options,
 - rapid implementation of decisions.

The above dimensions of Lean Management culture were described and expanded upon by the statements in question for the purposes of the empirical section. For the research process, 20 selected elements of Lean Management culture were distinguished, tailored to the specificity of the university.

3. Implementation of Lean Management culture elements – research results

From 2021 to 2025, the author conducted research on the use and implementation of Lean Management at public universities in Poland. The research included, among other things, an analysis of barriers, waste, and improvement in university management systems, an assessment of knowledge and use of Lean Management tools, and the subject of this article: the implementation of Lean Management culture elements. The article refers to a fragment of this research that has not been published to date.

Table 1 presents the most important assumptions of the presented study results.

Table 1.*Assumptions of the research*

Items	Description
Research goal	Assesses the degree of implementation of Lean culture elements at the universities studied
Research method	Quantitative research - survey study
The interviewees	The Rector and other managers of public academic universities in Poland. The survey questionnaire was received by 60 universities, the return rate was 80%
Date of realization	Period 2021-2025

Source: personal elaboration.

As part of the study, twenty elements constituting the Lean Management culture were analyzed based on the Lean Management culture dimensions model described by Liker (as previously mentioned). These elements include:

1. Strategic Perspective:
 - 1.1. Employees know and support a single, common vision for managing and improving the university.
 - 1.2. Employees participate in building the university's vision, mission, and strategy.
 - 1.3. Employees know the university's vision, mission, and strategy.
 - 1.4. Employees are integrated (loyal) with the university's vision, mission, and strategy.
 - 1.5. Employees feel responsible for their actions.
2. Eliminating waste:
 - 2.1. Sources of waste are identified on an ongoing basis and appropriate corrective actions are taken.
 - 2.2. Processes and their implementation are clearly described.
 - 2.3. Quality is a priority in all activities.
 - 2.4. Detected errors and irregularities result in the interruption of processes and activities.
 - 2.5. The communication system is informal, fast, and effective.
3. Human Capital Management:
 - 3.1. Superiors and leaders are role models through their commitment to managing and improving the university in line with the strategic concept.
 - 3.2. Relationships with superiors are partnership-based, informal, and based on trust and authority.
 - 3.3. The university is open to organizational, social, and technical changes, treating them as opportunities for development.
 - 3.4. The university provides space for discussion about changes and challenges.
 - 3.5. Partners and collaborators are treated as part of the university.
4. Problem Identification and Solving:
 - 4.1. Problems are identified on an ongoing basis by employees, and ways to solve them are indicated.
 - 4.2. Problem resolution is preceded by a thorough analysis.

- 4.3. Superiors and leaders are personally involved in resolving the problem at the point of origin.
- 4.4. All employees are committed to the continuous improvement of the university.
- 4.5. The results of audits and inspections form the basis for the continuous improvement of processes and activities at the university.

The graphs below (1 and 2) refer to the assessment of the degree of implementation of selected elements of Lean Management culture at the surveyed universities.

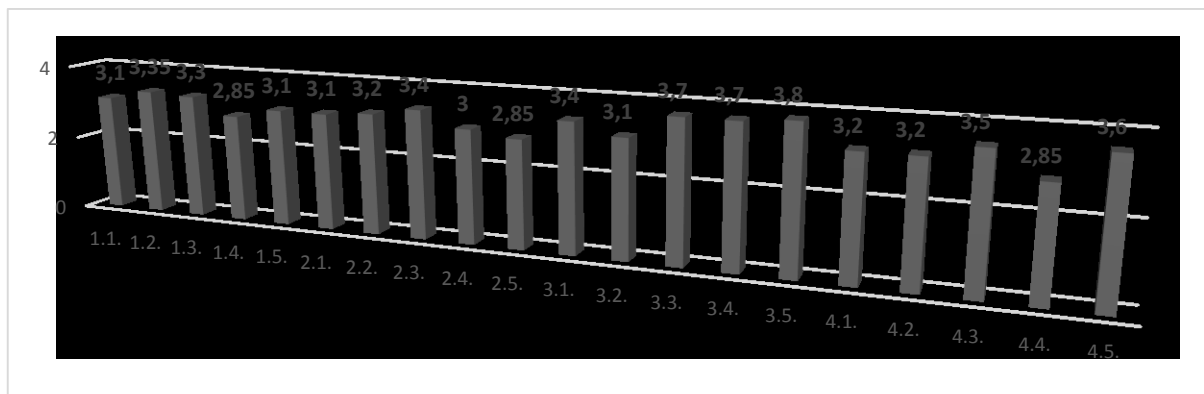


Figure 1. Implementation of selected elements of Lean culture – universities in total.

Source: personal elaboration.

The average degree of implementation for all Lean Management culture elements examined from all fully completed surveys was 3.27. Accepting a threshold of 3.0, which should be considered sufficient, shows that most of the assessed elements exceeded this level. From an empirical point of view, this is not a satisfactory situation. It would be if the score for Lean Management culture elements significantly exceeded 4.0. In such a case, a high degree of implementation of individual Lean Management culture elements would allow for its practical development at the university.

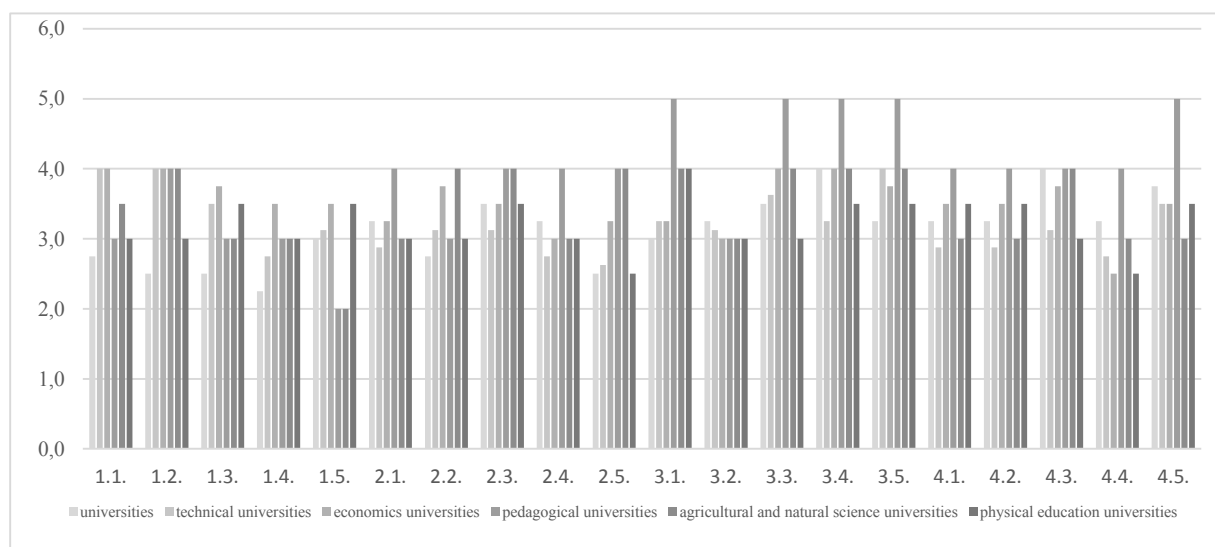


Figure 2. Implementation of selected elements of Lean culture – types of universities.

Source: personal elaboration.

The highest-rated elements of Lean Management culture included those related to the university's openness to organizational, social, and technical changes, the freedom within the university and the space for discussion and individual opinions, and the appreciation of the role of partners and collaborators, which should translate into their broader involvement in university processes. Elements related to improvement are also important, and here, the importance of internal audit as a tool for improving university processes and activities, quality as a priority in university operations, and the role of university management, personally engaging in problem-solving and establishing role models through involvement in university management and improvement, were highlighted. Building a Lean Management culture also involves active employee participation in developing the university's strategy, shaping its vision and mission, as well as engaging in problem-solving, identifying sources of waste, and taking improvement actions.

Analysis of the research results allowed us to identify elements of Lean Management culture that were rated below the accepted threshold. Although universities strive to actively involve employees in developing their strategy, vision, and mission, this is not entirely successful. This raises the issue of employee identification with the university and building a bond with it. Education and emphasizing the role and responsibility of each university employee are undoubtedly helpful in this regard. The communication system should also be improved, which should translate into better employee integration with the university and greater involvement in improving processes and services.

The possibilities for further and broader use of Lean Management principles and its instruments at the surveyed universities depend on the awareness and need for broadly understood improvement of the university management system, processes, and services. It is crucial to continuously assess emerging problems and barriers in university management that create waste, identify the waste itself, and develop improvement methods in response to these, using specific Lean Management instruments. Greater implementation of Lean Management culture elements stemming from its assumptions, such as the process approach and appreciation of the role of human capital, is also essential.

It is also recommended that university management staff receive more training in modern management and improvement concepts and systems, taking into account the different levels of education and the scientific disciplines represented. This will raise awareness among many people about the existence and potential use of concepts such as Lean Management.

4. Summary

The presented research results regarding the elements of a Lean Management culture suggest that human capital is a significant factor in its development. The elements assessed in the study, although they related to the degree of their implementation, also reflected a certain image of the university's internal organization.

The university's organizational culture is not directly focused on adopting concepts such as Lean Management. Therefore, the role of broadly understood education among all employees should be emphasized. Projects, integration, joint ventures, and teamwork create the foundation for creating a Lean Management culture at the university. Despite certain weaknesses that may result from the adopted method of presenting Lean Management culture elements, further research in this area should be undertaken, perhaps expanded upon to include additional cultural elements, learning paradigms, and approaches used at foreign universities. These are the issues that indicate further areas for the author's research.

To some extent, the characteristics of Lean Management culture elements are included in university strategic documents, such as development strategies. This includes elements related to the mission and vision, the implementation of certain processes, communication, the university's openness to change, discussion, and manifestations of improvement. Therefore, it can be concluded that elements of Lean Management culture are, in a sense, implemented by universities, although they are not fully aware that they draw on this very concept. As noted above, these contributions are a starting point for further research in this area. The study may be repeated in due course to compare results and assess potential progress in implementing the Lean concept at universities. Other higher education institutions, such as state vocational schools, could also be included in the study.

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MANAGERIAL ACTIONS IN SHAPING ENTREPRENEURIAL BEHAVIORS AND TEAM SYNERGY

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Purpose: The aim of this article is to analyse the relationship between the quality of collaborative work and the synergistic functioning of teams in the context of management and entrepreneurial leadership.

Design/methodology/approach: The research project focused on identifying and empirically verifying the foundations for building entrepreneurial potential in organizations. The study was qualitative and quantitative in nature, with two stages of research based on the developed model: first, a field study, and second, a diagnostic survey. Statistical analysis of the data verified the reliability of the scales (Cronbach's alpha), conducted a confirmatory analysis (CFA) and calculated Pearson's r correlation coefficients. The undertaken activities clarified the relationships between three key areas: the entrepreneurial activities of management staff, the entrepreneurial behaviour of employees (entrepreneurial activity within a team), and the occurrence of synergy in teamwork.

Findings: Based on theoretical analysis and empirical research, the quality of collaboration is shown to be a key factor in the development of team synergy and team entrepreneurship in organizations. Entrepreneurial leadership fosters synergy by fostering autonomy, trust, and reflective learning, leading to the integration of competencies and shared responsibility. Three interrelated dimensions of synergy were identified: cognitive (shared understanding of goals and roles), emotional (trust and support) and behavioural (coordination of activities and knowledge sharing). Integrating these dimensions determines the creation of added value in the form of high-quality collaborative work.

Practical implications: The research findings confirm the importance of entrepreneurial leadership as a mechanism for strengthening collaboration, innovation, and organizational learning. From a practical perspective, the paper emphasizes the need to Foster a culture based on trust, shared responsibility, and shared goal definition, which fosters synergy and a sustainable competitive advantage for organizations.

Originality/value: The originality of this article stems from its comprehensive, empirically verified approach to team synergy in the context of entrepreneurial leadership, as well as from the combination of qualitative field research and quantitative statistical analyses to examine how managerial actions influence teams' entrepreneurial activity and the quality of their collaborative work. The value of this study lies in identifying the three-dimensional structure of synergy (cognitive, emotional and behavioural) and demonstrating that integrating these

dimensions provides a source of real added value in organizations. The article also contributes by empirically confirming the role of entrepreneurial leadership as a key mechanism for enhancing collaboration, learning, and the development of team competencies, which extends existing approaches to the analysis of teamwork and entrepreneurial potential in organizations.

Keywords: entrepreneurial leadership; team synergy; collaborative work quality; organizational learning; team entrepreneurship.

Category of the paper: Research paper.

1. Introduction

Modern organizations operate in an increasingly complex, uncertain, and ambiguous environment, referred to in the literature as the BANI world concept (Brittle, Anxious, Nonlinear, Incomprehensible). In these circumstances, the ability to respond flexibly, act proactively, and integrate team potential is a key requirement. Managers constitute a crucial component of an organization's adaptability, as their activity determines the pace and effectiveness of organizational responses to change. Entrepreneurial leadership, which fosters proactive behaviour and synergy within work teams, is gaining increasing importance.

Entrepreneurial behaviour in an organization refers to initiating, developing, and implementing new ideas, which, in the context of the contemporary environment, leads to increased creativity (Aristana, Wisnawa, Sriasih, Junipisa, 2022). It is suggested that entrepreneurial leaders foster a belief in the team's creative capabilities ("team creative efficacy"), which acts as a mediating mechanism for creating both tangible and intangible value for the organization and its members. The literature also emphasizes that entrepreneurial leadership stimulates positive relationships between team members and supports the leader-subordinate relationship, especially if the work environment embraces a learning organizational culture (Shiferaw et al., 2023). Entrepreneurial leadership is demonstrated when a leader cultivates relationships with subordinates through fostering a collaborative learning environment, personal emotional and social competencies, and an entrepreneurial mindset. Well-designed interactions satisfy three inherent human needs of subordinates: autonomy, relatedness, and competence. This motivates employees to act in an entrepreneurial manner (Taylor, Corbett, Greenberg et al., 2025). These types of relationships increase the likelihood of taking action to innovate and capitalize on emerging opportunities.

A review of empirical research indicates that specific forms of leadership – particularly entrepreneurial and transformational leadership – are significantly associated with innovative and proactive employee behaviour. Research findings further suggest that this relationship is often mediated by the innovation climate and perceived employee autonomy. In light of these findings, it is pertinent to ask how managers' leadership activity influences the development of entrepreneurial behaviours in teams and whether it promotes synergy understood as a situation

in which the collective activity of a team leads to results exceeding the sum of individual effects (Jasińska, 2019). Research on the relationship between managerial practices and synergistic effects indicates that management serves as a catalyst, accelerating the team activation process through the use of appropriate practices such as delegating tasks, stimulating knowledge sharing, modelling proactive behaviour, and creating conditions of psychological safety (Edmondson, 1999). These practices foster process benefits resulting from team members' collaboration and mutual learning. To build team effectiveness, the importance of emotional intelligence, team leadership, organizational culture, work environment, and creative synergy should be emphasized as factors determining the quality of team-generated results (Paredes-Saavedra et al., 2024).

The purpose of this study is to provide a theoretical, analytical, and empirical justification for the relationship between managerial activity, entrepreneurial behaviour in teams, and synergy as a result of high-quality collaboration. To achieve this goal, the following research questions were formulated:

1. What management actions foster employee entrepreneurial behaviour?
2. How do managerial practices influence the creation of conditions for synergy within a team?
3. What is the impact of a team's entrepreneurial activity on the development of synergy in collaborative work?

The research methodology includes a review of the literature on entrepreneurial behaviour, team synergy, and the role of leadership and managerial actions, with particular emphasis on the concepts of entrepreneurial leadership and team entrepreneurship (Patzelt, Shepherd, 2018; Schulze, Pinkow, 2020). The following part of the article presents a theoretical model (Fig. 1) integrating these areas and the results of qualitative and quantitative analyses conducted to verify the adopted research assumptions.

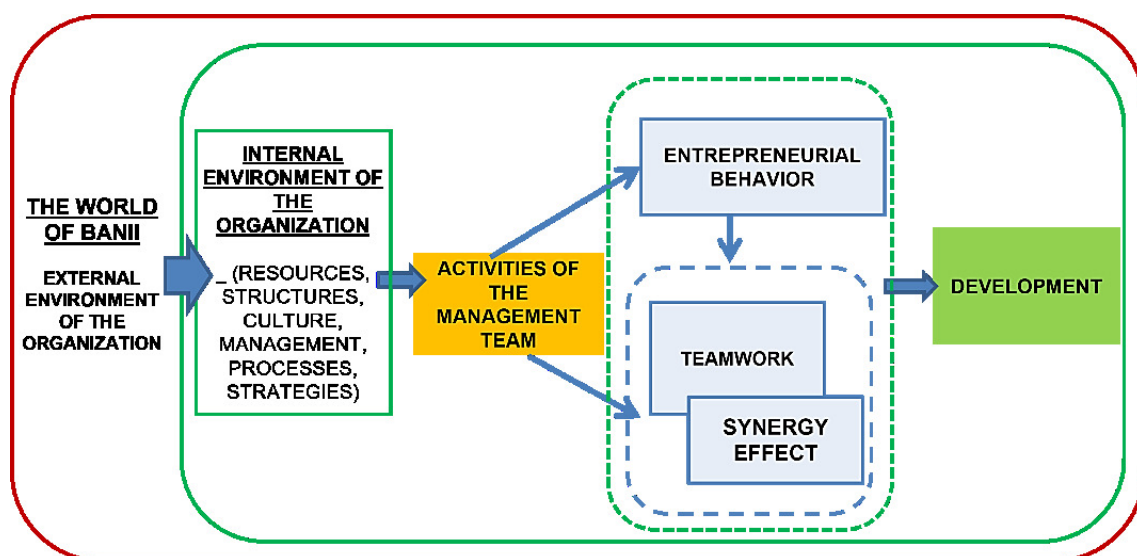


Figure 1. Conditions for building entrepreneurial potential in an organization.

Source: prepared by the authors.

Organizations operating in the knowledge economy paradigm and under conditions of unpredictable environmental changes are forced to systematically adapt their resources, structures, processes, organizational culture, and management methods. The BANI world concept redefines the concept of organizational effectiveness today – an organization's success depends not only on planning and control, but primarily on flexibility, collaboration, and the ability to learn together. In such an environment, team entrepreneurship and the synergy of joint action take on a new meaning, and the activity of management staff is a key factor determining the effectiveness of these processes.

2. Fundamentals of shaping entrepreneurial behaviour in teams – management actions as a factor determining employee activity

In an unstable and turbulent economic environment, the importance of an organization's ability to adapt, respond quickly to change, and generate innovative solutions is growing. These factors are currently key determinants of survival and maintaining a competitive advantage. Organizations respond to this situation by developing and leveraging entrepreneurial potential, which is based on creating an environment conducive to the development of organizational entrepreneurship. In the literature, corporate entrepreneurship is defined broadly – not as a process limited to the creation of new enterprises, but as a set of activities carried out within existing organizational structures. It encompasses both initiating new ventures and promoting proactive, innovative, and opportunity-oriented attitudes within the organization and its environment (Patzelt, Shepherd, 2018). This entrepreneurship is manifested through flexibility, creativity, and a willingness to take responsibility for initiatives undertaken under conditions of market uncertainty.

In the context of dynamic change, team entrepreneurship, understood as a set of proactive, innovative, and action-oriented behaviours implemented collaboratively by organizational members, is particularly important. Research indicates that the key characteristics of entrepreneurial teams are: autonomous action, willingness to take risks, initiative, and responsibility for work results (Shiferaw, Birbirs, Werke, 2023). The effectiveness of team entrepreneurship is further enhanced by factors such as:

- action-oriented and initiative-driven, which positively impact venture outcomes (Çağa et al., 2024),
- complementarity and diversity of competencies, which facilitate coping with uncertainty and generating innovation (Rehman et al., 2025),
- a shared mental model, vision, and purpose, facilitating cooperation, commitment, and effectiveness (Krawczyk-Bryłka, 2016),
- innovation and adaptability, enabling the creation and exploitation of new opportunities (Kocot, Kocot, Soboń et al., 2024).

Team entrepreneurship is a form of collective entrepreneurship, also known as intrapreneurship. It emphasizes the importance of collaboration, synergy, knowledge sharing, and organizational learning (Schoss, Brettel, Mauer, 2021). In this approach, team entrepreneurship means the ability of a group to jointly create and implement new solutions in conditions of uncertainty and risk (Krawczyk-Bryłka, Stankiewicz, Ziemiański, Tomczak, 2020). Its effectiveness depends on the balance between autonomy and interdependence, the quality of communication, the level of trust, and a shared vision. Access to a well-developed collaboration network, which provides a foundation for the flow of knowledge and social capital, is also a crucial factor. As evidenced (Omri, Boujelbene, 2015), entrepreneurial teams leverage extensive networks and prior professional relationships, enabling them to acquire resources and partnerships more effectively.

From the perspective of the Resource-Based View (RBV), team entrepreneurship represents a unique, difficult-to-imitate organizational resource that provides a sustainable competitive advantage. Entrepreneurial teams adapt their strategies to changes more quickly, test operational hypotheses, and improve processes, leading to higher efficiency, higher-quality solutions, and higher participant satisfaction (Yang, Pu, Guan, 2019). Empirical evidence confirms that team entrepreneurship generates internal competitive advantages resulting from better utilization of knowledge, diversity, and innovative capabilities. The ability of teams to respond entrepreneurially to challenges and collaborate is therefore a key factor in organizational success (Seyedalikhani, Bagheri, Sajadi, 2022).

Shaping entrepreneurial behaviour in contemporary organizations requires an integrated strategic approach, encompassing the design of a management model and the creation of an organizational culture that fosters innovation and proactivity. In this context, management plays a key role, responsible for creating working conditions, motivational systems, and structures that support the development of initiative and shared responsibility (Schulze, Pinkow, 2020). The literature distinguishes three main theoretical approaches to the role of leadership in shaping entrepreneurial behaviour:

- systemic – assuming that managers' actions initiate the team's self-organization process, leading to the integration of individual potentials,
- psychosocial – focusing on shaping an entrepreneurial climate that strengthens a sense of community and commitment,
- behavioural – emphasizing that employee behaviour is a function of leadership style, motivational systems, and organizational culture.

Theoretical analysis indicates that transformational and entrepreneurial leadership are considered key management styles conducive to shaping innovative and entrepreneurial behaviours (Jun, Lee, 2023; Irshad, Ziaullah, Hayyat, 2023). Transformational leadership mobilizes through vision and motivation, while entrepreneurial leadership focuses on identifying opportunities, accepting risk, and supporting experimentation (Shiferaw et al., 2023). It combines vision, innovation, and the leader's ability to adapt under conditions of

uncertainty (Kuratko, 2007). Leaders of this type initiate and support creative activities, mobilize resources, and create an environment conducive to organizational learning. As Gupta, MacMillan and Surie (2004) point out, an effective entrepreneurial leader is able to balance exploratory (creating new opportunities) and exploitative (improving existing processes) activities, maintaining the strategic flexibility of the organization.

Effective entrepreneurial leadership requires not only the ability to inspire, but also the use of appropriate organizational instruments, such as:

- motivational systems that reward innovation and collaboration (Alkandi et al., 2023),
- mentoring, coaching and project training supporting action learning (Rae, 2006; Bagheri, Harrison, 2020),
- knowledge management and creating spaces for sharing experiences, e.g. through communities of practice (Nonaka, Takeuchi, 1995; Aljuwaiber, 2016),
- autonomy of project teams, which enhances responsibility and decision-making independence (Cobb, Hackman, 2003; Cohen, Ledford, 1994),
- a climate of psychological safety that enables experimentation and open communication (Edmondson, 1999; Zhu, Lv, Feng, 2022).

However, the process of developing entrepreneurial behaviour encounters numerous barriers, including excessive control, lack of trust, rigid organizational structures, and pressure for short-term results. These factors limit employees' willingness to take initiative and experiment. Overcoming these barriers, therefore, requires systemic changes, not just ad hoc training interventions (Doeleman, Have, Ahaus, 2012).

The culmination of team entrepreneurship processes is the achievement of synergy – a state in which team members' collaboration leads to results that exceed the sum of their individual efforts. Synergy is based on trust, communication, and shared responsibility, which determine the quality of collaborative work. Research confirms that a climate of psychological safety, knowledge exchange, and interpersonal support foster both innovation and the ability to generate shared value (Edmondson, 1999; West, 2012). In this context, entrepreneurial leadership represents a contemporary management paradigm, integrating elements of vision, innovation, and flexibility. Its key function is to create an environment in which team entrepreneurship can thrive, leading to the creation of synergies and sustainable competitive advantage. In this process, management's actions act as a mediator between organizational conditions and teamwork outcomes, determining the quality of collaborative work and the organization's ability to learn and adapt.

3. The quality of collaborative work and its relationship to synergistic team functioning – the context of management and entrepreneurial leadership

The quality of collaborative work is a key indicator of organizational team effectiveness and a fundamental factor in the development of team synergy. In the management and organizational psychology literature, this concept is defined as the degree of effectiveness in the implementation of joint tasks, encompassing cohesion of actions, mutual trust, and satisfaction with interpersonal relationships (Salas, Reyes, McDaniel, 2018; Kozlowski, Chao, 2018). Contemporary research on knowledge-based organizations considers the quality of collaborative work to be a measure of organizational maturity, determining the ability of individuals and teams to collaborate, learn, and innovate.

According to the IMOI (Input–Mediator–Output–Input) model of team effectiveness, the quality of collaboration is the result of a dynamic interaction between the input structure (e.g. team member competences and diversity), mediating processes (such as communication, trust, cohesion, and psychological safety), and organizational outcomes, which in turn initiate subsequent cycles of action (Ilgen, Hollenbeck, Johnson, Jundt, 2005; Mathieu, Hollenbeck, van Knippenberg, Ilgen, 2017). This suggests that the quality of collaboration is not a static state, but a process of continuous learning and adaptation within complex social and organizational interactions. In this context, the concept of team synergy is crucial, understood as a phenomenon in which the effect of joint action exceeds the sum of the individual contributions of its members (Katzenbach, Smith, 2015; Kozlowski, Ilgen, 2006). Synergy is emergent in nature, resulting from complementary competencies, role interdependence, trust, and shared goals. From a cognitive perspective (West, 2012), it occurs when a team develops a shared mental model – a shared vision of goals and understanding of roles – that fosters effective coordination and adaptation in a changing environment.

Jasińska (2019) expands on this concept, arguing that synergy in teamwork is a social process in which individual potentials and resources are integrated through trust, communication, and shared responsibility, leading to the creation of “added value” in the form of quality of collaborative work. In this approach, synergy is not the result of formal collaboration, but rather the result of internalized attitudes of cooperation and mutual cognitive openness. A team achieves synergy when three dimensions coexist: cognitive (shared understanding of goals and tasks), emotional (trust, support, empathy) and behavioural (coordination of activities, willingness to share knowledge). Integrating these three dimensions enables the full utilization of a team’s potential and translates into lasting organizational results.

Research on teams indicates that factors that foster synergy include effective communication, role clarity, shared responsibility, trust, and psychological safety (Edmondson, 1999). Psychological safety is particularly important in modern organizations, as it allows for open expression of opinions, sharing ideas, and experimentation without fear of negative

consequences. Such conditions foster both innovation and team cohesion (Carmeli, Gittell, 2009). High-quality collaborative work, therefore, signifies the team's ability to collaborate creatively, coherently, and in an integrated manner, resulting in synergistic learning and the creation of new value. Although synergy develops within team processes, a key factor initiating and sustaining it is the way the leader shapes the conditions for collaboration. A key mechanism currently enhancing synergistic processes is entrepreneurial leadership – a management concept focused on mobilizing the potential of individuals and teams in conditions of complexity and uncertainty (Gupta, MacMillan, Surie, 2004; Renko, 2017). Entrepreneurial leaders combine an innovative orientation with the ability to inspire and engage team members in experimental activities aimed at value creation and organizational development (Shiferaw, Birbirs, Werke, 2023).

The mechanisms by which entrepreneurial leadership influences the quality of collaboration and the development of synergy can be explained based on social exchange theory (Blau, 2017) and the concept of psychological safety (Edmondson, 1999). Entrepreneurial leaders create a climate of trust, reciprocity, and recognition that strengthens emotional commitment, reduces knowledge hiding, and enhances team identification (Carmeli, Spreitzer, 2009). Behaviourally, they serve as moderator of collaboration – supporting autonomy, collaborative decision-making, and shared responsibility, which ultimately enhances creativity and work quality.

Empirical research indicates that entrepreneurial leadership fosters synergy by strengthening tacit knowledge sharing and deepening emotional bonds within teams (Pu, Sang, Yang, Ji, Tang, 2022). In learning organizations, according to the concept of double-loop learning (Argyris, Schön, 1996), synergy develops through teams' ability to reflectively learn and modify their mental models. In this process, the leader acts as a catalyst – supporting dialogue, enabling the exchange of experiences, and building a culture of practice-based learning (Nonaka, Takeuchi, 1995). Research confirms (Shiferaw et al., 2023) that entrepreneurial leadership enhances team learning, which mediates between entrepreneurship and innovation, leading to higher levels of cognitive integration and adaptive flexibility.

In management practice, entrepreneurial leadership means designating a work environment based on trust, shared responsibility, and shared goal-defining. Effective entrepreneurial leaders not only inspire but also enable – by creating conditions for experimentation, autonomy, and shared learning. These activities lead to increased collaboration, innovation, and team member satisfaction. Team synergy is therefore a key dimension of collaborative work quality and a fundamental mechanism for value creation in entrepreneurial organizations. It arises from the integration of competencies, trust, and communication, supported by leadership based on vision, reflexivity, and openness. From this perspective, team entrepreneurship becomes a strategic organizational resource, integrating individual competencies and strengthening the organization's capacity for sustainable learning, innovation, and adaptation in a turbulent environment.

4. Research methodology

The main objective of the conducted research was to identify and empirically verify the foundations for building entrepreneurial potential within an organization. The analysis focused on explaining the relationships between three key areas: entrepreneurial activities of management staff, entrepreneurial behaviours of employees (entrepreneurial activity within a team) and the occurrence of synergy in teamwork. To achieve the research objective, we characterized managerial activities that foster the development of entrepreneurial behaviours and shape the organizational conditions necessary for the emergence of team synergy. Furthermore, it was determined how entrepreneurial activity within teams manifests itself in organizational practice and how it influences the qualitative dimension of collaboration, understood as the effect of synergistic interaction.

The subsequent research focused on determining the extent to which these elements coexist and mutually reinforce each other, creating a systemic foundation for building entrepreneurial potential within organizations. The assumption was made that the analysed areas constitute a coherent system of factors that determines an organization's ability to create added value, strengthens its strategic flexibility, and increases adaptability in conditions of increasing complexity and volatility in the environment.

With respect to the research subject, the methodological approach considered the processes and mechanisms shaping organizational entrepreneurship, understood as a dynamic phenomenon occurring in the interaction between leaders and team members. The study was quantitative and qualitative in nature, enabling both the identification of structural relationships between variables and an in-depth contextual interpretation of the obtained results. Empirical verification of the theoretical assumptions was conducted based on the model presented in Figure 2. This model integrates key research constructs and demonstrates the relationships between managerial actions, team entrepreneurship, and synergy effects, which form the basis for developing the entrepreneurial potential of modern organizations.

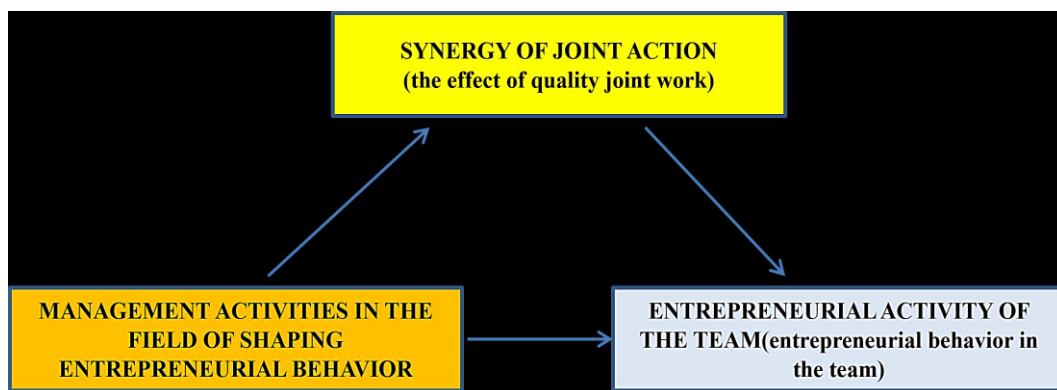


Figure 2. Foundations of building entrepreneurial potential in an organization – theoretical assumption model.

Source: prepared by the authors.

The developed research model is the result of experience gained from implementing the research grant concept. This allowed for a complex process of obtaining information on the phenomenon of synergy in teamwork in learning organizations.

To achieve the goal stated at the beginning of this article and in reference to the presented research model (Figure 2), the following research questions were formulated in this paper:

- P1: What management actions foster entrepreneurial behaviour among team members?
- P2: How do management actions fostering entrepreneurial behaviour influence the creation of conditions for synergy within the team?
- P3: What is the impact of a team's entrepreneurial activity on the development of synergy in collaborative work?

Based on the specific research questions and the previous theoretical model based on the interdependencies between management's actions (entrepreneurial leadership), team entrepreneurial behaviour, and team synergy (the quality of collaborative work) — the following research hypotheses were formulated:

- H1: Entrepreneurial management actions (i.e. building an entrepreneurial organizational culture, shaping a motivational system that promotes autonomy and responsibility, and implementing regulations and procedures that support organizational learning and knowledge exchange) significantly influence the development of entrepreneurial behaviours among employees in teams (i.e. increased levels of proactivity and innovation, employee willingness to take on challenges and initiate change, as well as independence and adaptability of entrepreneurial behaviours within teams).
- H2: Management efforts aimed at developing entrepreneurial behaviours within the team (entrepreneurial leadership, shaping organizational culture, high levels of communication, trust, and support from leaders) positively influence the occurrence of synergy (higher levels of satisfaction with joint activities).
- H3: Entrepreneurial activity of the team (high level of proactivity and openness to innovation, readiness to learn and experiment) positively influences the creation of synergy in teamwork, both in terms of task effectiveness and psychosocial effectiveness (effectiveness and satisfaction with cooperation, mutual strengthening of team members' competences, greater cohesion, commitment and social integration).

The study covered 58 organizations in Poland, classified as learning organizations, in which entrepreneurial behaviour was observed during the preliminary research phase. The entities included represent both the private and public sectors, primarily large and medium-sized enterprises with manufacturing, manufacturing and services, and service sectors. From an economic perspective, these organizations maintain good or fairly good financial liquidity, indicating their operational stability. At the same time, they operate in conditions of high variability and complexity of the external environment, which can be interpreted as an environment conducive to the activation of entrepreneurial activities. The study also assessed the organizational development stage of individual companies. The empirical section shows

that most of them are in the phase of implementing change, entering a new development phase, or experiencing dynamic growth. This indicates that these are organizations demonstrating innovation tendencies or actively developing competencies in this area.

The study involved 203 work teams, comprising a total of 1394 participants. After taking into account correctly completed questionnaires, 1380 surveys were obtained, representing a 99% return rate for all distributed research tools. These data provide a solid foundation for quantitative analyses and qualitative interpretations. Respondents' responses primarily focused on their functioning in medium-sized and large teams, focused on projects, decision-making, or problem-solving, allowing for the identification of diverse forms of team collaboration.

To achieve the research objectives, a mixed methods approach was employed, combining elements of quantitative and qualitative research. This approach enabled both the identification of statistical relationships between variables and an in-depth contextual interpretation of the mechanisms shaping entrepreneurial potential in organizations. The study was conducted in two stages: qualitative and quantitative. The first stage involved exploratory research aimed at identifying the main areas and processes determining entrepreneurial behaviour in organizations and initially identifying factors that facilitate the occurrence of synergy in teamwork. To gather empirical data, a field study was employed, utilizing in-depth interviews with middle and senior managers and a preliminary survey among project team members. The qualitative analysis ultimately allowed for:

- identification of three primary areas of management activity (systemic, emotional, and behavioural),
- clarifying the dimensions of team entrepreneurial activity,
- identifying the psychosocial and organizational determinants of synergy.

The obtained results served as the basis for constructing the research model and developing the measurement tool used in the quantitative phase.

The second stage of the research was quantitative and verifiable. It employed a diagnostic survey method using a proprietary questionnaire developed based on the results of qualitative research and a review of literature in the field of entrepreneurial leadership, team entrepreneurship and organizational synergy. The questionnaire included statements measuring three main research constructs:

1. Entrepreneurial activities of management staff – encompassing three indicators:
 - building an entrepreneurial organizational culture – (systemic aspect) treated as an element of systemic support for employee activity (5 items regarding: flexibility, adaptability, risk tolerance, openness to new things and changes, promotion and support for new solutions),
 - shaping a motivational system that fosters proactivity – (emotional aspect) focused on strengthening and rewarding initiative and proactivity (6 items related to: supporting collaboration and knowledge exchange, rewarding and motivating

- activity, building engagement, appreciating innovation, and recognizing work results),
- creating regulations supporting autonomy and knowledge management within the team (behavioural aspect) (5 items regarding: providing recognition, autonomy of innovators, shaping openness to challenges and stimulating active work, principles of participation).
2. Entrepreneurial activity of teams – measured by four traits: openness to innovation, proactivity and adaptability, willingness to take risks and challenges, and independence in learning and developing competencies.
 3. Team synergy effect – understood as a state of psychosocial integration and satisfaction with joint action, described by ten indicators, including: level of engagement, quality of cooperation, autonomy and participation, sense of community, and benefits resulting from cooperation.

Each statement was rated using a five-point Likert scale (1-5), where 1 indicated disagreement and 5 indicated complete agreement with the statement.

The defined indicators enabled a comprehensive understanding of the process of building entrepreneurial potential in organizations and formed the basis for constructing the empirical model presented in Figure 3.

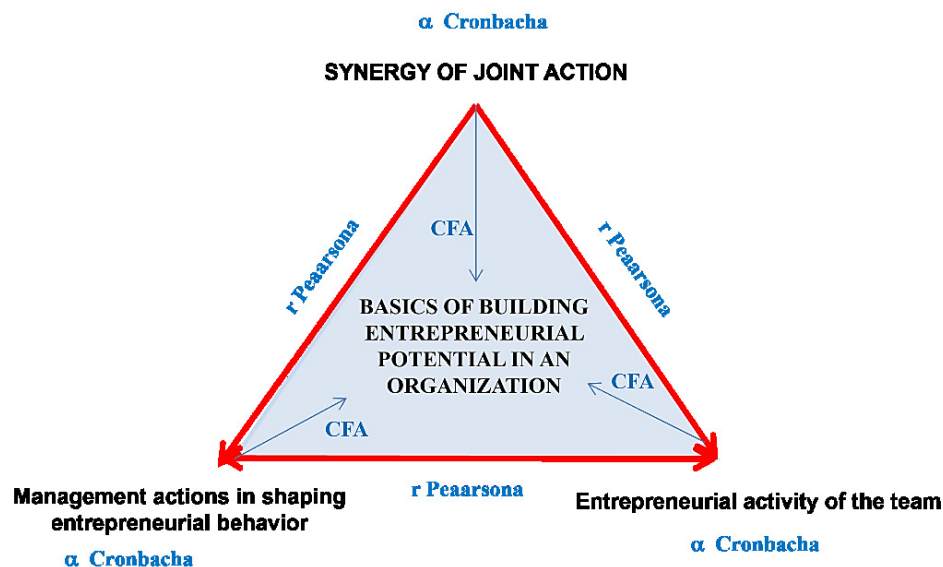


Figure 3. Basic relationships in the analysis of factors building entrepreneurial potential – empirical model.

Source: prepared by the authors.

In accordance with the developed empirical model (Figure 3), the acquired data were analysed using Statistica 10 statistical software. First, the reliability of the scales (Cronbach's alpha) was verified, obtaining values ranging from 0.835 to 0.986, confirming the high level of internal consistency of the instrument. Confirmatory analysis (CFA) was then conducted to confirm the structural validity of the theoretical model. The CFA confirmed the validity of the

research model. This is reflected in the high factor loadings (from 0.703 to 0.919), confirming the convergent validity of the model and the adequacy of the selection of variables describing the studied constructs. All coefficient values were statistically significant at the $p < 0.001$ level. Furthermore, the quantitative analysis calculated Pearson's r correlation coefficients for the main research constructs. The obtained correlation coefficient values indicated strong and statistically significant relationships between the studied variables, with r ranging from 0.578 to 0.850. These values confirm that managerial actions aimed at developing entrepreneurship foster both strengthening team activity and building synergy in collaborative work.

The methodology used not only allowed for the verification of the adopted research hypotheses but also for a deeper understanding of the mechanisms shaping organizational entrepreneurship and synergistic collaboration within teams. Ultimately, it can be concluded that the measurement tool is characterized by high reliability, validity, and structural stability, which constitutes a basis for considering the obtained results as credible empirical confirmation of the developed theoretical model. Therefore, it can be assumed that the conducted research provides an appropriate basis for further theoretical and empirical analysis in the areas of strategic management, entrepreneurial leadership, and the development of organizational innovation potential.

5. Research results, discussion, and conclusions

The purpose of this section of the article is to present and interpret the results of empirical research on the relationship between entrepreneurial activities of management staff, entrepreneurial activity of teams, and the synergy effect in collaborative work. The analysis of the results is a direct continuation of the previously described research procedure and is based on data obtained during the quantitative phase of research conducted in 58 organizations operating in Poland. The collected empirical material was subjected to statistical analysis, which included verification of the reliability and validity of the measurement tool, followed by an assessment of the interdependencies between the model's main constructs – the main results of the analysis are presented in Figure 4. Therefore, this section will present the results of Cronbach's alpha coefficient, structural analysis of variables, including factor loadings and correlation coefficients, verification of the adopted research hypotheses, and interpretation of the obtained relationships in a theoretical and practical context. The aim of this part of the study is not only to empirically confirm the model of building entrepreneurial potential in organizations, but also to provide an in-depth explanation of the mechanisms that facilitate the creation of synergy effects in teamwork.

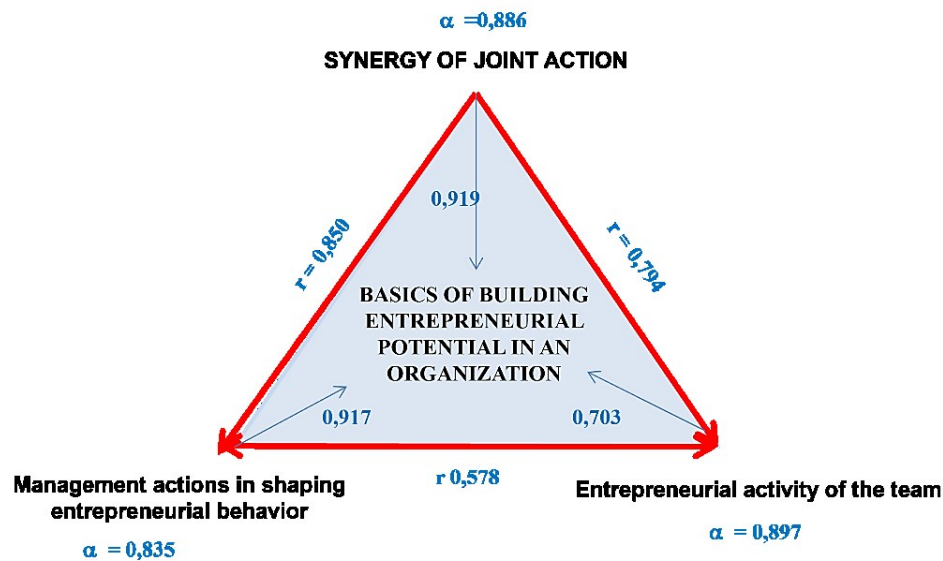


Figure 4. Results of Cronbach's alpha reliability assessment, factor analysis (CFA) and Pearson's r correlation of the basic factors explaining the relationships in building entrepreneurial potential.

Source: own study using the Statistica 10 statistical program.

The empirical research results allowed for a full empirical verification of the adopted theoretical model of building entrepreneurial potential in organizations. This model, presented in the form of a triangle (Figure 4), encompasses three key dimensions: entrepreneurial actions of management staff, entrepreneurial activity of teams, and the effect of team synergy. The relationships between the identified constructs are characterized by high levels of internal consistency and statistical significance, confirming the validity of the adopted research framework. First, the reliability of the measurement scales was assessed using Cronbach's alpha. The obtained values were very high:

- for management actions – $\alpha = 0.835$,
- for team entrepreneurial activity – $\alpha = 0.897$,
- for team synergy – $\alpha = 0.886$.

The obtained results indicate high internal consistency of the research tool and stability of the scales used. This demonstrates the appropriate selection of measurement items and their consistency with the adopted theoretical constructs.

In the next step, confirmatory analysis (CFA) was conducted to assess the structural validity of the model. The obtained factor loadings for individual variables ranged from 0.703 to 0.919. For the individual variables defined in the model, the CFA results were as follows:

- synergy of joint action – 0.919,
- management actions in shaping entrepreneurial behaviour – 0.917,
- team entrepreneurial activity – 0.709.

The obtained CFA results confirm the high convergent validity of the model and the correct assignment of observable variables to the studied latent constructs. All coefficient values were statistically significant ($p < 0.001$), demonstrating the high quality of measurement and the validity of the developed research tool.

Based on the calculated Pearson r correlation coefficients, strong and positive correlations were identified between all analysed constructs:

- between management actions and team synergy – $r = 0.850$,
- between management actions and team entrepreneurial activity – $r = 0.578$,
- between team entrepreneurial activity and synergy – $r = 0.794$.

High coefficient values confirm the existence of close relationships between the studied areas, which is consistent with the adopted research hypotheses. The results indicate that entrepreneurial managerial activities, such as building an entrepreneurial organizational culture, supporting autonomy and knowledge exchange, and employing motivators that enhance proactivity, are key factors in shaping team entrepreneurial activity. At the same time, it was confirmed that a high level of this activity fosters synergy, manifesting itself in greater commitment, trust, and satisfaction from working together. These relationships demonstrate that an organization's entrepreneurial potential stems from the interactive interplay of three areas: entrepreneurial leadership, team entrepreneurship, and teamwork synergy. The combined impact of these factors creates a foundation for dynamic organizational learning, increased innovation, and the development of a sustainable competitive advantage.

The empirical analysis confirmed the validity of the adopted model for building entrepreneurial potential in organizations. The results clearly indicate that the entrepreneurial activities of management staff are a fundamental factor initiating the development of team entrepreneurship and determining the occurrence of synergy in collaborative work. High reliability and correlation coefficients confirm that management mechanisms based on trust, autonomy, open communication, and a culture of innovation are crucial for strengthening teams' entrepreneurial activity. It was also confirmed that entrepreneurial activity within teams serves as a mediator between entrepreneurial leadership and team synergy, demonstrating that effective collaboration is not solely the result of the leader's actions but also the result of shared dynamics, learning, and mutual reinforcement of competencies within the team. In this approach, a high level of synergy is not only a result but also a catalyst for further organizational and innovative development.

Theoretically, the obtained results align with the concept of dynamic organizational capabilities (Teece, Pisano, Shuen, 1997), indicating that entrepreneurial leadership and a learning culture shape teams' ability to flexibly respond to change and generate added value through collaboration. This indicates that an organization's entrepreneurial potential is not a set of isolated competencies, but an integrated system of interactions in which management creates the conditions, the team initiates actions, and synergy is the measurable result of this collaboration.

The starting point for further analytical activities in this section is the verification of three research hypotheses stemming from the previously formulated research problems. The analysis conducted in this area was based on an empirical model (Figure 3), which integrates three key theoretical constructs: entrepreneurial managerial actions, entrepreneurial team activity,

and team synergy. The research results (Figure 4) provide empirical confirmation of the relationships between these areas and provide a basis for interpreting the mechanisms shaping organizational entrepreneurship in the context of contemporary management challenges. The following issues were identified within the analysed scope:

Hypothesis H1: Entrepreneurial activities of management staff – including building an entrepreneurial organizational culture, shaping a motivational system that promotes autonomy and responsibility, and implementing regulations that support activity, including organizational learning and knowledge exchange – significantly influence the development of entrepreneurial behaviours of employees in the team (proactivity, innovation, readiness to take on challenges, independence and adaptability).

The research results confirm a high and statistically significant correlation between management's actions and employee entrepreneurial activity ($r = 0.578$, $p < 0.001$). This means that management, through communication, fostering autonomy, and shaping a culture of openness and trust, actually stimulates entrepreneurial attitudes among team members. The obtained results are consistent with the concept of entrepreneurial leadership, according to which leaders act as initiators and catalysts of change, inspiring employees to seek innovative solutions and take risks (Gupta, MacMillan, Surie, 2004). Similarly, the learning organization theory (Senge, 2006) emphasizes that supporting learning and creating an environment conducive to knowledge exchange builds the foundation for entrepreneurial behaviour. In light of the obtained data, it can be concluded that an organizational culture based on openness, shared responsibility, and trust serves as a structural catalyst for entrepreneurial activity within a team.

Given the above analytical results, it can be concluded that hypothesis H1 is confirmed – entrepreneurial managerial actions are a key factor in the development of employee entrepreneurial attitudes, strengthening their initiative, innovation, and adaptability in a dynamic environment.

Hypothesis H2: Management actions aimed at developing entrepreneurial behaviours within a team (entrepreneurial leadership, shaping organizational culture, communication, and support) positively influence the occurrence of synergy.

Correlation analysis revealed statistically significant relationships between managerial actions and synergy ($r = 0.850$, $p < 0.001$), indicating that teams operating in an environment supported by entrepreneurial leadership demonstrate higher levels of trust, cohesion, and satisfaction with collaboration. This means that team synergy does not arise spontaneously, but is a consequence of leaders consciously shaping conditions that foster shared responsibility and autonomy. This relationship is supported by the concepts of transformational leadership (Bass, 1999) and participatory management theory (Cotton et al., 1988; Somech, 2002), which emphasize the importance of a common goal, trust, and participation in decision-making

processes. From a knowledge management perspective (Nonaka, Takeuchi, 1995), actively supporting communication and experience sharing between team members creates conditions for synergistic combination of competencies, which leads to the creation of new organizational value.

Based on the presented analytical results, it can be concluded that hypothesis H2 was confirmed – managerial actions that Foster entrepreneurship not only foster team activity but also create the psychosocial conditions for synergy, manifested by mutual strengthening of competences, greater engagement, and satisfaction with teamwork.

Hypothesis H3: Team entrepreneurial activity (proactivity, openness to innovation, willingness to learn) positively influences the development of synergy in teamwork.

The research results confirm a positive and statistically significant correlation between team entrepreneurship and synergy ($r = 0.7945$, $p < 0.001$). This means that the higher the level of engagement and proactivity of team members, the greater the likelihood of synergy, understood as an effect exceeding the sum of individual contributions. This phenomenon confirms the theoretical assumptions of the social capital concept (Cohen, Prusak, 2001) and the team dynamics theory (Kozlowski, Ilgen, 2006), which indicate that cooperation based on trust and shared values fosters outcomes that are difficult to achieve individually. In the context of organizational entrepreneurship, team entrepreneurial activity therefore serves as a mediating link between managerial actions and collective effectiveness.

The obtained results of the analysis indicate that hypothesis H3 was confirmed – the entrepreneurial activity of teams is one of the key factors determining the occurrence of synergy in joint actions, which strengthens the innovation potential of the organization.

The empirical research conducted confirms the coherence of the model for building entrepreneurial potential in organizations. Analysis for the relationships between the constructs revealed that:

1. Entrepreneurial managerial actions are a fundamental factor initiating team entrepreneurship processes.
2. Entrepreneurial activity within teams serves as a mediator between entrepreneurial leadership and the synergy effect.
3. The synergy effect is the result of the integrated action of three factors: management actions and organizational culture, entrepreneurial leadership, and team activity.

In light of the above, it can be concluded that an organization's entrepreneurial potential is systemic and dynamic – the result of the interplay of managerial, team, and organizational behaviours. In practical terms, the obtained results indicate that the development of entrepreneurship in an organization requires creating an environment conducive to autonomy, trust, learning, and shared responsibility, which constitute the foundation of sustainable team synergy.

6. Conclusion

Theoretical analysis and empirical findings confirmed that the quality of collaborative work is a key determinant of team effectiveness and a fundamental mechanism for creating organizational synergy. Research has shown that the quality of collaboration is not solely the result of individual competences but is the result of complex social interactions based on trust, communication, shared goals, and a climate of psychological safety. These results are consistent with the assumptions of the IMO model (Ilgen et al., 2005), in which mediating processes – such as support, cognitive openness, and coordination – form the foundation of team synergy.

The empirical study demonstrated that a significant determinant of the quality of collaborative work is the leadership style and nature of managers' actions. Entrepreneurial leadership, identified as a contemporary management paradigm, fosters conditions for self-regulation, knowledge sharing, and reflective learning. Entrepreneurial leaders act as moderators of collaborative processes, enhancing team autonomy, accountability and innovation. Organizations with higher levels of such leadership are characterized by better communication, greater cognitive integration, and higher quality of collaboration, confirming previous theoretical findings (Gupta et al., 2004; Schulze, Pinkow, 2020; Jun, Lee, 2023).

Empirically, a positive relationship between the quality of collaborative work and the level of team synergy was also confirmed. Synergy has been shown to be an emergent phenomenon in which the effect of joint action exceeds the sum of individual contributions, and its source is the integration of cognitive, emotional and behavioural dimensions (Jasińska, 2019). Teams with high levels of trust and a shared vision were characterized by greater adaptability and creativity, which aligns with the concept of learning organizations (Argyris, Schön, 1996; Nonaka, Takeuchi, 1995).

Both the theoretical analysis and the research findings confirmed that entrepreneurial leadership serves as a catalyst for synergy and the quality of collaborative work. Managers who base their actions on trust, autonomy, and shared responsibility enhance the effectiveness, learning, and cognitive development of teams. From a practical perspective, the results point to the need to design management systems that promote a culture of collaboration, open communication, and reflective leadership. From a theoretical perspective, this study contributes to the development of the team entrepreneurship paradigm by integrating the concepts of synergy, collaborative work quality, and entrepreneurial leadership into a coherent model.

In summary, an entrepreneurial leader is a key link between the organizational context and team effectiveness. It is his actions – aimed at building an environment of trust, autonomy and a shared vision – that determine the organization's ability to achieve synergy, innovation and sustainable development.

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DETERMINANTS OF THE CHOICE OF THE PETROL STATION BY HOUSEHOLDS IN THE SOUTH-EAST POLAND

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Purpose: The main objective of this article is to present the results of research aimed at identifying the determinants of gas station selection by households residing in southeastern Poland. The research problem will focus on answering questions regarding the primary and secondary factors determining the choice of gas stations by individual customers in the studied region. Specific questions will address differences in supplier selection based on location, age structure, income sources, household size, and daily geographic scope of activity. Therefore, the subject of this research is the primary and secondary factors determining the choice of gas stations by individual customers. The research subject is households. The research area is the retail market for transport fuels located in the Podkarpackie Voivodeship.

Design/methodology/approach: The structure of the article consists of the following sections: establishing the current state of knowledge on the subject matter, describing the research method, presenting the measurement results and their interpretation, and presenting the final conclusions. The research method employed is a critical review of the literature on the subject and quantitative methods.

Originality/value: This publication has a practical dimension. The adopted main topic and research objective respond to identified needs expressed by individual clients in relation to the current state of knowledge, achievements, and experience of the researcher. The actions undertaken are aimed at advancing scientific knowledge in the discipline of management and quality science in the area of commercial systems, their organization, and management.

It should be emphasized that the research results presented in this article constitute the second stage of scientific research, the subject of which is: Attributes and determinants of the commercial offerings of fuel station chains targeted at households in southeastern Poland. The aim of the research is to identify the scope and form of cooperation between a retail supplier of liquid fuels and individual customers residing in Poland, in the Podkarpackie Voivodeship. The research is being carried out in three stages: determining the attributes of the commercial offerings of fuel station chains targeted at households in the studied region, identifying the determinants of the choice of transport fuel supplier by households residing in the Podkarpackie Voivodeship, and determining the extent to which the commercial offerings of fuel station chains targeted at individual customers in the studied region reflect actual market needs.

Keywords: supplier, liquid fuels, individual customers.

Category of the paper: Research paper.

1. Introduction

A household is an economic category that includes one person or group that lives together, is related or unrelated, supports itself and makes financial decisions to meet the common and individual needs of household members (Statistics, 2024c). The basic functions of farms commonly include: economic functions, including consumption and production, and social functions related to reproduction and upbringing. However, the division of households included in the literature on the subject most often takes into account social criteria (i.e. number of members, their age structure, biological type, level of education, etc.), economic criteria (i.e. size and structure of income and expenses, professional structure, etc.) and geographical criteria (i.e. place of residence, classes of town, etc.) (Statistics, 2024c). A household budget is a statement of both monetary and non-monetary income and expenses. Expenditures include expenses incurred for the purchase of consumer goods and services and other expenses. Consumer goods are non-durable goods (including transport fuels), semi-durable goods and durable goods (Statistics, 2024c).

In recent years, Poland has seen an increase in the share of the costs of purchasing transport fuels in the structure of household expenses. This was related to their persistently high price level. In 2021, in Poland in the south-eastern region, i.e. Podkarpackie Voivodeship, the average number of people in a household was 2.98 (nationally 2.55). There is a low standard of living of the inhabitants in this region. GDP per person amounted to 69.4% of the national economy. The Podkarpackie Voivodeship was characterized by one of the lowest average gross salaries per person in the country (87.3% compared to the average in Poland). Disposable income per person in a household reached 82.6% of the national level. The average monthly expenses per person amounted to 76.4%. In the structure of household expenditure, 9.4% was transport (9.4% nationally), while expenses incurred for the use of an apartment or house and the purchase of energy carriers were 17.4% (18.9%) (Statistics, 2022). In 2023, the number of passenger cars in the studied voivodeship reached 1.3 million, which constituted 655 cars per 1,000 inhabitants (723 in the country) (Statistics, 2024a). In the analyzed period, in the Podkarpackie Voivodeship, the largest share in the structure of fuel consumption in road transport had motor gasoline - 46.8% (53.6% in the country) and diesel oil - 36.8% (32.4%). The share of LPG was 16.0% (13.4%). However, electric passenger vehicles and hybrid cars accounted for 0.12% (0.20%) and 0.18% (0.24%), respectively (Statistics, 2024b).

In the Podkarpackie Voivodeship, there was strong competition on the retail market of transport fuels, both from domestic and foreign companies. Over the past period, the petrol station market has changed towards a shopping and service center. At the stations, depending on their purpose, one could not only refuel the vehicle, but also do basic shopping, rest during the trip, provide financial services, eat a meal or perform simple maintenance and repair activities (Polish, 2024). Petrol stations operated as dependent chains or independently,

and as independent operators or stations at stores (Polish, 2024). The Central Statistical Office reports that in 2021, the total number of petrol stations in the Podkarpackie Voivodeship was 448 (5.5% share in the country) (Statistics, 2022). According to the Polish Organization of Petroleum Industry and Trade, in 2023 domestic concerns had a 24.4% market share, foreign ones 25.6%, independent chains 18.5%, other independent operators 29.0%, and stores 2.5%. In their entity structure, the highest share was held by PKN Orlen SA 24.4%, BP Polska Sp. z o.o. 7.3%, Shell Polska Sp. z o.o. 5.8, Anwim SA (Moya) 5.7%, Circle K Polska Sp. z o.o. 5.2%, and Mol Polska Sp. z o.o. 5.0% (Polish, 2024).

A review of the literature on the subject reveals that there are few studies on the petrol station sector in Poland. It should be emphasized that there are no detailed studies that take into account the economic and social specificity of a specific region. Available scientific works present nationwide factors determining the choice of petrol stations (Zawadzki, 2015; Zielińska, 2018; Lewicki et al., 2020; Domasiewicz et al., 2023) or a study of mobility recorded at petrol stations (Norman D., 2006). They present forms of management of petrol stations (Zawadzki et al., 2017) and issues of spatial arrangement and location conditions (Roj-Rojewski et al., 2018; Aslani et al., 2011; Tuzmen et al., 2011; Zhu et al., 2024). Moreover, the literature on the subject indicates trends and expectations in the distribution of fuels and the direction of transformation in road transport in the use of alternative power sources (Kamiński et al., 2021; Bayram et al., 2022; Domasiewicz et al., 2023). Many available scientific works emphasize the adverse impact of the operation of petrol stations on the area in which they are located, human health and their long-term consequences (e.g. Terrés et al., 2010; Maksoud et al., 2019; Adedeji et al., 2022). It should be emphasized that research on the determinants of the choice of petrol stations in the Podkarpackie Voivodeship was conducted by the author of this publication and the final results are presented in the article: Determinants of the choice of petrol stations by micro and small road transport enterprises in the Podkarpackie Voivodship (Jedynak, 2023c). Their aim was to identify the primary and secondary factors determining the choice of fuel stations by micro and small road transport enterprises headquartered in the province. Podkarpackie.

In response to the above issues, it was assumed that the main purpose of the article will be to present the results of research aimed at identifying the determinants of the choice of petrol stations by households living in south-eastern Poland in the Podkarpackie Voivodeship. The structure of the implementation of the research topic and objective will include: 1) determining the current state of knowledge in the field of the issues discussed; 2) description of the research method; 3) measurement and interpretation of the obtained results; 5) final conclusions. The research method used is a critical review of the subject literature and quantitative methods. The literature review was conducted based on electronic databases, i.e. Scholar.Google.com, Scopus.com, Academica.edu.pl and in a traditional form - library resources.

The research results presented in the article constitute the second stage of scientific research: *Attributes and determinants of the commercial offerings of petrol station network aimed at households in south-eastern Poland*. The aim of the research is to identify the scope and form of cooperation between a retail supplier of liquid fuels and individual customers residing in south-eastern Poland in the Podkarpackie Voivodeship. It will be implemented by: 1) determining the attributes of the commercial offer of the petrol station network addressed to households in the Podkarpackie Voivodeship; 2) indication of the determinants of the choice of a transport fuel supplier by households residing in the Podkarpackie Voivodeship; 3) determining the extent to which the commercial offer of the petrol station network addressed to individual customers in the Podkarpackie Voivodeship reflects the actual needs of the market.

2. Theoretical basis

Petrol stations play an important role in the automotive industry. Zielińska E. describes a petrol station as a technical base for the automotive industry (Zielińska, 2018). Norman D. notes that many activities performed at petrol stations also take place in street traffic, and thus petrol stations reflect changes and needs recorded in the automotive industry (Norman, 2006). Petrol stations primarily enable the distribution of various types of fuel, without which neither the owner of new or used vehicles could operate their own cars, in accordance with their individual transport needs (Zielińska, 2018). They may be publicly available or with limited access (Roj-Rojewski et al., 2018). In his scientific work on mobility at petrol stations, Norman emphasizes that they are a place of transition between the "static" and "mobile" states (Norman, 2006).

Kamiński A., Jakubiec J., Pusz A. note that currently petrol station facilities are architectural objects with complex construction, development and equipment (Kamiński et al., 2021). According to the Regulation of the Minister of Economy of November 21, 2005, a liquid fuel station is a building which may include: a building, underground storage tanks for liquid fuels, underground or aboveground liquid gas tanks, liquid fuel and liquid gas dispensers, technological installations, including devices for storing and loading liquid fuels and liquid gas, water, sewage and energy installations, driveways and roofs, and other devices service and support spaces (Regulation, 2005). The structure of the petrol station space will include sales and service facilities as well as technical facilities. Within the sales and service part of a petrol station, three basic zones should be indicated, i.e. refueling, vehicle service and passenger service (Zielińska, 2018).

Numerous criteria apply to the characteristics of petrol stations. When adopting the criterion of the permanent location of infrastructure facilities, portable (container) and permanent (stationary) stations should be indicated (Energy, 2024; Roj-Rojewski et al., 2018). Due to the

breadth and depth of the commercial offer, we distinguish residential, basic and highway stations (Roj-Rojewski et al., 2018; Zielińska, 2018). Similarly, Lewicki M., Zawadzki T. distinguishes petrol stations located in cities, on highways and expressways, transit stations, next to supermarkets and others (including automatic ones) (Lewicki et al., 2020). The division of petrol stations in the literature also takes into account the business organization model, on this basis we distinguish dependent and independent chains, independent operators and store stations (Polish, 2024). Adopting this criterion, Zawadzki T., Suszyńska K. indicates five possible forms of running a petrol station, i.e. running an independent petrol station operating under its own brand, running an association petrol station operating under a common brand, running a franchise petrol station, leasing the petrol station facility to a fuel concern and running a petrol station as an agent (Zawadzki et al., 2017). In the available studies, the Polish Organization of Petroleum Industry and Trade takes into account the origin of capital and subjective criteria in the division of fuel steel (Polish, 2024). The Central Statistical Office also uses geographical criteria in its studies (Statistics, 2024a).

The core activity of every petrol station is the sale of transport fuels (Roj-Rojewski et al., 2018). However, currently these entities do not focus their activity only in this area. The Polish Organization of Petroleum Industry and Trade notes that the petrol station market is changing towards the model of a shopping and service center. This meant that at stations you could not only refuel your vehicle, but also do basic shopping, rest during the journey, provide financial services, eat a meal or perform simple maintenance and repair activities (Polish, 2024). According to the Polish Organization of Petroleum Industry and Trade, important factors behind the observed changes are large road investments, changes in the location of stations, and takeovers by both domestic companies and independent chains. In addition, a ban on Sunday trading was introduced (Polish, 2024). Similarly, Zawadzki T., Suszyńska K. notes that the commercial offer of petrol stations addressed to customers is expanding to include more and more services that were previously reserved for other commercial entities, such as sending and receiving courier parcels, selling motor insurance or car rental (Zawadzki et al., 2017). Norman D. emphasizes that at petrol stations we are dealing with a very diverse group of people based on the criteria of age, gender, profession, education, financial status, etc. (Norman, 2006).

It is commonly emphasized in the literature on the subject that the scope of services offered depends mainly on its location and, therefore, the purpose of the petrol station (Zielińska, 2018; Aslani et al., 2011; Tuzmen et al., 2011). Additionally, it depends on the package of products and services available to a given operator and is significantly influenced by local competition (Jedynak, 2022). Domasiewicz M., Anuszkiewicz A. notes that the advantage of stations compared to other commercial facilities is their 24-hour availability, good location and thus access or access on days when other commercial units are closed due to applicable regulations (Domasiewicz et al., 2023). Zawadzki T., based on research, points to three key factors that Polish drivers pay particular attention to when choosing a station: convenient location, fuel price and the station's membership in a given network - understood in the context of the quality

of the fuel sold (Zawadzki, 2015). However, Roj-Rojewski S., Kotarska E. notes that the operation of petrol stations is influenced by many factors, the most important of which are the offered fuel prices and the appropriate location (Roj-Rojewski et al., 2018).

Domasiewicz M., Anuszkiewicz A. note that currently buying fuel is accompanied by purchasing food and drinks, using toilets, operating vehicles or simply resting. Based on the research conducted, they conclude that station customers are guided not only by the fuel purchase offer, but also by the gastronomic offer. Domasiewicz M., Anuszkiewicz A. in their scientific work indicate that every refueling customer uses additional options. Moreover, petrol stations must expand their customer base not only among drivers, but also among fellow passengers who satisfy their consumer needs at petrol stations. Domasiewicz M., Anuszkiewicz A. note that with constant attempts to increase the attractiveness of the station's offer, the sales of the fuel itself are decreasing (Domasiewicz et al., 2023). Zawadzki T., Suszyńska K. state that it is the relatively low margin per liter of fuel sold that is the source of dynamic changes in the offer of petrol stations, both in terms of the range of goods and services offered. In terms of personnel management, the emphasis is placed on enforcing the obligation to actively sell (so-called "cross-selling") in relation to each customer, and store promotions at petrol stations are shaped in the same way as in the case of other types of commercial units (Zawadzki et al., 2017).

Lewicki M., Zawadzki T. indicate that the most common reason for choosing a given petrol station by individual customers is a convenient location, station brand, price of fuel and other products, the possibility of using a loyalty program, convenient infrastructure and signage (Lewicki et al., 2020). Moreover, based on own research, it indicates that the main reason for stopping at a petrol station located on highways and expressways in the country is the need to refuel (91% of respondents), the need to use the toilet (35%) and buy other products (32%) (research conducted among 603 respondents) (Lewicki et al., 2020). Other Payback Opinion Poll studies show that for 41.2% of Poles, price is a decisive element when choosing a petrol station, and 36% of respondents indicate the location. In addition, available loyalty programs are an important selection factor (Payback Opinion Poll, 2023). The survey was conducted in July 2023 among 684 respondents. Based on the research conducted, Jedynak Z. concluded that the price of fuel is an essential factor in the selection of petrol stations by micro and small enterprises. The importance of non-price factors changes with the geographical scope of the business and the size of the fleet of vehicles at disposal. However, the main determinants were indicated by (Jedynak, 2023c):

- linking purchases, a significant number of customers refuel their vehicles at petrol stations included in the retail chain,
- permanent form of cooperation, enterprises prefer cooperation with petrol stations based on permanent contracts, however, the importance of a permanent form of cooperation varies depending on the size of the enterprise, the number of vehicles owned or geographical scope,

- the main factor in choosing petrol stations by the surveyed enterprises is price,
- non-price conditions were a secondary factor in the selection of petrol stations by the surveyed enterprises, the most important factors in their structure were: transaction execution conditions (including the form of cash and non-cash payment and a collective invoice for a given period), petrol station services (including a parking lot/TIR parking lot and a car wash) and the number of petrol stations and their location,
- traditional form of cooperation, the surveyed enterprises did not show much interest in the possibility of using e-book and the availability of a mobile application,
- in the case of primary and secondary factors in the selection of petrol stations by the surveyed enterprises, the criterion of enterprise size, fleet operated or geographical range of services provided does not indicate significant differences.

3. Methodology

The stages of implementing the research procedure include: 1) indicating the research topic, its purpose, scope and method; 2) determining and defining evaluation criteria; 3) selection of a sample for research; 4) measurement; 5) interpretation of the obtained results; 6) final conclusions; 7) dissemination of research results.

The research topic adopted is: *Determinants of gas station selection by households in south-eastern Poland*. The main goal will be to identify the primary and secondary factors that determine gas station selection by households residing in the south-eastern part of Poland.

The essence of the research problem will be to answer questions regarding the primary and secondary factors determining the choice of petrol stations for individual customers in the studied region. Detailed questions will refer to the indication of differences when choosing a supplier, taking into account the criteria of respondents' place of residence, age structure, main sources of income, number of people in the household or geographical scope of daily activity. Therefore, the research focuses on the primary and secondary factors that determine individual customers' choice of fuel station. The research is conducted on households. The research area is the retail market for transportation fuels located in south-eastern Poland in the Podkarpackie Voivodeship.

In terms of the state of knowledge, taking into account the researcher's achievements and experience, the following research hypothesis was formulated, i.e. the price of fuel is an essential factor in the selection of petrol stations by households in the Podkarpackie Voivodeship in Poland. The importance of non-price factors changes with the geographical scope of daily activities of people in the household.

The research method used is quantitative research. The research technique is a survey. Research tool Interview form. Data measurement will be carried out by surveys. Geographical scope of research: Podkarpackie Voivodeship. It was assumed that the measurement would be carried out in March-April 2025. MS Excel analytical tool. The confidentiality of data and the reliability of its collection will be maintained in the research.

For the needs of the conducted research, the following research areas were indicated, i.e. initial criterion - characteristics of respondents (*Entry criterion*); applicable form of cooperation (Form of cooperation); primary and secondary selection factors (*Determinants*). The adopted areas were defined using 22 questions. The survey form is presented in Table 1-3.

Table 1.
Interview form – Entry criterion

TESTED PARAMETER		DESCRIPTION		
I.1	Place of residence of the respondent:	A	city/village name:	
		B	name commune:	
		C	name of poviats:	
I.2	Gender of the respondent:	A	☐ woman	
		B	☐ man	
I.3	Age of the respondent:	A	☐ 18-25	
		B	☐ 26-35	
		C	☐ 36-45	
		D	☐ 46-55	
		E	☐ 56 and above	
I.4	Education of the respondent:	A	☐ higher/higher incomplete	
		B	☐ medium	
		C	☐ other	
I.5	The main source of income in the household:	A	☐ pension and annuity	
		B	☐ agricultural activities	
		C	☐ hired work (employed person)	
		D	☐ self-employed (entrepreneur)	
		E	☐ other (living on unearned sources)	
I.6	Number of people in the household:	A	☐ 1	
		B	☐ 2	
		C	☐ 3	
		D	☐ 4	
		E	☐ 5 and above	
I.7	Geographic scope of people's daily activities in households: * you can mark multiple answers.	A	☐ local (poviats, commune)	
		B	☐ regional (Podkarpackie Voivodeship)	
		C	☐ interregional (Podkarpackie Voivodeship area and neighboring voivodeships)	
		D	☐ domestic	
		E	☐ continental	
I.8	Type and number of vehicles at your disposal in the household: * you can mark multiple answers.	A	☐ passenger car	pcs.
		B	☐ delivery vehicle up to 3.5 tons (DMC)	pcs.
		C	☐ motorbike, quad, scooter, etc.	pcs.
		D	☐ electric bike, electric scooter, etc.	pcs.
		E	☐ other self-propelled vehicles	pcs.

Cont. table 1.

I.9	Type of fuel used: * you can mark multiple answers.	A	☐ ON
		B	☐ ON Premium
		C	☐ PB 95
		D	☐ PB 98 (Premium)
		E	☐ LPG
		F	☐ Electricity
I.10	Average monthly number of kilometers traveled in the household	A	☐ up to 1000 km
		B	☐ 1001-2500 km
		C	☐ 2501-4000 km
		D	☐ over 4000 km
I.11	Average monthly expenses incurred for the purchase of fuel in the household:	A	☐ up to 300 pln
		B	☐ 301-600 pln
		C	☐ 601-900 pln
		D	☐ over 900 pln

Source: own study.

Table 2.*Interview form – Form of cooperation*

TESTED PARAMETER		DESCRIPTION	
II.1	Do you use petrol station services?	A	☐ yes
		B	☐ no
II.2	Please circle the correct answer:	A	☐ I refuel my vehicles only at one selected brand of petrol station
		B	☐ I refuel my vehicles only at selected brands of petrol stations
		C	☐ when choosing a petrol station, the type of brand does not matter
II.3	What type of petrol station do you use? * you can mark multiple answers.	A	☐ station networks (e.g. Orlen, Moya, BP, Shell, CircleK, Mol, etc.)
		B	☐ independent stations (private owner)
II.4	Do you use loyalty programs offered by the petrol station?	A	☐ yes
		B	☐ no

Source: own study.

Table 3.*Interview form – Determinants*

TESTED PARAMETER		DESCRIPTION	
III.1	The importance of fuel prices when choosing a petrol station:	A	☐ is of fundamental importance (the most important)
		B	☐ on par with non-price conditions
		C	☐ secondary importance, below non-price conditions
III.2	Do you use discount coupons for fuel purchases offered by the petrol station?	A	☐ yes, if available
		B	☐ occasionally
		C	☐ no
III.3	Do you use discount coupons for the purchase of non-fuel products and services offered by the petrol station?	A	☐ yes, if available
		B	☐ occasionally
		C	☐ no

Cont. table 3.

III.4	Basic non-price factors when choosing a petrol station: <i>*you should indicate a maximum of 5 (on a scale of 1-5, where 1 is the most important factor, 5 is the lowest rated factor)</i>	A	☐ loyalty program
		B	☐ respecting the Large Family Charter
		C	☐ mobile application
		D	☐ electronic internet platform (e-book)
		E	☐ services offered at the petrol station (e.g. parking, car wash, repairs, catering, etc.)
		F	☐ location of petrol stations
		G	☐ opening hours
		H	☐ number of petrol stations and their geographical range
		I	☐ position and importance of petrol stations on the market
		J	☐ opinion about the petrol station from buyers
		K	☐ availability of gift cards
		L	☐ other, i.e.
III.5	As part of access to the mobile application , the following is of key importance when choosing a supplier: <i>*you should indicate a maximum of 5 (on a scale of 1-5, where 1 is the most important factor, 5 is the lowest rated factor)</i>	A	☐ I don't use it
		B	☐ access to an electronic loyalty card
		C	☐ access to fuel and non-fuel transactions
		D	☐ access to sales documents
		E	☐ offered discount coupons for the purchase of fuel and other products/services
		F	☐ quick payment at the distributor
		G	☐ map location of petrol stations
		H	☐ online store
		I	☐ electronic loyalty catalogues
		J	☐ road and parking fees
		K	☐ access to navigation and maps
		L	☐ other, i.e.
III.6	As part of access to e-bok (electronic internet platform), the selection of a supplier is of fundamental importance: <i>*you should indicate a maximum of 5 (on a scale of 1-5, where 1 is the most important factor, 5 is the lowest rated factor)</i>	A	☐ I don't use it
		B	☐ access to an electronic loyalty card
		C	☐ access to fuel and non-fuel transactions
		D	☐ access to sales documents
		E	☐ offered discount coupons for the purchase of fuel and other products/services
		F	☐ quick payment at the distributor
		G	☐ map location of petrol stations
		H	☐ online store
		I	☐ electronic loyalty catalogues
		J	☐ road and parking fees
		K	☐ access to navigation and maps
		L	☐ other, i.e.
II.7	As part of the services provided at stations, the selection of a supplier is of fundamental importance: <i>*you should indicate a maximum of 5 (on a scale of 1-5, where 1 is the most important factor, 5 is the lowest rated factor)</i>	A	☐ shop
		B	☐ parking
		C	☐ catering services
		D	☐ toilet/sanitation
		E	☐ hotel services
		F	☐ repair/technical inspection
		G	☐ car wash
		H	☐ parcel pickup/sending
		I	☐ direct service at the distributo
		J	☐ mobile cashiers
		K	☐ self-service checkouts in the petrol station building
		L	☐ double-sided refueling at the distributor
		M	☐ electric vehicle charging stations
		N	☐ other, i.e.

Source: own study.

4. Empirical Results and Discussion

The research was conducted in March and April 2025. The number of respondents was 584. The sample was selected randomly. The research was direct. Due to failure to meet the geographical criterion, 29 research forms were rejected. Additionally, 20 formal errors were recorded. A total of 535 correctly completed research forms were subject to further evaluation and interpretation of the obtained results.

In accordance with the adopted geographical scope of the research, the respondents' place of residence was the Podkarpackie Voivodeship. The study was conducted in 24 poviats. Their total number in the studied voivodeship is 25 (of which 21 land counties and 4 city counties). A significant part of the respondents' structure were people living in the Rzeszów district and the city of Rzeszów. Their total share was 39.6%. It should be emphasized that the number of inhabitants of these two counties constitutes 17.8% of the Podkarpackie Voivodeship. An important group of respondents also included people representing the Dębica, Ropczyce-Sędziszów, Łańcut and Leżajsk counties. In total, their share in the research structure amounted to 19.9%, and in the number of inhabitants of the studied region - 17.1%. The geographical structure of respondents is presented in Figure 1.

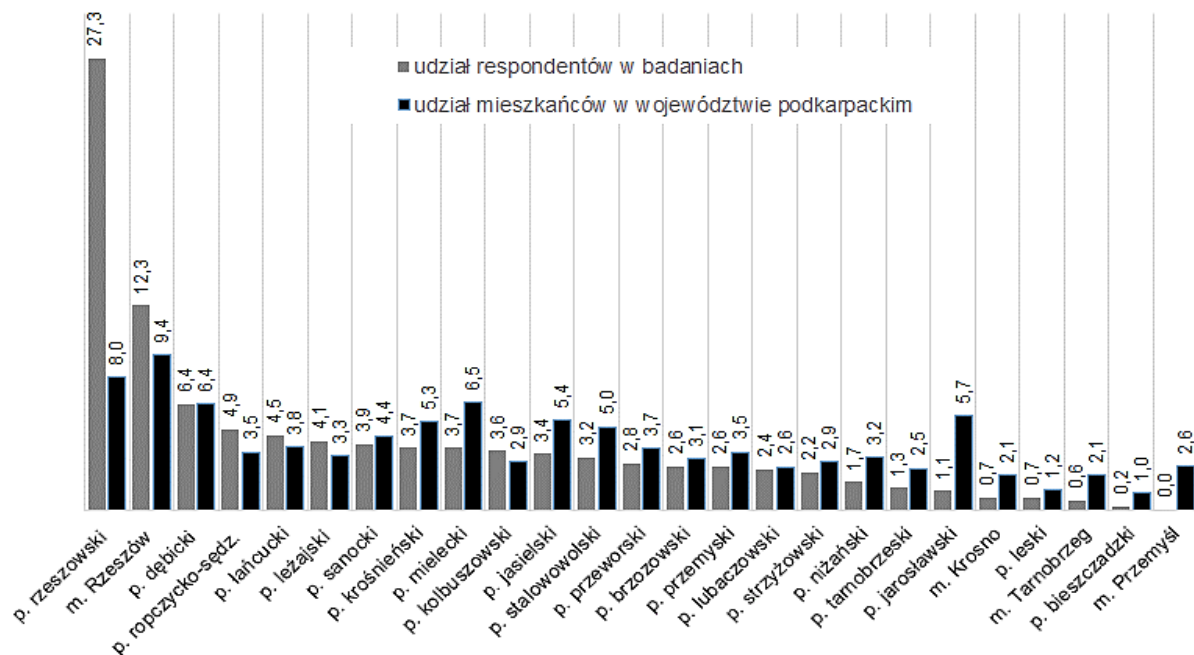


Figure 1. Geographical structure of respondents (by poviats).

Source: own study.

65.2% of the surveyed people were men. In the age structure, 73.3% are people aged 18-25 and 36-55. Taking into account education - 50.7% were people with higher education, and 43.0% with secondary education. Their main source of income was hired work - 62.0% of respondents. Self-employed people also constituted an important group (22.3%). Assuming the

criterion of the number of people in a household, the largest group were 3- and 4-person households (their total share was 58.0%). A high share was also recorded by more than 4 people (20.1%).

The geographical scope of everyday activity of people in the surveyed households was mainly local and regional (87.9% in total). 83.3% of respondents traveled a distance of up to 2500 km on average per month.

In the vehicle type structure, 72.8% were passenger cars. The average number of passenger cars per household was 2.1 vehicles. Assuming the criterion of the type of fuel used, Standard fuels had the largest share (69.4% in total, where PB 95 - 41.9%, diesel - 28.2%). However, expenses incurred for the purchase of transport fuels were mainly in the range of PLN 301-900/month (64.5% of respondents). The measurement results in the Initial Criterion area are presented in Table 4.

Table 4.
Measurement results in the area of Entry criterion

TESTED PARAMETER		MEASUREMENT										
		Total answer		I.7 [%]					I.10 [%]			
		pcs.	%	A	B	C	D	E	A	B	C	D
I.2	A	186	34,8	34,8	34,8	35,3	31,5	29,1	12,0	28,6	42,0	29,0
	B	348	65,2	65,2	65,2	64,7	68,5	70,9	88,0	71,4	58,0	71,0
I.3	A	131	24,5	24,5	24,5	23,5	27,0	25,9	16,7	0,0	25,7	21,6
	B	67	12,5	12,5	12,5	11,4	15,4	24,1	16,7	0,0	10,6	15,1
	C	114	21,3	21,3	21,3	22,7	19,5	14,8	16,7	14,3	16,8	26,1
	D	147	27,5	27,5	27,6	26,6	26,1	29,6	33,3	57,1	26,5	28,0
	E	75	14,0	14,0	14,0	15,8	12,0	5,6	16,7	28,6	20,4	9,2
I.4	A	229	43,0	43,0	43,0	38,9	48,8	58,2	48,0	57,1	38,5	41,2
	B	270	50,7	50,7	50,6	53,4	47,9	40,0	52,0	42,9	52,7	54,6
	C	34	6,4	6,4	6,4	7,8	3,3	1,8	0,0	0,0	8,8	4,2
I.5	A	46	8,5	8,5	8,5	11,0	5,7	3,6	4,0	14,3	15,4	2,3
	B	15	2,8	2,8	2,8	3,1	2,5	1,8	0,0	0,0	3,1	3,2
	C	334	62,0	62,0	61,9	62,9	63,5	58,9	64,0	57,1	55,3	72,1
	D	120	22,3	22,3	22,3	18,7	23,0	33,9	28,0	28,6	20,6	19,2
	E	24	4,5	4,5	4,5	4,3	5,3	1,8	4,0	0,0	5,7	3,2
I.6	A	41	7,6	7,6	7,6	8,8	6,1	9,1	8,0	0,0	11,1	4,5
	B	77	14,3	14,3	14,3	16,5	10,6	12,7	12,0	14,3	20,8	10,9
	C	151	28,1	28,1	28,1	25,8	28,2	27,3	20,0	28,6	30,1	25,3
	D	161	29,9	29,9	29,9	28,1	33,9	30,9	32,0	14,3	21,7	40,3
	E	108	20,1	20,1	20,1	20,9	21,2	20,0	28,0	42,9	16,4	19,0
I.7	A	388	54,1	54,1	54,0	69,4	30,9	22,6	21,7	12,5	67,7	48,5
	B	242	33,8	33,8	33,8	22,9	58,5	24,2	20,0	12,5	26,2	37,6
	C	55	7,7	7,7	7,7	5,0	7,2	44,4	13,3	18,8	3,9	9,2
	D	25	3,5	3,5	3,5	2,3	2,9	6,5	41,7	12,5	1,4	3,4
	E	7	1,0	1,0	1,0	0,4	0,5	2,4	3,3	43,8	0,7	1,4
I.8	A	1098	72,8	72,8	72,9	72,7	71,8	73,2	64,9	76,2	82,0	71,3
	B	68	4,5	4,5	4,5	5,2	4,0	5,4	6,2	0,0	3,7	4,7
	C	162	10,7	10,7	10,7	11,0	12,0	10,7	9,3	9,5	6,3	10,8
	D	73	4,8	4,8	4,8	3,6	5,6	4,8	9,3	0,0	2,8	4,6
	E	107	7,1	7,1	7,1	7,4	6,6	6,0	10,3	14,3	5,2	8,6
I.9	A	260	28,2	28,2	28,2	27,0	29,9	26,2	21,2	20,0	24,0	30,5
	B	41	4,4	4,4	4,4	3,9	6,0	9,3	7,7	0,0	4,7	4,1
	C	381	41,3	41,3	41,3	42,6	37,8	36,4	40,4	50,0	47,1	38,1
	D	78	8,5	8,5	8,5	8,8	9,7	11,2	13,5	10,0	7,9	9,6
	E	140	15,2	15,2	15,2	14,9	13,9	15,9	13,5	20,0	14,3	14,9
	F	23	2,5	2,5	2,5	2,7	2,6	0,9	3,8	0,0	2,0	2,9

Cont. table 4.

I.10	A	226	42,4	42,4	42,4	49,0	30,3	20,0	16,0	28,6	100,0	0,0
	B	218	40,9	40,9	40,9	37,0	46,1	49,1	40,0	57,1	0,0	100,0
	C	60	11,3	11,3	11,3	8,3	18,3	18,2	24,0	14,3	0,0	0,0
	D	29	5,4	5,4	5,4	5,7	5,4	12,7	20,0	0,0	0,0	0,0
I.11	A	88	16,5	16,5	16,5	19,7	8,3	7,3	8,0	14,3	36,9	1,4
	B	201	37,8	37,8	37,8	40,5	37,3	30,9	24,0	14,3	51,6	38,5
	C	142	26,7	26,7	26,7	22,3	30,3	34,5	36,0	57,1	9,3	44,5
	D	101	19,0	19,0	19,0	17,4	24,1	27,3	32,0	14,3	2,2	15,6

Source: own study.

96.3% of surveyed people use petrol station services. Almost half of the respondents (i.e. 48.4) refuel their vehicles only at selected brands of petrol stations. 27.0% buy fuels only at one selected brand of petrol station. For the remaining respondents, the type of brand is not important when choosing a petrol station. The preferred type of station by respondents is stations that are part of the sales network (79.0%). 63.2% of surveyed people used loyalty programs.

Regardless of their daily activity or the number of kilometers traveled, almost all respondents use the services of petrol stations. A significant number of them use the services of retail chains and loyalty programs. Almost half of people refuel their vehicles only at selected brands of petrol stations. It should be emphasized that the results obtained, which take into account daily activity and the number of kilometers traveled, are consistent with the overall assessment. There were no significant deviations in the structure of the responses. The measurement results in the Form of cooperation area are presented in Table 5.

Table 5.*Measurement results in the area of Form of cooperation*

TESTED PARAMETER		MEASUREMENT										
		Total answer		I.7 [%]					I.10 [%]			
		pcs.	%	A	B	C	D	E	A	B	C	D
II.1	A	492	96,3	95,2	96,2	95,9	100,0	100,0	95,0	97,6	98,2	100,0
	B	19	3,7	4,8	3,8	4,1	0,0	0,0	5,0	2,4	1,8	0,0
II.2	A	143	27,0	28,5	27,1	27,3	32,0	57,1	26,9	27,3	23,3	34,5
	B	256	48,4	45,3	50,4	49,1	32,0	42,9	44,8	52,8	51,7	37,9
	C	130	24,6	26,2	22,5	23,6	36,0	0,0	28,3	19,9	25,0	27,6
II.3	A	482	79,0	79,0	78,5	83,1	65,6	100,0	80,8	81,7	68,0	69,7
	B	128	21,0	21,0	21,5	16,9	34,4	0,0	19,2	18,3	32,0	30,3
II.4	A	60,1	71,5	70,9	68,0	85,7	54,4	72,0	63,3	69,0	60,1	71,5
	B	39,9	28,5	29,1	32,0	14,3	45,6	28,0	36,7	31,0	39,9	28,5

Source: own study.

Almost half of respondents said that price is of primary importance when choosing a petrol station. For 39.8% of people, it was treated equally with the rest of the commercial offer. When purchasing fuel, 52.3% of respondents always use available discount coupons, and 27.0% occasionally use them. When purchasing non-fuel products and services offered by the station, only 23.2% take advantage of the discount offer. However, most respondents do not use discount coupons or use them only occasionally.

The basic non-price factors when choosing a petrol station were mainly indicated by its location - 19.5%, services offered at petrol stations - 12.5% and opening hours - 12.2%. Additionally, buyers' opinions about petrol stations were important - 11.1% and the available loyalty program - 9.6%. The lowest rating was given to the electronic online platform - 2.0% and the availability of gift cards - 3.2%.

As part of access to the mobile application, discount coupons for the purchase of fuel and other products or services were important when choosing a supplier - 14.9% and access to an electronic loyalty card - 13.6%. In addition, electronic access to transactions was also important - 10.6%, quick payment at the pump - 9.5% and a map of the location of petrol stations - 8.9%. 15.8% of respondents do not use the mobile application. And the lowest ratings were given to access to navigation and maps - 4.0%, online store - 4.2% and road and parking fees - 4.5%.

69.7% of respondents do not use the online platform. Users rated access to sales documents the highest - 4.4% and access to transactions - 4.0%. Electronic loyalty catalogs have the lowest - 2.1%. Moreover, similarly to the mobile application, access to navigation and maps - 2.1% and road and parking fees - 2.3%.

Among the services provided at petrol stations, toilet/sanitary conditions were of primary importance - 15.8%, accessible shops - 13.8% and parking 12.9%. Additionally, the decision was influenced by double-sided refueling at the pump - 11.8% or an available car wash - 10.2%. The lowest rated were hotel services 1.8% and electric vehicle charging stations 1.9%.

Taking into account daily activity and the number of kilometers traveled, almost all respondents indicated that price is of primary importance when choosing a petrol station. The answer recorded a high result, along with other purchase conditions. Regardless of the form of activity or the number of kilometers traveled, almost half of respondents use discount coupons for fuel purchases. However, in the case of non-fuel coupons, the vast majority are not interested or only use them occasionally. The basic non-price factors in choosing a petrol station, regardless of daily activity or the number of kilometers traveled, correspond to the overall results. There were no significant deviations in the structure of the responses. The situation is similar when assessing the functionality of a mobile application, e-book or access to services provided at petrol stations. The measurement results in the Determinants area are presented in Table 6.

Table 6.
Measurement results in the area of Determinants

TESTED PARAMETER		MEASUREMENT										
		Total answer		I.7 [%]					I.10 [%]			
		pcs.	%	A	B	C	D	E	A	B	C	D
III.1	A	262	49,0	50,1	48,1	30,9	52,0	57,1	47,3	50,0	53,3	41,4
	B	213	39,8	38,3	39,5	43,6	24,0	28,6	42,5	39,9	30,0	41,4
	C	60	11,2	11,6	12,3	25,5	24,0	14,3	10,2	10,1	16,7	17,2

Cont. table 6.

III.2	A	279	52,3	49,1	58,5	49,1	48,0	71,4	46,5	59,0	51,7	51,7
	B	144	27,0	26,9	26,6	27,3	20,0	14,3	27,0	26,7	31,7	20,7
	C	110	20,6	24,0	14,9	23,6	32,0	14,3	26,5	14,3	16,7	27,6
III.3	A	122	23,2	21,8	25,5	29,6	33,3	33,3	20,7	23,8	23,7	37,9
	B	200	38,0	37,9	41,4	35,2	45,8	33,3	32,9	42,5	42,4	34,5
	C	204	38,8	40,3	33,1	35,2	20,8	33,3	46,4	33,6	33,9	27,6
III.4	A	242	9,6	9,4	9,9	8,9	7,7	18,8	9,7	9,8	7,7	10,7
	B	134	5,3	5,6	5,1	4,4	4,9	9,4	5,9	5,2	3,3	6,0
	C	212	8,4	8,2	8,6	8,9	8,4	9,4	7,7	9,1	9,0	6,7
	D	50	2,0	1,9	1,6	2,2	4,2	0,0	1,8	1,8	2,7	2,7
	E	317	12,5	12,3	13,8	12,6	10,5	6,3	11,3	13,1	15,0	12,1
	F	492	19,5	19,5	19,3	19,3	15,4	21,9	20,0	18,6	22,0	17,4
	G	308	12,2	12,9	12,0	11,5	11,2	9,4	13,3	11,7	11,0	10,7
	H	193	7,6	7,2	7,3	9,3	8,4	3,1	7,6	7,2	9,7	7,4
	I	208	8,2	7,9	8,4	8,5	9,8	3,1	8,2	8,9	4,7	10,7
	J	281	11,1	11,6	10,5	11,9	11,9	18,8	10,9	11,7	10,3	10,1
	K	80	3,2	3,1	2,9	1,9	6,3	0,0	3,0	2,8	3,7	5,4
	L	9	0,4	0,3	0,5	0,7	1,4	0,0	0,5	0,1	1,0	0,0
III.5	A	239	15,8	17,8	12,5	16,8	9,7	17,6	23,5	11,1	12,7	11,8
	B	206	13,6	12,5	14,6	13,5	11,7	17,6	13,0	14,0	13,3	15,3
	C	160,0	10,6	9,7	10,8	11,0	13,6	11,8	9,4	11,5	11,6	8,2
	D	130	8,6	8,6	8,6	6,5	5,8	5,9	8,5	9,1	8,3	5,9
	E	226	14,9	14,6	16,0	16,8	13,6	23,5	13,9	15,6	14,9	16,5
	F	144	9,5	9,2	10,5	10,3	10,7	11,8	7,0	11,1	10,5	10,6
	G	134	8,9	8,9	9,7	8,4	8,7	0,0	8,3	9,0	10,5	8,2
	H	63	4,2	4,5	3,9	3,9	4,9	5,9	3,8	4,1	5,0	5,9
	I	82	5,4	5,5	5,1	4,5	7,8	5,9	5,3	5,5	4,4	8,2
	J	68	4,5	4,4	5,3	5,2	5,8	0,0	3,2	5,0	6,1	4,7
	K	60	4,0	4,3	3,0	3,2	7,8	0,0	4,1	4,1	2,8	4,7
	L	0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
III.6	A	490	69,7	69,2	64,8	70,4	52,4	45,5	78,1	61,3	63,1	100,0
	B	25	3,6	3,5	4,1	5,6	4,8	18,2	2,6	5,0	2,4	0,0
	C	28	4,0	4,3	4,7	2,8	4,8	0,0	3,0	5,7	2,4	0,0
	D	31	4,4	4,5	4,1	5,6	7,1	18,2	3,3	6,0	3,6	0,0
	E	24	3,4	3,3	3,8	4,2	4,8	18,2	3,3	4,4	1,2	0,0
	F	22	3,1	3,3	4,1	2,8	7,1	0,0	2,2	3,1	7,1	0,0
	G	26	3,7	3,9	3,6	2,8	4,8	0,0	3,0	4,1	6,0	0,0
	H	11	1,6	1,6	2,1	1,4	2,4	0,0	0,7	1,9	3,6	0,0
	I	15	2,1	2,0	2,4	0,0	4,8	0,0	1,1	3,1	2,4	0,0
	J	16	2,3	2,2	3,3	1,4	4,8	0,0	1,5	2,8	3,6	0,0
	K	15	2,1	2,2	3,0	2,8	2,4	0,0	1,1	2,5	4,8	0,0
	L	0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
III.7	A	351	13,8	14,5	13,3	13,7	12,5	18,5	14,8	12,9	14,3	12,7
	B	327	12,9	12,6	12,1	12,9	9,9	18,5	13,9	12,3	11,9	12,0
	C	240	9,4	9,5	10,4	9,7	7,9	7,4	8,6	9,8	10,8	10,2
	D	402	15,8	15,6	16,8	18,0	13,8	25,9	15,1	16,2	17,8	13,9
	E	46	1,8	1,8	1,5	1,8	3,3	0,0	1,7	2,0	1,4	2,4
	F	92	3,6	4,1	3,5	3,6	4,6	0,0	3,2	3,8	3,1	5,4
	G	259	10,2	9,8	10,9	11,2	11,2	3,7	9,7	10,5	11,5	9,0
	H	103	4,1	4,1	4,1	2,5	5,9	3,7	4,1	4,1	3,5	4,2
	I	161	6,3	6,4	6,9	5,8	5,9	7,4	6,3	6,5	6,3	6,0
	J	103	4,1	3,7	4,0	3,6	3,9	0,0	4,8	3,8	2,8	3,6
	K	106	4,2	4,0	3,7	4,0	5,3	3,7	3,7	4,3	4,2	6,0
	L	300	11,8	11,9	11,3	9,7	10,5	11,1	12,3	11,9	10,1	10,8
	M	48	1,9	1,8	1,4	2,9	3,9	0,0	1,7	2,0	1,4	3,6
	N	4	0,2	0,2	0,2	0,7	1,3	0,0	0,2	0,0	0,7	0,0

Source: own study.

5. Conclusions

The implementation of the topic and purpose of the research allowed to identify the following determinants of the choice of petrol stations by individual customers whose place of residence is the Podkarpackie Voivodeship in Poland, i.e.:

- Regular suppliers, the majority of respondents use the services of selected brands of petrol stations or are attached to one selected brand. Based on the answers provided, it was concluded that the type of brand is important when choosing a petrol station.
- Linking the purchase, a significant number of respondents refuel their vehicles at petrol stations included in the retail chain and use available loyalty programs.
- The main factor in choosing petrol stations by households is price. In the answers provided, price was mainly of primary importance or was treated equally with non-price factors. It should be emphasized that a significant number of respondents use available discount coupons for fuel purchases. However, in the case of non-fuel products and services, they show only occasional or no interest.
- A secondary factor in the selection of petrol stations by households were non-price conditions. The most important factors in their structure were: the location of the petrol station, the services offered there and its opening hours. Opinions about petrol stations and the available loyalty program were also important.
- The preferred form of cooperation is mobile. Only 15.8% of respondents do not use the mobile application. As part of access to the mobile application, discount coupons and access to a loyalty card were important when choosing a supplier. Additionally, access to transactions via the application, quick payment at the pump and a map of petrol station locations.
- Lack of interest in the available online platform. 69.7% of respondents do not use e-book.
- Required basic standard in the scope of services provided to support purchases. As part of the services provided at petrol stations, toilet/sanitary conditions, accessible shops and parking spaces were of primary importance to the surveyed respondents. Additionally, the decision was influenced by double-sided refueling at the pump or an available car wash.
- In the case of primary and secondary factors in the selection of petrol stations by the surveyed households, the additional criteria of daily activity or the number of kilometers traveled per month do not indicate significant differences.

To sum up, the adopted topic and purpose of the article is a response to the identified needs reported by the retail market of petrol stations in relation to the current state of knowledge, achievements and experience of the researcher. The implementation of the topic and purpose of the research allowed us to identify the determinants of the choice of petrol stations by

households living in the Podkarpackie Voivodeship in Poland. In the article, the actions taken to achieve progress in scientific knowledge have led to the expansion of knowledge in the discipline of management and quality science in the area of commercial systems, their organization and management. The adopted research hypothesis was partially rejected. Price turned out to be a crucial factor when choosing a petrol station by households living in the Podkarpackie Voivodeship. However, factors related to daily activity or the average number of kilometers traveled per month did not significantly differentiate the results.

No significant limitations were noted during the research procedure. The number of surveyed respondents was 584. Their selection was random. Due to failure to meet the geographical criterion, 29 research forms were rejected. Additionally, 20 formal errors were recorded. The greatest difficulty when filling out the forms was related to answering questions III.4-III.7. In these questions, it was necessary not only to select the factors determining them but also to provide their scale of importance. A significant number of respondents limited themselves to only indicating them. Consequently, this form of response was taken into account when presenting and interpreting the research results. It should also be noted that a significant part of the respondents, above their average in the studied voivodeship, came from the Rzeszów poviat and the city of Rzeszów.

The study revealed the need for further research into the fuel sector in the Podkarpackie Voivodeship in Poland. Additionally, by introducing the time criterion, taking into account the social and economic structure of households and the purpose and type of a given petrol station. It should be noted that the literature on this subject is very limited. This becomes very clear when we take into account the geographical criterion. The author is aware that the presented study does not exhaust the topic.

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INCONSISTENCY BETWEEN VALUE CREATION AND GOING CONCERN RISK: LONG-TERM EVIDENCE FROM POLISH ENTERPRISES

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Purpose: The article addresses the gap in assessing long-term inconsistencies between value creation and going-concern risk. It confronts the assumptions of Value-Based Management with empirical evidence, showing that the value–risk relationship is non-linear and time-varying. The objective is to measure this inconsistency, identify determinants, and classify enterprise structures.

Methodology: The study covers 44,974 non-financial enterprises in Poland during 2007-2025. A designed multifaceted value measure combines shareholder benefits with value added transmitted to the economy, and the logit model integrates determinants of financial security. Other uses include: displacement and ranking methods, taxonomic similarity metrics, normative pattern recognition, and cause-and-effect assessment.

Findings: Shareholder value creation declines in favor of economy-wide value added, temporarily reversing during systemic shocks (e.g., the pandemic). Financial security exhibits a downward, phased trend and heightened volatility during turbulent periods. Security sources move from operational efficiency toward resource mobilization. The initially strong positive value–security correlation weakens and turns negative. Enterprise structures show low similarity and a rare coexistence of high value creation and high security with low volatility.

Research limitations/implications: The analysis is restricted to enterprises with over 9 employees and focuses solely on financial aspects. Annual data may not capture short-term fluctuations. Future research should include sectoral comparisons, shifts in security sources, threshold effects in the value–risk link, and the impacts of policy interventions.

Practical and social implications: Managerial systems should shift focus from shareholder value maximization toward sustainable value creation. Integrating operational, financial, and strategic risk management with liquidity and capital buffers is essential. Short-term performance pressure fosters excessive crisis profits and social tension, reinforcing the need for balanced stakeholder value and stronger governance.

Originality/value: The study provides the first long-term analysis of the full enterprise population, simultaneously using a multifaceted value measure and a logit model of financial security. By integrating value–security assessment with profile and normative pattern analysis, it challenges the linear value–risk paradigm and highlights the role of integrated/sustainable risk-adjusted management.

Keywords: value creation; value-based management; financial security of going concern.

Category of the paper: research paper.

1. Introduction

Value-Based Management (VBM) has become the dominant paradigm in recent decades, assuming the maximization of shareholder wealth as the overriding goal of enterprise financial management. However, aggressive enterprise value creation has a "dark side": beyond a critical threshold, marginal value gains produce disproportionately high risk increments, endangering enterprise sustainability (Roggi, Andersen, 2012). The relationship between enterprise value creation and business risk is dualistic: risk acceptance is essential for value growth, but excessive exposure leads to its destruction and potential bankruptcy.

This challenge is compounded by the temporal dimension: short-term metrics pressure weakens the management of risks that emerge over the long term (Bromiley, McShane, 2015). E.H. Bowman's paradox shows that enterprises with higher strategic risk fail to achieve proportional returns and exhibit inferior long-term performance compared to those with moderate risk (Miller, Waller, 2003). This prompts the question: Does the enterprise value creation–business risk link embody a contradiction or a dialectical coexistence of opposing profiles?

The study investigates the inconsistency between enterprise value creation and business risk via financial effects:

- value creation:
 - for shareholders (internal value created),
 - transmitted to the economic system (external value created),
- financial security of a going concern.

External value created approximates stakeholder value, while the financial security of a going concern counters bankruptcy risk. The financial lens stems from the premise that sustainable development and management yield premium profits and sustainable value as quantifiable financial outcomes. The sample comprises 44,974 enterprises (with over 9 employees) from sections B-N of the Polish Classification of Activities.

Empirical objectives include measuring and evaluating the inconsistency between value creation and the financial security of a going concern, characterizing the population, classifying profiles, and performing comparative analysis. Methodologically, a multifaceted value measure (MVM) and value drivers assess value creation. A logit model quantifies the financial security of a going concern (FSD). Ordering draws on ranking, variability, and normative patterns.

Tested hypotheses are:

- H1. The impact of shareholder value and rate of value added on the multifaceted value measure is equivalent and stable.
- H2. Changes in the financial security of a going concern are phased, and the distribution and balance of the determinants' forces are constant.

H3. The correlation between value creation and the financial security of a going concern is directly proportional.

H4. The profiles of structures in terms of value creation and financial security of going concern are similar.

Hypothesis results appear in the findings section, with implications discussed next. The conclusion summarizes key insights, limitations, and research directions. This article is part of a publication series on the Polish enterprise sector studies.

2. Cross-implications of value creation and risk management

2.1. Value creation

The essence of an enterprise is captured by three core principles that guide its operations: the ability to generate profit, the ability to operate under risk conditions, and entrepreneurial initiative (Penc-Pietrzak, 2003, p. 14). Enterprise activities are purposeful: goals direct planning, motivate employees, and form the basis for performance evaluation, though they do not always constitute a coherent hierarchy (Cyfert, 2004, pp. 25-32). The most general goals remain survival and development. Survival is a prerequisite for all other objectives, while development embodies their essence and serves as the ultimate measure of success.

Measuring and evaluating these two fundamental categories - their interdependencies and dynamics - forms the primary focus of this article. Enterprise development hinges on its durability, understood as sustainability in both operational and strategic terms. Sustainable development transcends narrow eco-development; it is supported by evolving tools and processes of sustainable management, reflecting the tight correlation between long-term enterprise growth and effective stakeholder relationship management (Svenson, Wood, Callaghan, 2010).

This perspective conflicts with the dominant Value-Based Management (VBM) philosophy, which prioritizes shareholder value creation. Pursuing broad stakeholder goals may dilute enterprise value creation, generating tensions. In response, "illuminated VBM" proposes complementarity between stakeholder approaches and VBM principles (Lenssen, Smith, 2019, pp. 224-225). Enterprise performance under this framework is still assessed primarily through financial metrics. Accommodating stakeholder expectations - including broader environmental and local community interests - occurs only insofar as it enhances financial outcomes (Hahn, Figge, Barkemeyer, 2007). Value creation metrics then provide financial justification for sustainable development strategies, bolstered by well-designed sustainable business models (Bocken, Short, Evans, 2014).

In summary, enterprise development yields diverse effects that create value and ultimately meet stakeholders' expectations. Among these, owners and their core financial goal of value creation hold a central position. By creating value for shareholders, enterprises also generate it for other stakeholders (Lubin, Esty, 2010). At the microeconomic level, created value naturally extends to the macroeconomic sphere as value added: the foundation of GDP and a key measure of economic growth.

2.2. Financial threat

Under widespread uncertainty, the critical consequence of entering a deep state of distress is an enterprise crisis. Crises are inherently complex, typically resulting from multiple interacting factors, a chain of cause-and-effect events, and an escalation path (Slatter, Lovett, 2001, p. 46). Crisis symptoms stem directly from their causes, vary widely, and form a unique web of interdependencies. Financially quantifiable failures are most commonly regarded as symptoms.

A key challenge is overcoming crises, but the primary one is predicting them early. This underpins the development of early warning systems (EWS), which diagnose crisis symptoms but do not forecast bankruptcy (Platt, Platt, 2002, pp. 184-199). Econometric prediction models underpin EWS functionality, with a critical emphasis on their diagnostic accuracy and appropriate reference points. Despite efforts to shift it, this remains bankruptcy in its narrow legal sense. Advanced multidimensional models, including logit models, are now used to estimate the probability of distress (Prusak, 2005, pp. 105-186).

Excessive operational risk (e.g., flawed liquidity management, suboptimal cost-to-income ratios) or poorly controlled strategic risk (e.g., excessive debt financing risk exposure without matching revenue growth) can erode payment capacity (Nawrocki, Jonek-Kowalska, 2016). The former undermines cash flow and operational profitability, while the latter amplifies financial leverage and vulnerability to exogenous shocks. In extreme cases, this culminates in bankruptcy.

Beyond purely financial risks, a corporate culture fixated on aggressive value creation breeds subtle yet equally destructive threats: managerial short-termism, risks of abuse and creative accounting, and reputational risk (e.g., consumer boycotts, regulatory penalties).

2.3. Risk-value relationship

The linkages between value creation and risk can be classified into three analytical categories.

Positive synergistic relationship: Effective operational risk management (OPRM) - reducing cash flow volatility, mitigating errors, and enhancing process resilience - lowers the cost of capital and increases the discounted value of future value-creating cash flows (Damodaran, 2019). OPRM strongly influences key value drivers, including process efficiency, financial results, and cash flow (Hahn, Kuhn, 2011).

Substitution relationship: Short-term value maximization by managers (e.g., deferring investments) creates an illusion of value creation that erodes over longer horizons. Agency theory explains this through information asymmetry between managers and stakeholders (Jensen, Meckling, 1976). This effect is amplified by the absence of risk-adjusted performance metrics in compensation systems (Syed, Khalid, 2007).

Destructive relationship: Strategic risk paradoxically associates with performance (Bowman's paradox). Higher strategic risk leads to diminished future outcomes (Santacruz, 2020), particularly in enterprises below industry medians. Prospect theory accounts for this via a heightened propensity for extreme strategic risks ("gambling for resurrection") (Kahneman, Tversky, 1979).

Primary threats to value creation from inadequate risk management:

- Short-termism in performance metrics: Evaluation and compensation systems based on short-term results provoke cost cuts that erode adaptive capabilities, OPRM effectiveness, and tolerance for latent strategic risks (Graham, Harvey, Rajgopal, 2005). This increases earnings volatility and depresses market-based value measures (Rappaport, 2005).
- Fragmented risk management: Risk is handled in isolated silos (compliance, treasury, strategic, reputational) without assessing cumulative effects (Beasley, Clune, Hermanson, 2005). This escalates value destruction from the operational to the strategic level (Hoyt, Liebenberg, 2011).
- Underestimation of tail risk: Conventional risk measures focus on the distribution's core, overlooking tails (operational failures, strategic black swans) with outsized impacts (Taleb, 2008, p. 480). For instance, high cost-to-income ratios increase the risk of insolvency during turbulence by depleting slack resources (Yildirim, Philippatos, 2007).

The review of the economic literature on the linkages between enterprise value creation and operational risk reveals a fundamental inconsistency that poses theoretical, methodological, and practical challenges. On one hand, Value-Based Management (VBM) posits a linear, directly proportional relationship between shareholder value and accepted risk levels. On the other hand, empirical studies demonstrate that short-term value maximization erodes it over the long term, while higher strategic risk diminishes future performance, especially in weaker enterprises. Thus, is the value–risk relationship non-linear? Can opposing profiles coexist? What management mechanisms can reshape it toward synergy rather than destruction? The empirical section addresses these questions and offers recommendations for balancing value-risk dynamics.

3. Methodology of Research

The study is long-term, spanning Q2.2007-Q2.2025. The analytical dataset comprises 44,974 non-financial enterprises (with over 9 employees), which generate 95.6% of the sector's value added. Enterprises are classified by PKD sections B to N (13 sections), activity type (production, trade, services), and size class (small, medium, large) (Table 1). This selection ensures sector representativeness and enables structural differentiation analysis.

Table 1.

Characteristics by type of activity and size of studied enterprises in Poland (Q2.2025)

Type of activity	Number of enterprises	Number of employees	Sales revenue	Total assets	Equity
Studied enterprises	44,974	5,307,635	5,836,671	5,070,356	2,327,424
<i>Share of total (>9 employees)</i>	93.3%	94.9%	96.4%	97.4%	96.7%
Production (section B-E)	33.4%	44.3%	46.6%	47.0%	53.6%
Trade (section G)	25.7%	20.3%	32.8%	15.7%	13.3%
Services (section F, H-N)	40.9%	35.4%	20.6%	37.3%	33.1%
Small (10-50 employees)	62.9%	12.4%	13.4%	11.5%	12.0%
Medium (50-250 employees)	29.0%	27.1%	24.8%	26.1%	25.9%
Large (over 250 employees)	8.1%	60.5%	61.8%	62.4%	62.1%

Note. Sales revenue, total assets, equity - in PLN million.

Source: GUS in Warsaw (Statistics Poland) - limited-access databases. Available online: <https://stat.gov.pl/en/databases/> (accessed 10 February 2026); Pont Info Warsaw, Gospodarka SŚDP - commercial databases. Available online: <http://baza.pontinfo.com.pl/index.php> (accessed 12 February 2026).

The constructed methodology enables a coherent assessment of the relationships between value creation, the financial security of going concern, and their determinants across the full population.

Value creation is measured via a multifaceted value measure (MVM), integrating two dimensions:

- value creation for owners: return on equity (ROE).
- value added for the economy: rate of value added (VAR).

ROE is determined by return on assets (ROA) and equity multiplier (EM). VAR is shaped by net financial result referred to sales revenues (ROR), and value added retention ratio (VAH). Retention denotes the portion of value added retained in the enterprise for development. ROR is a stimulant; VAH, from a macroeconomic (GDP) perspective, is a destimulant of the value-added rate.

These two value measures are combined using statistical procedures: standardization, a destimulant-to-stimulant transformation, and scalar subtraction to eliminate negative values. Distance (d_{i0}) from the anti-pattern (origin of the coordinate system) is:

$$d_{i0}(MVM) = \sqrt{\sum_{j=1}^K (x_{ij} - x_{0j})^2} ; x_{ij} = \begin{cases} stym(ROE) \\ stym(VAR) \end{cases} \quad (1)$$

where:

$x_o = (0, \dots, 0)_K$,

K – number of multivariate measure components ($j = 1, \dots, K$).

The resulting MVM serves as a synthetic micro-level measure of enterprise value creation and the transmission of value added to the economy.

The financial security degree (FSD) measurement relies on an estimated logit model. FSD is the opposite of financial distress, going concern, and bankruptcy, and is perceived as a stimulant. The model takes the form (Kaczmarek, 2012, pp. 130-137):

$$FSD = \left(1 - \frac{1}{1 + \exp \left[- \left(-0,70 - 0,42 \frac{AP - 1,89}{1,09} - 0,93 \frac{SF - 0,39}{0,31} + 0,65 \frac{STL - 0,47}{0,27} - 0,73 \frac{RoOA - 2,94}{13,46} \right) \right]} \right) \cdot 100\% \quad (2)$$

where:

AP - asset productivity ratio,

SF - self-financing ratio,

STL - short-term liability ratio,

$RoOA$ - operating return on assets.

The measure ranges from (0,100%), with higher values indicating a greater probability of maintaining the financial security of a going concern over one year. Model diagnostics (sensitivity 82.4%, specificity 82.1%) confirm high predictive utility.

Object classification uses mean and standard deviation, identifying four normative patterns in MVM-FSD space: (1) high and stable; (2) high and highly variable; (3) low and stable; (4) low and highly variable. These patterns, along with MVM/FSD levels and determinants, underpin profile analysis.

Profile similarity is assessed via taxonomic measure of similarity (TMS), ranging from $<0-1>$; values nearer to 1 indicate greater structural similarity (Kaczmarek, Kolegowicz, Szymła, 2022). Distribution density employs the DM measure, proportional to the area of the ellipse enclosing the dataset (Kaczmarek, 2022), capturing concentration and dispersion in the MVM-FSD space.

Causal analysis converts the product chain of independent variables dynamics (DX) into a sum chain, assuming the dependent variable logarithm (DY) equals unity. This derives structural shares from the influence of independent variables (RX) on the dependent variable (RY), identifying value drivers and sources of changes in financial security.

Correlation analysis uses a significance level of $\alpha = 0.05$. A $p\text{-value} < \alpha$ indicates rejection of the null hypothesis of no correlation. The Pearson r coefficient scales dependence strength as: <0.1 slight; $0.1\text{--}0.3$ weak; $0.3\text{--}0.5$ average; $0.5\text{--}0.7$ strong; $0.7\text{--}0.9$ very strong; >0.9 almost perfect.

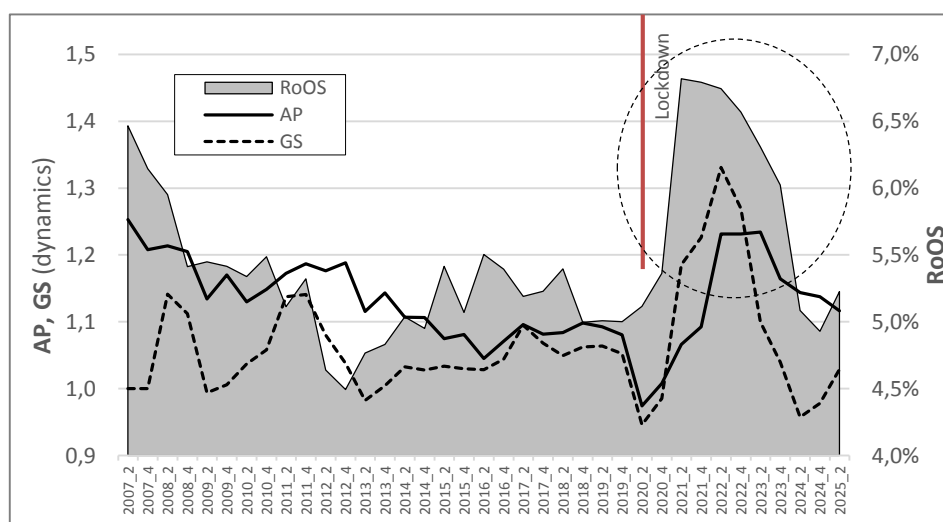
4. Findings

4.1. Economic conditions and enterprise performance

From the current vantage, the Warsaw Stock Exchange WIG index curve makes pinpointing the pandemic onset challenging. The 2008-2009 financial crisis inflicted a deeper plunge, with recovery lasting until 2017. GDP dynamics clearly mark the start of the pandemic and lockdown. The anticipated swift rebound materialized but quickly shifted from a "V" to a "W" shape. Pandemic effects included severed global supply chains and surging inflation.

The enterprise sector exhibited distinct financial condition patterns. Pandemic onset depressed sales revenues (GS), yet operating return on sales (RoOS) not only held but exploded in Q2.2021, remaining elevated through Q4.2022. The following year saw a decline, with 2024 reverting to pre-pandemic levels. High revenue dynamics from inflation partly explain RoOS growth: revenues outpaced inflation-driven costs, enabling enterprises to capture pandemic profiteering and price gouging amid uncertainty. Averaging RoOS over three pre- and two post-pandemic years, excess profits exceeded 327 billion PLN in 2021-2023.

Asset productivity (AP) trended downward until 2016, stabilized, dipped briefly during the pandemic, then rose sharply. The post-pandemic revenue slowdown did not drag AP proportionally (Figure 1).



Note. RoOS – operating return on sales; AP – asset productivity; GS – gross sales revenues.

Figure 1. Performance of enterprises in Poland, Q2.2007-Q2.2025.

Source: author's own work based on sources in Table 1.

Solvency (cash flow to short- and long-term liabilities) declined sharply until 2020, surged in three subsequent years, then stabilized after a dip. Liquidity (current and quick ratios) fell for three pre-pandemic years before rising annually. Cash stocks grew steadily from 2007 uninterruptedly. This stemmed from 250-300 billion PLN in public aid (shields, subsidies, ZUS exemptions, loans, guarantees), sustaining liquidity, liability servicing, production, and employment - despite egregious channeling into supernormal profits. Short-term liabilities rose from 2016, peaking in 2022-2023; long-term liabilities declined from 2021. Investments grew in volume but shrank as a share of revenues. Inventory and receivables cycles remained stable, while a weakened payables cycle briefly extended the cash conversion cycle.

In conclusion, the Polish enterprise sector demonstrated strong resilience during the pandemic, with operating profitability (RoOS) rising despite declining sales. Inflationary dynamics and public support measures sustained liquidity and allowed enterprises to generate excess profits in 2021–2023. Profitability and solvency later normalized to pre-pandemic levels, while investment volumes increased but declined relative to revenues. Overall, enterprise financial stability remained sound throughout the period.

4.2. Determinants of multifaceted value measure

An assessment of changes in return on equity (ROE) and the rate of value added (VAR) as determinants of the multifaceted value measure (MVM) over Q2.2007-Q2.2025 yields several key insights.

First, object displacements relative to the analysis period's start and end suggest dispersion (24.5%). However, two phases emerge: gradual concentration from Q2.2007-Q4.2018, followed by dispersion peaking at Q2.2022 amid the pandemic. Concentration generally aligns internal (ROE) and external value created (VAR) profiles across objects.

Second, ROE-VAR factor directions aligned closely until Q2.2017: rising in one corresponded to rising in the other ($r = 0.77$; $p\text{-value} < 0.000$). Thereafter, three patterns appear: (1) continued VAR growth amid ROE decline to Q4.2020; (2) ROE-VAR direction reversal from Q2.2021-Q4.2023; (3) VAR rise against ROE fall from Q2.2024 (Figure 2).

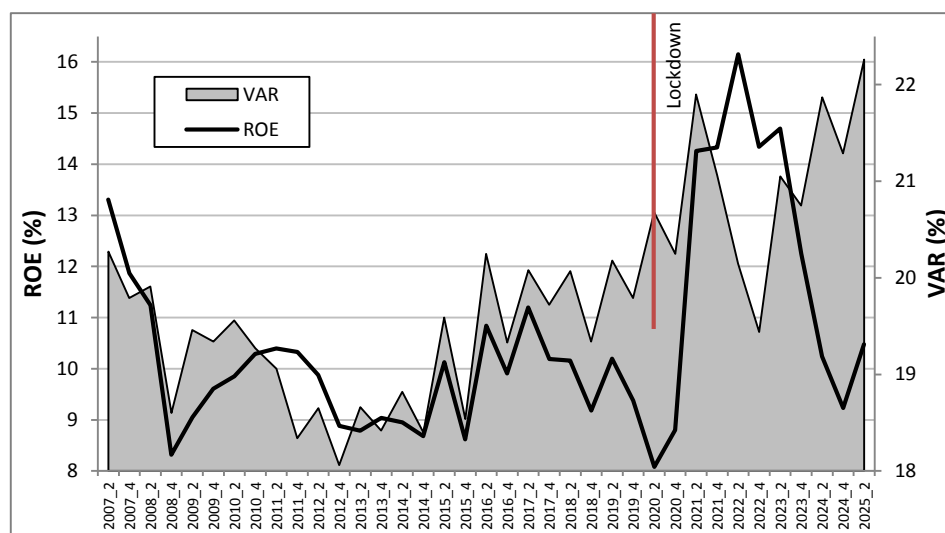


Figure 2. Return on equity (ROE) and rate of value added (VAR) of enterprises in Poland, Q2.2007-Q2.2025.

Source: author's own work based on sources in Table 1.

Mean values settled at ROE = 10.57% and VAR = 19.79%. ROE-VAR correlation stood at $r = 0.46$ for all enterprises; $r = 0.85$ production; $r = 0.63$ trade; $r = 0.45$ services (all p -value < 0.000). By activity, mean ROE neared general levels in production (10.96%), exceeded them in trade (14.57%), and lagged in services (8.04%). VAR patterns inverted: trade (10.85%) below general, services (30.62%) above.

Third, decomposing MVM dynamics into ROE and VAR contributions (deterministic approach, logarithm method) shows ROE share falling from 53.0% in Q2.2007 to 45.2% in Q2.2025 (+7.8 pp rise for VAR). Pandemic proportions briefly flipped toward ROE dominance (57.0% at Q2.2022), then declined to 45.2% by Q2.2025.

In conclusion, the analysis of the multifaceted value measure (MVM) indicates shifting dynamics between internal performance (ROE) and external value creation (VAR) among Polish enterprises over 2007-2025. While the early years showed growing alignment between the two factors, the pandemic period introduced greater dispersion and temporary dominance of ROE. Sectoral variation was notable, with trade achieving the highest ROE and services the highest VAR. Over time, the contribution of ROE to MVM declined in favor of VAR, reflecting an increasing emphasis on value creation beyond equity returns.

4.3. Financial security degree

For general enterprises, financial security degree (FSD) exhibits a long-term downward trend (average rate of change per year, ARC = -1.9%), briefly halted during the pandemic. Pandemic volatility surged markedly (Q4.2020 peak 0.181, standard deviation), remaining over 60% above pre-pandemic stabilization levels (Q2.2013-Q4.2017) despite post-pandemic moderation. Such FSD volatility preceded the GDP drop in Q4.2012-Q4.2013 and emerged two years before the lockdown.

Production enterprises saw FSD decline from Q2.2011 to Q4.2020, pausing briefly during the pandemic before plunging to a Q4.2023 minimum. Services followed a downward path to a Q2.2020 trough, then rose and stabilized after the lockdown. Trade experienced the strongest positive pandemic effect, though gains faded, driving FSD below pre-pandemic levels (Figure 3).

The decile distribution shows improvement in the first (highest threat), second, and third deciles, thereby lifting the mean. Interdecile spreads peaked at D2/D1 (10.2 pp), D3/D2 (4.5 pp), D4/D3 (3.3 pp), narrowing to 1.7-2.1 pp thereafter. The differentiation measure (D9-D1) and the standard deviation (SD = 1.8 pp) indicate low variability.

Decomposing the FSD model reveals average shares: AP (asset productivity) 24.1%, SF (self-financing) 23.8%, STL (short-term liabilities) 37.4%, RoOA (operating return on assets) 14.6%. From Q2.2007 to Q2.2025, AP influence rose +56.1% and STL +19.3%, while SF fell -33.8% and RoOA -31.1%. Variability coefficients were highest for RoOA (30.3%), SF (19.6%), AP (11.3%), and lowest for STL (6.0%). Pandemic-driven RoOA volatility peaked its share during that period.

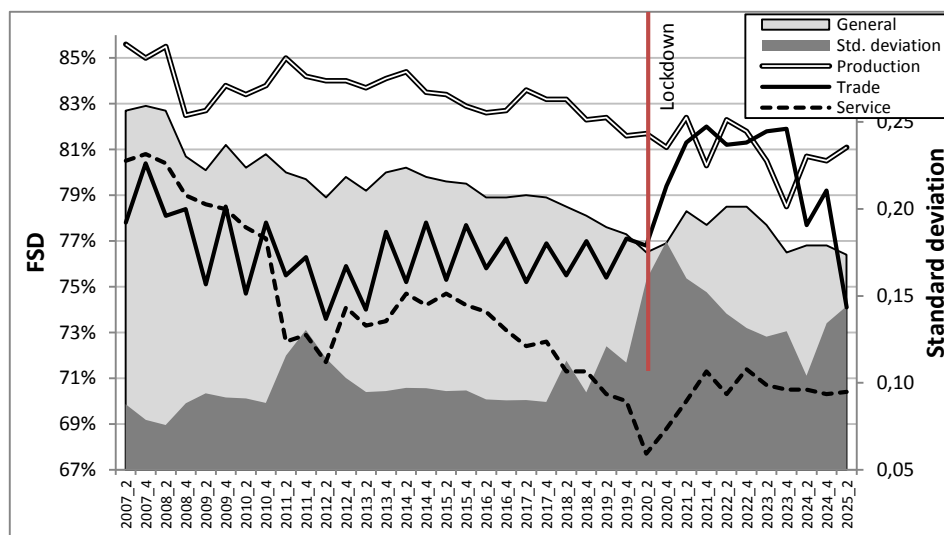


Figure 3. Financial security degree (FSD) by enterprise activity type in Poland, Q2.2007-Q2.2025.

Source: author's own work based on sources in Table 1.

In conclusion, the financial security degree (FSD) of Polish enterprises trended downward in the long term, with pandemic-era volatility peaking sharply and persisting above pre-pandemic levels. Sectoral differences emerged: production deteriorated post-pandemic, services rebounded after a 2020 low, and trade saw temporary gains that later reversed. Decile analysis shows easing threats in lower groups with low differentiation, while FSD decomposition highlights rising asset productivity and short-term liabilities amid declining self-financing and volatile RoOA.

4.4. Value creation and financial security

Analysis of the relationship between value creation and the financial security of a going concern yields several partial conclusions.

Until Q4.2015, the correlation between multifaceted value measure (MVM) and financial security degree (FSD) was very strong, positive, and statistically significant ($r = 0.78$). It then waned, turning negative by Q2.2021. Over the full Q2.2007-Q2.2025 period, the correlation was weak and negative ($r = -0.28$). FSD's long-term decline broke sharply a year before the lockdown, rebounded, then fell again. MVM changes were phased until lockdown onset, followed by a sharp rise and gradual decline. FSD–MVM correlation peaked positively for Q2.2020–Q2.2025 ($r = 0.70$, $p\text{-value} < 0.000$) (Figure 4).

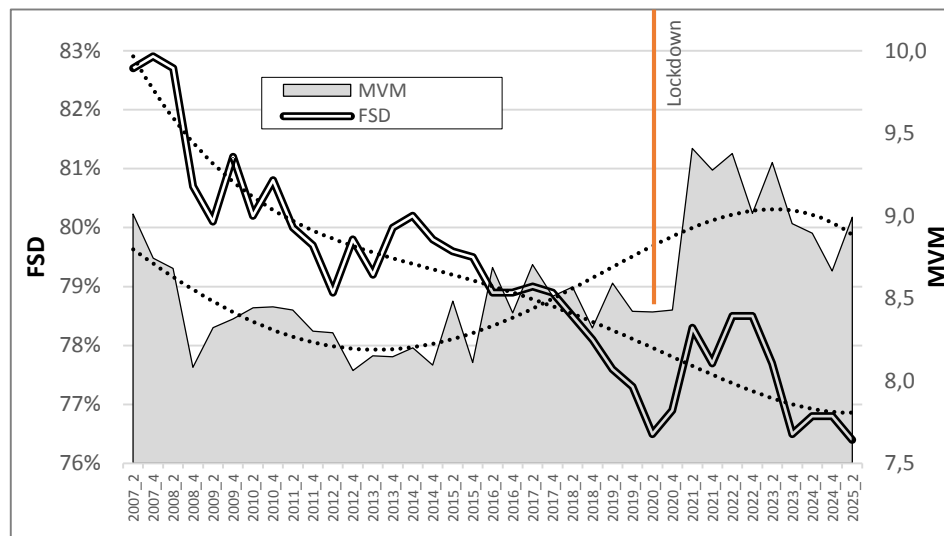


Figure 4. Multifaceted value measure (MVM) and financial security degree (FSD) for enterprises in Poland, Q2.2007-Q2.2025.

Source: author's own work based on sources in Table 1.

Overall dispersion rose 57.7% after a period of relative stability. The pandemic start triggered a 1.92-fold dispersion surge, followed by contraction (−18.0%). Rising dispersion signals widening gaps between contemporaneous FSD and MVM values. By activity and size, displacements favored FSD declines over MVM gains. Production enterprises showed the largest relative deterioration (Euclidean distance difference), and among size classes, large enterprises fared worst.

Period averages were $MVM = 8.58$ and $FSD = 79.1\%$. Using these as classification benchmarks, service enterprises fell below both (Euclidean distance $ED = 7.96$) (Figure 5). Production performed better ($ED = 8.72$), while trade led in value creation at the average security ($ED = 9.64$). Small enterprises ranked highest in size classes ($ED = 8.88$).

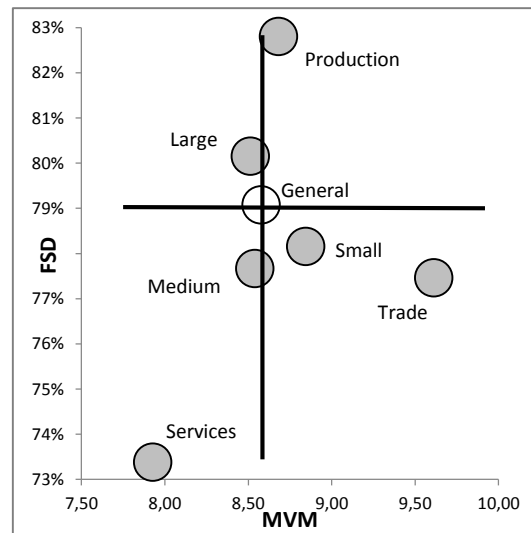


Figure 5. Average position by multifaceted value measure (MVM) and financial security degree (FSD) for enterprises in Poland, Q2.2007-Q2.2025.

Source: author's own work based on sources in Table 1.

In conclusion, the correlation between the multifaceted value measure (MVM) and the financial security degree (FSD) shifted from a strong positive to a weak negative overall, peaking positively during the pandemic. Dispersion between MVM and FSD widened substantially, surging at lockdown onset and signaling growing gaps favoring FSD declines. Sectorally, services lagged both metrics, production showed the largest deterioration, and trade excelled in value creation; small enterprises performed best.

4.5. Profiles of enterprise structures in value creation and financial security

Evaluating enterprise structure profiles requires a tailored research methodology (four-factor for MVM, five-factor for FSD), which guides further studies and the dissemination of results. For this article's preliminary, general assessment, several overarching conclusions emerge.

First, the macrostructure profile of value creation (by activity type and size class) mismatches the financial security profile over Q2.2007-Q2.2025. Divergences also appear relative to the start and end of the period. Initially, MVM and FSD balanced for general and production enterprises; by period end, equilibrium held only for production, but with weakened value creation and security. These findings and visualization (Figure 6) provide a qualitative profile comparison.

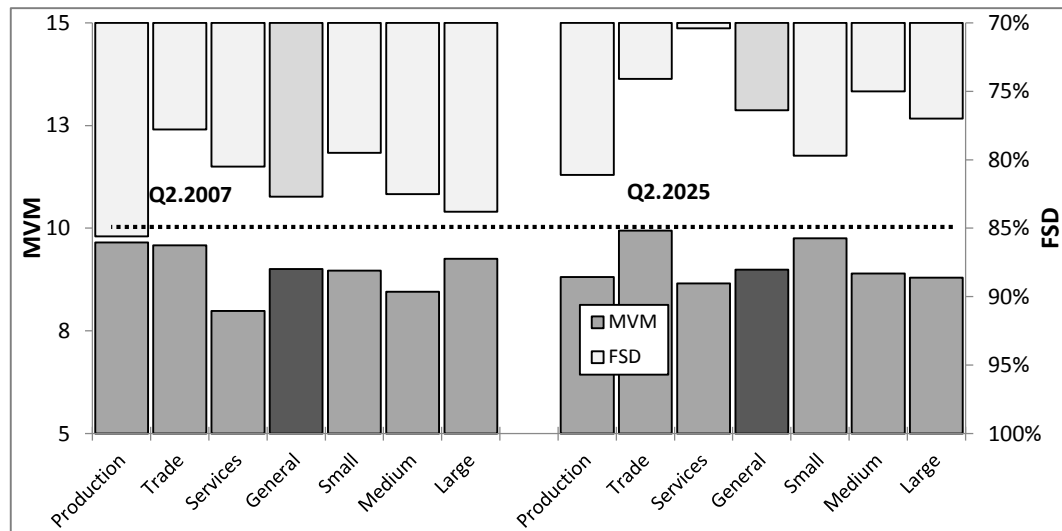


Figure 6. Profiles by multifaceted value measure (MVM) and financial security degree (FSD) for enterprises in Poland: a) Q2.2007 and b) Q2.2025.

Source: author's own work based on sources in Table 1.

For quantitative assessment, the taxonomic measure of similarity (TMS) was applied. For macrostructure (13 PKD sections), MVM-FSD similarity was $TMS = 0.62$ in Q2.2007-Q2.2025, rising +17.2%. For microstructure (70 PKD divisions), $TMS = 0.73$, up +7.5%.

A second profile dimension jointly evaluates value creation and financial security by combining average values and variability (standard deviation) using normative patterns (Table 2).

Table 2.

Multifaceted value measure (MVM), financial security degree (FSD), and normative patterns for enterprises in Poland, Q2.2007-Q2.2025

Enterprises	av MVM	sd MVN	av FSD	sd FSD	Pattern MVN	Pattern FSD
Production	8,68	0,377	82,8%	1,55 pp	4	3
Trade	9,61	0,772	77,5%	2,36 pp	4	2
Services	7,92	0,537	73,4%	3,43 pp	2	2
General	8,58	0,375	79,1%	1,69 pp	x	x
Small	8,84	0,832	78,2%	2,60 pp	4	2
Medium	8,54	0,485	77,7%	2,33 pp	2	2
Large	8,51	0,370	80,2%	2,06 pp	1	4

Note. av – average value, sd – standard deviation.

Source: author's own work based on sources in Table 1.

The optimal pattern 3 combines above-average value creation and financial security with below-average variability in both. This occurred solely for FSD in production enterprises.

Its antithesis - least desirable pattern 2 - prevailed, recurring sixfold. Normative pattern congruence was limited, observed only twice: services enterprises and medium enterprises, both in unfavorable pattern 2.

In conclusion, enterprise structure profiles show a persistent mismatch between value creation (MVM) and financial security (FSD) across activity types and size classes. Initial balance in production and general enterprises weakened over time, with production alone

retaining relative equilibrium. Taxonomic measures indicate a moderate improvement in profile alignment. Normative patterns reveal limited congruence, with most groups converging toward suboptimal performance and variability.

5. Discussion

The empirical findings on inconsistencies between value creation and business risk in Polish enterprises over Q2.2007-Q2.2025 substantially contribute to debates on the Value-Based Management paradigm and its limitations under systemic turbulence.

Hypothesis H1: positing equivalent and stable impacts of shareholder value (ROE) and rate of value added (VAR) on multifaceted value measure (MVM) - is rejected. ROE's share in MVM declined in favor of VAR, only to reverse during the pandemic. This aligns with Hoyt and Liebenberg (2011) on exogenous influences on value creation. In stability, shareholder value dominates; crises redefine priorities, prioritizing ROE protection over VAR distribution to stakeholders. This echoes Hahn, Figge, and Barkemeyer (2007) on sustainable value creation, though turbulence elevates financial aspects. Sectoral ROE–VAR variation supports Beasley, Clune, and Hermanson (2005) on industry-specific value-risk management, augmented by Miller and Waller (2003) on scenarios and uncertainty.

Hypothesis H2: phased FSD changes with constant determinant distribution - is partially rejected. Phasing occurred (long-term decline, pandemic stabilization), but determinant shares proved unstable. Alarming drops in self-financing and operating return on assets (RoOA) shares, with high RoOA volatility, signal operational fragility. Graham, Harvey, and Rajgopal (2005) illustrate hidden risk acceptance, and Taleb (2008) tail risk underestimation. The mechanism reflects security source substitution: from endogenous efficiency to exogenous resource mobilization (Bromiley, McShane, 2015).

Hypothesis H3: directly proportional value creation–financial security correlation - is rejected overall, starkly opposing prior strong positives. Pandemic positives surged amid extensive state intervention. Damodaran (2019) concurs: the performance-value linkage holds in stable conditions; systemic shocks decompose it, with interventions sustaining it. Pandemic stratification matches Bowman's paradox (Santacruz, 2020). In Poland, Niemiec (2014) partially confirms this paradox via risk-performance cyclicity and nonlinearity.

Hypothesis H4: profile similarities in value creation and financial security - is rejected. Taxonomic measure of similarity reveals low structural convergence. Normative pattern alignment is low ($\sim 1/3$). The rarity of the desirable high-value/high-security/low-variability pattern contrasts with the overrepresentation of the worst. Short-term focus depresses value measures (Segal, 2011, p. 432) and heightens volatility (Rappaport, 2005), underscoring the need to emphasize core value drivers (Copeland, Koller, Murrin, 2000, pp. 20-27).

6. Conclusions

The study's objective was to measure inconsistencies between value creation and business risk, encompassing shareholder value (ROE), value transmitted to the economic system (rate of value added, VAR), and financial security of going concern (FSD). The research is extensive and rare due to its duration, vast data scope, and sourcing from restricted-access databases.

Empirically, ROE-VAR as multifaceted value measure (MVM) determinants proved fundamentally variable: ROE share declined in favor of VAR, fully reversing during the pandemic, signaling a redefinition of priority under systemic shock. FSD changes were phased with a long-term downward trend, pandemic interruption, and elevated volatility. Determinant instability - falling self-financing and operating return on assets (RoOA) shares - indicates security source substitution from endogenous operational efficiency to exogenous resource mobilization.

A pivotal finding is the transformation of the value–security relationship from a very strong positive to a weak negative correlation. The pandemic sharply stratified enterprises by concurrent goal attainment; massive state intervention (250-300 billion PLN) merely temporarily paused the decline. Taxonomic measure of similarity confirms low-profile congruence, as well as the rarity of the desirable pattern (high value and security, low variability) and the overrepresentation of the unfavorable one.

Practical implications urge abandoning simplistic shareholder value maximization in favor of sustainable value creation, balancing stakeholders and long-term value drivers. Risk management must integrate operational, financial, and strategic dimensions, incorporating risk-adjusted performance, shock-absorption reserves, and tail risk, while addressing extreme events that exert disproportionate impacts on enterprise value.

Limitations include a financial perspective, a focus on enterprises with over 9 employees, and the capture of turbulence periods, potentially limiting generalizations about stability. Annual FSD modeling overlooks shorter threat cycles; profile analysis needs multifactor deepening.

Future research directions encompass detailed PKD sections, divisions, and size classes; FSD source substitution mechanisms; and critical thresholds that shift value–risk from synergy to destruction. Findings will inform practice in balancing value creation with financial security.

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GAMIFICATION AS A NEW FORM OF MOTIVATING EMPLOYEES – A CASE STUDY

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Purpose: The aim of the article is to present gamification as a modern method of motivating hybrid employees, responding to the challenges resulting from generational changes in the labor market, and to assess the implementation of the functioning and effectiveness of gamification solutions.

Design/methodology/approach: The study is qualitative and uses a standardized case study questionnaire covering four areas: (1) characteristics of the company and the implemented tool, (2) prerequisites for implementation, (3) implementation and functioning of the system, (4) monitoring of its effectiveness. The analysis was carried out on a company that creates and implements gamification solutions, which also applies them to its own employees. In addition to the analysis and evaluation of the gamification process, the study provides an opportunity to validate the designed research tool (case study) in terms of its analytical values, comprehensiveness and level of understanding by practitioners.

Findings: The study allows to collect data on the prerequisites for the implementation, functioning and control of the effectiveness of gamification solutions. The analyzed company was well prepared to implement the system, which can be a reference point for other organizations. The study confirmed the correctness of the tool's design, which, after minor modifications, can be used in further empirical research.

Research limitations/implications: The study is a case study and involves a single company, which limits the possibility of generalizing the results. In further stages, it is planned to expand the sample and consider the perspective of employees.

Practical implications: The results provide guidance for organizations implementing gamification in a hybrid environment. The results obtained and the developed tool can be used to assess the readiness of the organization and monitor the effectiveness of motivation systems, tailored to different groups of employees.

Social implications: Gamification promotes increased employee engagement and satisfaction, strengthening organizational culture and team relationships. It can also support the integration and development of modern forms of cooperation in a hybrid environment.

Originality/value: The article develops research on the use of gamification in motivating hybrid employees - an area that has so far been poorly recognized. The validated tool enables systematic testing of the effectiveness of implementations, providing theoretical and practical value.

Keywords: Gamification, motivation, human resources.

Category of the paper: case study.

1. Introduction

The dynamic development of flexible work models, including hybrid work, has become one of the key trends of the modern labor market. This change poses new challenges for organizations in terms of maintaining the motivation, engagement and sense of belonging of employees who function in conditions of limited direct contact. Research indicates that traditional methods of motivation often turn out to be insufficient in distributed environments, especially in the context of the growing expectations of younger generations of employees, accustomed to interactivity, immediate feedback and greater diversity of forms of activation (Kaczmarek, Włodarkiewicz-Klimek, 2023).

In this context, gamification, defined as the use of mechanisms known from games - such as points, levels, challenges or competitive elements - in non-entertainment environments is attracting increasing attention from organizations. Numerous studies indicate that properly designed gamification solutions can support internal motivation, build engagement, strengthen cooperation and facilitate monitoring of employee progress. At the same time, it is emphasized that the effectiveness of gamification depends on the organizational context and the quality of implementation, which justifies the need for in-depth analyses based on practical examples.

The aim of the article is to present gamification as a modern method of motivating hybrid employees, responding to the challenges resulting from generational changes in the labor market, and to assess the method of implementation and effectiveness of gamification solutions in organizational practice. The implementation of this goal is based on two pillars: a literature review, which allows for a theoretical approach to the phenomenon, and a case study, which allows for a detailed analysis of the implementation of gamification in a selected IT company. The combination of both perspectives allows for an understanding of both the general principles of designing gamification tools and the specifics of their functioning in real hybrid work conditions.

2. Gamification as a motivational tool

2.1. Definition of gamification

Gamification was first defined in 2011 by Pelling, who was professionally involved in game development and noticed that their mechanisms could be effective in other conditions as well. This opened up a field for broad discussion and testing of experimental solutions. Gamification began to appear in areas related to marketing or sales, and finally its mechanisms and impact on motivation began to be tested (Ghosh, Kumar, 2025; Karimi, Nickpayam, 2017; Luo et al., 2022; Sailer et al., 2014). This led the researchers to take up the topic of using gamification not

only on the company-customer line, but also on the employer-employee line, as a tool aimed at effectively motivating the employee (Gupta, Gomathi, 2017). During this time, many new definitions of gamification were created, which gradually expanded its understanding and, consequently, the possibilities of its application. The Table 1. below lists a few of them that present the development of meaning and will be crucial for further considerations.

Table 1.
Overview of gamification definitions

Author	Year	Definition
(Pelling, 2011)	2011	Game-like, accelerated user interface to make electronic transactions both fun and fast.
(Deterding et al., 2011)	2011	Use of game elements in a context other than games
(Tkaczyk, 2012)	2012	Transferring mechanisms known from games (including computer games, but not only) to the real world in order to change human behavior.
(Siadkowski, 2014)	2014	This is a field that uses game mechanics to encourage people to do things they don't usually feel like doing or don't know they can do differently. Gamification turns activities that are not particularly attractive into ones that permanently attract our attention, and creates fun from something that usually has little to do with play. Additionally, it uses game elements in non-gaming contexts to motivate people to perform certain activities.
(Gibek, 2018)	2018	Defines gamification as mechanics, aesthetics and thinking created on the basis of games, in order to engage people, motivate them to act, promote science and solve problems.
(Witoszek-Kubicka, 2025)	2025	The use of game elements as a system of incentives motivating the target group to undertake the desired behaviors, which are a condition for achieving the assumed goals of the project.

Source: Own study.

The definitions cited above indicate how the scope of understanding gamification has changed over time. Nevertheless, all definitions share several common elements. Gamification is all about transferring logic from games to areas outside of it. The main purpose of such a transfer is to increase engagement and appropriately target the actions taken by its recipients. Its essence is therefore to build motivation through participation in properly designed experiences (Gopinath Bharathi et al., 2016).

The analysis of the definition indicates that gamification as understood today is a modern motivation tool, especially adequate for hybrid and remote environments, where traditional motivation systems are sometimes insufficient (Bernal, Lempialä, 2025; Ur Rahiman, Kodikal, 2025).

2.2. Key mechanisms

Gamification as a tool is defined by the three elements that make up the MDA model (M - mechanics, D - dynamics, A - aesthetics) (Zichermann, Cunningham, 2011, p. 43). In order to properly recognize whether a given tool used in the company is a solution using gamification, it is worth focusing on identifying the gamification mechanics present in it. Mechanics are key to understanding the essence of gamification. This is confirmed by the summary prepared by R. Szydło on the basis of the analysis of definitions. Assuming that gamification is the use of

game mechanics in a context unrelated to games, mechanics play a key role in gamification (Szydło, 2021, p. 134). A proper understanding of the existing mechanics therefore allows for an unambiguous identification of the occurrence of gamification in the analyzed solutions. There are many ways of grouping individual elements in the literature. For the purposes of this study, the division proposed by M. Helmeffalk was used, which is presented in Table 2.

Table 2.
Overview of gamification mechanics

Shared mechanics	Group
Achievements, Badges, Earn/Earn, Rewards, Stamps, Tokens, Unlockable Content, Virtual Items (Currency/Commodities),	Badges
Competences, merits, skills development,	Skill development
Leaderboards, Performance charts, Ranking	Rankings
Clear Goals, Competition, Conflicting Goals, Restrictions, Rules, Time Pressure, Uncertain Outcomes, Win Condition	Objectives/Principles
Betting/Gambling, Challenges, Levels, Mini-Games, Missions/Quests, Pattern Recognition, Progression, Puzzles, Trials,	Missions/Tasks
Activity Counter, Lives, Points,	Points
Autonomy, Avatars, Character, Customization, Roles, Self-expression, User profiles,	Identity/Role
Collaboration, Gifts, Sharing, Social + Concept, Status, Teams, Vote,	Social mechanics
Dashboard, Gamified Passwords, Interface, Virtual Territories, Visual Metaphor / Aesthetics,	Aesthetics
Economy/Market, Reviews, Location-Based Mechanics, Storytelling, User Generated Content, Escape, Fantasy, Fun, Entertainment, Recreation, Motion.	Other

Source: Own study based on (Helmeffalk, 2019, p. 9).

The presented classification of gamification mechanics shows the multitude of elements that can be used in building the target tool. At the same time, it shows that gamification goes beyond simple point systems. In Helmeffalk's view, the mechanics were grouped according to their function and the way they affect the participants. This allows for a detailed analysis of the solution elements.

The most used are points - the simplest, but at the same time the most universal way of quantifying activity. Other reward mechanics, including badges, m.in, are also a core group. They act as external reinforcements, strengthen the sense of progress and highlight the achievements of the individual. They are complemented by the category of skills development, which refers to intrinsic motivation and allows participants to monitor the real level of competence development. Rankings and leaderboards, on the other hand, introduce an element of competition, being an important motivating factor, especially in environments with high transparency of results. Mechanics related to goals and rules, such as clear rules, time pressure, and victory conditions, organize the participant's experience and give structure to the activities.

Identity and role, which enable the personalization of the experience, and social mechanics, which support cooperation, sharing of effects and building community, are also important elements. Aesthetics and mechanics classified as "other" are responsible for the overall

atmosphere, narrative and coherence of the system, often determining the quality of the user experience.

The discussed classification allows us to analyze gamification as a set of various mechanisms, which only in the appropriate configuration create an engaging and effective environment of activity that can be applied in organizations.

2.3. Gamification in organizations

Gamification has become an important area of interest for both management practitioners and researchers in organizational sciences in recent years. Its growing popularity is due to the need to create more engaging work environments (Rahiman, Kodikal, 2023), especially in the context of digital transformation (Badreldin et al., 2024) and changes in the way work is organized. The literature on the subject indicates that the implementation of mechanisms known from games can support the increase in motivation, engagement and effectiveness of employees (Szydło, 2021; Sedeeq et al., 2016).

When analyzing the possibilities of using gamification in organizations, it is worth citing the research conducted by Polish researchers: A. Dziopak-Strach and A. Witoszek-Kubicka. They conducted empirical analyses of solutions implemented in Polish enterprises. A. Dziopak-Strach's research included several organizations of various sizes, in which gamification was introduced as a tool supporting motivation, team integration and development of employee competencies. The author pointed out that the effectiveness of implementations depends largely on the adequate selection of mechanics and their compliance with the organizational culture (Dziopak-Strach, 2023). In turn, Witoszek-Kubicka (2025) identifies both benefits (e.g. increased activity, improvement in the quality of work) and barriers, such as lack of system consistency or insufficient communication.

The authors' conclusions correspond with international literature, which emphasizes the need for conscious design of gamification solutions (Van Roy, Zaman, 2017). A review of research indicates that gamification can bring significant benefits to organizations, but its effectiveness depends on the context of implementation, user alignment, and systematic monitoring of results.

3. Research on the use of gamification - a case study

3.1. Purpose and Questions

The aim of the study is to present gamification as a modern method of motivating hybrid employees, considering the challenges resulting from generational changes and the growing need to build engagement in a distributed environment. The study also aims to assess the

implementation, functioning and effectiveness of gamification solutions used in organizations. The implementation of this goal allows for the identification of both the potential and limitations of such tools, as well as the determination of the conditions necessary for their effective application in the practice of human resource management.

The formulated research questions were directly translated into the structure of the research tool in the form of a standardized case study. The study is a pilot and is the first phase of a broader empirical project, the next stages of which will include the analysis of multiple organizations. The design of the tool was verified by an expert-practitioner, which made it possible to assess its readability and analytical value.

Three key research questions include:

- 1) **What are the reasons for implementing a tool that uses gamification elements?**
 - This question allows you to determine the motivations of the organization and the business context in which the decision to implement is made.
- 2) **What areas of employee motivation are implemented with the use of gamification?**
 - aims to identify the gamification function and its links with the human resource management system.
- 3) **How does the implementation of gamification affect employee motivation?**
 - This question focuses on the assessment of the implementation effects declared by the organization.

Each of the questions has been embedded in appropriately selected questionnaire modules, which allows for systematic data acquisition and comparison of inter-organizational results.

3.2. Research tools

The designed research tool is based on the methodology of a case study, recommended in the literature as an approach enabling an in-depth analysis of complex organizational phenomena, including solutions in the field of employee motivation. The study is focused on a contemporary phenomenon and focuses on a single event in its real context (Glinka, Czakon, 2021). In this study, case is the process of using gamification to motivate employees in the studied organization. The study is qualitative, which is in line with the adopted goal - to identify the premises, method of implementation and effects of using gamification in a hybrid work environment.

In order to collect the data, a standardized interview based on a previously developed case study questionnaire was used. The interview scenario corresponded to the structure of the case study tool to enable comparative analyses between different organizations at the stage of further research. Standardization ensured the consistency of the research process, and at the same time allowed the respondent to deepen their statements to the extent relevant to understanding the specifics of the implementation of gamification. The interview was conducted online, which made it possible to ensure the availability of respondent, and at the same time to record the

conversation. The audio recordings formed the basis for the preparation of the transcription, which ensured the accuracy of the analysis of the empirical material.

The case study questionnaire consists of 24 questions structured into four complementary analytical areas. The first area refers to the characteristics of the company and the general specification of the implemented gamification solution, which allows the survey to be correctly embedded in the organizational context. The second area covers the prerequisites for implementation, referring, among other things, to strategic conditions. The third area focuses on the implementation process and functioning of the tool, taking into account: the scope of gamification mechanisms used, the level of integration with existing HR processes and employee reactions. The fourth area concerns the monitoring of effectiveness, including evaluation methods and control mechanisms.

The entire structure allows for a systematic passage through the full life cycle of the solution: from preparation and design, through implementation and realization, to verification and control of activities. The tool constructed in this way allows to answer all the research questions and ensures high comparability of results in further stages of research.

3.3. Limitations of the study and selection of participants

The analysis was carried out on the example of one company due to the pilot character of the study. The survey was therefore intended to make it possible to assess the relevance of the questions, their completeness and comprehensibility for the question. It should also be emphasized that the study, although it does not provide the possibility of statistical inference, is an important preparatory stage for a broader, multi-subject study that will allow for a more complete analysis of the phenomenon.

A company from the IT sector, specializing in the design and implementation of IT solutions, including those using gamification elements for business customers, was selected for the study. Importantly, the company also uses such mechanisms internally, in relation to its own employees, which makes it a particularly valuable research case. The organization has the character of a small enterprise, employing several dozen employees, operating in a hybrid model and implementing projects with a high degree of innovation.

The selection of the participant was deliberate, in accordance with the logic of qualitative research. The selection criteria were: the organization's experience in implementing gamification, the availability of detailed data and the possibility of obtaining in-depth information from the person responsible for designing the solution. The interview was conducted with a representative of the company directly responsible for the implementation and development of the analyzed tool.

The survey was conducted in the form of a remote standardized interview, supported by a questionnaire. The session was recorded in audio format, which allowed for later transcription and content analysis. The data obtained were used to initially assess the functioning of

gamification mechanisms in a small organization and to prepare the tool for further use in a larger-scale study.

4. Preliminary results

The preliminary results of the study are presented in a system corresponding to three research questions, and their synthetic approach is presented in the form of tables. This allowed for a structured analysis of the premises for the implementation of gamification, areas of its application and effects observed after implementation. The study provided data on the rationale for the introduction of the system, how it works and the mechanisms for evaluating effectiveness. The company analyzed was well prepared to implement gamification, which makes it a valuable reference point for other organizations. The results obtained also confirm the correctness of the design of the research tool, which, after minor modifications, can be used in further empirical research. The results are divided into three sections, each of which corresponds to one research question. The answer to research question 1 is presented in Table 3, to research question 2 in Table 4 and to question 3 in Table 5 below.

- 1) What are the premises for implementing a tool that uses gamification elements?

Table 3.

Analysis of the results related to the research question no 1

Question	Result
Deployment initiator	Top-down initiative - management / management. An initiative resulting from an internal organization.
Deciding factor	The excel test was a success, and employee engagement was high. The aim was to create a tool that would allow for a wider appreciation of engaged employees in a non-financial form and provide an employee benefit that is cheaper to maintain than traditional packages.
Was it preceded by research?	NO
Was the choice preceded by an analysis of available on the market?	Yes, However, they did not meet the needs of the company. Most of them concern sales processes.
Nature of the solution	Complements / extends the existing.

Source: Own study.

The analysis of the results indicates that the decision to implement gamification in the audited company was top-down and was initiated by the management. This means that the solution was part of a broader organizational strategy aimed at improving engagement and streamlining motivational processes. At the same time, it was noted that the initiative has been strengthened internally, which may indicate the high openness of employees to new tools and readiness to co-create changes.

The key factor determining the implementation was the results of a pilot test in the form of an Excel tool, which showed high user engagement. This element is important - it confirms that

the introduction of the full version of the system was preceded by practical proof of concept, which increased the likelihood of success in further implementation.

The organization decided to develop the solution primarily to create a non-financial mechanism for appreciating employees. Gamification was supposed to serve as a "cheaper benefit", at the same time more directly related to the behavior and attitudes of employees. This indicates the company's orientation towards non-financial motivation, which consistently fits into modern HR trends.

It is worth noting that the implementation was not preceded by diagnostic tests in terms of employee needs, which indicates a certain intuitiveness of the decision and at the same time a potential risk. However, an analysis of the available market systems was carried out - although the existing solutions turned out to be insufficient, mainly due to their focus on sales processes. As a result, the organization decided to create a proprietary tool that extends existing solutions.

Interpreting the above results, it can be stated that the prerequisites for the implementation of gamification in the surveyed company were both strategic (management as the initiator, the need for non-financial forms of motivation) and operational (positive results of the pilot, lack of appropriate tools on the market). This indicates a conscious decision to adapt gamification as a tool to respond to the specific needs of the organization and its employees.

2) What areas of employee motivation are implemented with the use of gamification?

Table 4.

Analysis of the results related to the research question no 2

Question	Result
In what area is gamification carried out?	✗ Recruitment and selection of candidates. ✓ Onboarding and onboarding. ✓ Motivating in everyday work. ✓ Implementation of training. ✓ Employee integration. ✗ Sales. ✓ Knowledge sharing. ✓ Personal development. ✗ Other....
What group of employees is covered by the gamification solution?	All employees.
What groups of employees is the gamification solution aimed at?	The solution is universal and covers every employee to the same extent.
What elements of employee motivation were used as part of the gamification solution in the company?	Bonuses or bonuses were rarely used in the company - non-financial forms of recognition prevailed. As part of gamification, employees earned coins that they could exchange for training or equipment, thus replacing the lack of a cafeteria. The "shop" element was initially assessed negatively. Limited resources led to unhealthy competition: some workers maximized benefits, which created a sense of injustice in others, according to the 80/20 rule. However, after the rules were properly regulated, the system improved, although it turned out to be a more effective solution to base motivation on unlimited, non-financial recognition.

Source: Own study.

In the company surveyed, gamification has been implemented in a wide range of HR-related processes, including both mandatory activities and development initiatives. This means that the tool served as not one, but many motivational mechanisms, supporting both employee adaptation and maintaining their ongoing engagement. Importantly, gamification was not limited to selected positions - the solution included all employees, which proves its universal nature and the intention to egalitarian strengthen the organizational culture.

The system mainly used non-financial motivators, in line with the assumptions of modern approaches to intrinsic motivation. Traditional financial elements were practically non-existent, and appreciation took the form of symbolic recognition. At the same time, the system made it possible to exchange the points earned ("coins") for real rewards, such as training or equipment. According to the respondent's statement, however, this element turned out to be problematic - maximizing behaviour and competition for limited resources appeared, which consequently disrupted the original assumptions of the system based on recognition. After proper adjustment, the situation improved. At the same time, the respondent indicated that good effects can be obtained in the model of an intangible, unlimited form of appreciation, limiting the function of the "marketplace".

Interpreting the results, it can be concluded that gamification in the surveyed company served as a comprehensive motivational tool, supporting key areas of HR and promoting developmental behavior. At the same time, the experience of organizations shows that combining intrinsic motivation with financial elements can lead to tensions, which is an important guideline for designing similar solutions in other organizations.

3) How does gamification implementation affects employee motivation?

Table 5.

Analysis of the results related to the research question no 3

Question	Result
What changes have been observed after the implementation of motivation based on gamification solutions? [ORGANIZATION]	It gave employees a chance to be noticed, a gateway for them to gain recognition, improvement of the recognition system, automation of office activities (cleaning) - they ceased to be a problem.
What aspects of employee activity are observed as a result of the introduction of such a motivating solution? [EMPLOYEE]	Employee retention was very high compared to the industry - employees left extremely rarely, which made it possible to build greater loyalty to the company through engagement. The frequency of interaction between employees has also increased: new discussions, topics for conversation have appeared, and participants have "caught the bug" of rivalry. As a result, it was also easier to get to know their character traits.
Has the goal of motivating employees been defined as part of gamification? If so, what kind of?	Writing articles - journalistic activity. Language learning - increase your English level rewarding initiatives and presenting them in a forum / sharing knowledge. Marketing goals - involvement in activity on SM - promoting the company.
Has the motivation goal been achieved?	YES Success - but you can't force activity on all participants. When building gamification, you should create categories in terms of what people can offer.

Source: Own study.

The analysis of the data clearly indicates that the implementation of gamification was accompanied by a significant strengthening of the process of motivating employees in the studied organization. From the perspective of the organization, the gamification system improved the visibility of the team's efforts - it became a tool that made it possible to really notice and appreciate employees. As a result, the discretionary system was organized and improved, and some repetitive administrative activities were automated, which further relieved the staff and eliminated previously occurring operational problems.

From the perspective of employees, there is a clear increase in engagement and greater attachment to the company. A very high level of retention - unheard of in the industry - indicates that gamification has had a lasting impact on the strengthening of intrinsic motivation. Additionally, gamification has contributed to increasing the frequency of interaction between employees, supporting integration, building relationships and natural knowledge exchange. Competition and the element of play became an impulse to discover the character traits of co-workers and build a culture of greater openness.

The motivational goals are clearly defined: competence development (expert articles, language learning), marketing activity and knowledge sharing. All these goals - as declared - have been achieved, although it is noted that gamification does not work equally for every person and it is not possible to force the full participation of all employees. Therefore, it is recommended to differentiate categories and tasks in terms of the predispositions of the participants.

The respondent associates the implementation of gamification with a decidedly positive impact on motivating employees, increasing their engagement, strengthening the bond with the organization and enabling the achievement of clearly defined development and business goals.

5. Summary and conclusions

The aim of the article was to present gamification as a modern method of motivating hybrid employees and to assess the functioning and effectiveness of gamification solutions in organizational practice. This goal was achieved through a combination of two research perspectives: an analysis of the literature on the subject and a case study of a company implementing gamification for both customers and its own employees. The literature review allowed to organize the key theoretical assumptions concerning the genesis, mechanisms and effects of the use of gamification in organizations, while the empirical part provided knowledge about the actual premises, method of implementation and consequences of this type of solutions.

The results of the study confirm that gamification is a tool with significant potential in motivating employees, especially in hybrid environments, where maintaining engagement, team cohesion and visibility of individual achievements remains a challenge. The case study showed that a properly designed gamification solution can strengthen the organization's culture, increase the frequency of interactions between employees, as well as build a sense of appreciation and attachment to the workplace. At the same time, the study revealed the limitations of such systems, m.in. the need to clearly regulate the rules for the exchange of rewards and the monitoring of employee behavior to avoid undesirable effects related to competition and differences in access to resources.

It should be emphasized that the presented results of the pilot study allow us to formulate preliminary observations on potential directions of gamification system design in a hybrid environment, which require further empirical verification. The identified organizational and behavioral changes co-occur with the implementation of gamification, but at the current stage of the study it is not possible to unambiguously resolve the cause-and-effect relationship. The observed effects may also have been amplified by other factors, such as:

- specificity of the organizational culture of the audited enterprise,
- increased attention of the management staff accompanying the implementation of the new solution,
- the effect of novelty related to the innovative nature of the tool,
- the selection effect resulting from high employee motivation already at the implementation stage.

These results confirm the usefulness of the research tool designed. The standardized case study questionnaire turned out to be adequate for diagnosing the premises, course and effects of the implementation of gamification, the use in a conversation with an expert-practitioner confirmed both the structural correctness and the potential for further use. This tool - after minor modifications - can be the basis for in-depth empirical research, including quantitative research conducted among employees, which will allow to verify the organizational perspective at the level of individual experience of system users.

Further research directions include extending the analysis to a larger group of companies, which will make it possible to compare different implementation models and identify success factors and barriers to the use of gamification in different contexts. It is also worth developing the quantitative component of the survey, including surveys assessing the reception and effectiveness of gamification from the perspective of employees.

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INTERNATIONAL STUDENT EXPERIENCES IN SILESIAN HIGHER EDUCATION: IMPLICATIONS FOR REGIONAL INTERNATIONALIZATION

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Purpose: The purpose of the article is to analyse the experiences of international students studying at higher education institutions in Silesia and to identify implications for the development of regional internationalization, particularly in the context of integration, institutional support and graduate retention.

Design/methodology/approach: The study employed a quantitative survey approach. Data were collected using a CAWI questionnaire among 366 international students studying at Silesian universities in 2025. The analysis included descriptive statistics and non-parametric tests (Mann–Whitney U test and chi-square test) to examine differences between student groups and relationships between variables. A composite scale measuring regional openness towards international students was constructed and tested for reliability (Cronbach's $\alpha = 0.91$).

Findings: The results show that international students evaluate the academic environment of Silesian universities highly, while the regional environment is perceived as moderately open. Significant differences were identified between students from Europe and those from outside Europe in the evaluation of regional openness. The findings also reveal a statistically significant relationship between perceived employment opportunities and the willingness of students to remain in the region after graduation.

Research limitations/implications: The study is based on a cross-sectional survey and self-reported data, which may involve response bias. Although the sample size is relatively large, the representation of national groups is uneven. Future research should include longitudinal studies and comparative analyses across regions to better understand international student retention and integration processes.

Practical implications: The findings suggest the need to strengthen mechanisms facilitating the transition of international students from education to employment in the region, improve administrative accessibility for foreign students and develop targeted integration measures addressing cultural diversity.

Social implications: Improving the integration of international students may contribute to strengthening intercultural relations, increasing regional openness and supporting the long-term development of human capital in regions undergoing economic transformation.

Originality/value: The article contributes to the literature by linking international student experiences with the concept of regional internationalization and by providing empirical evidence on the relationship between student integration, labour market opportunities and regional retention of international graduates.

Keywords: international students, internationalization of higher education, regional internationalization, student mobility, intercultural integration, regional development.

Category of the paper: research paper.

1. Introduction

The internationalisation of higher education is one of the key phenomena shaping contemporary education systems and socio-economic development strategies. In J. Knight's classic approach, internationalisation means 'the process of integrating the international, intercultural and global dimensions into the objectives, functions and implementation of higher education activities' (Knight, 2003, p. 2). Contemporary approaches emphasise that internationalisation is not an end in itself, but a tool for improving the quality of education and building the competitiveness of education systems and regions (Altbach, Reisberg, Rumbley, 2010, p. 5; de Wit, 2011, p. 242).

One of the most visible manifestations of internationalisation is student mobility. According to the latest OECD report, *What are the key trends in international student mobility?*, the number of international students continues to grow, and their presence is an important element of the education and migration policies of OECD countries (OECD, 2025a, p. 3). The report *Education at a Glance 2025* indicates that educational mobility is directly related to human capital building and economic development, especially in regions competing for highly qualified graduates (OECD, 2025b, pp. 214-216). Student mobility has been widely analysed as part of broader global migration processes linked to education and knowledge circulation. Research indicates that international students increasingly combine educational mobility with longer-term migration strategies and career planning (Brooks, Waters, 2011, pp. 1-4).

The literature emphasises that the experiences of international students are multidimensional and include academic, social and cultural adaptation (Marginson, 2016, p. 418). Research conducted in diverse European contexts indicates that the integration of international students depends on institutional policies, the availability of administrative support and the level of inclusiveness of the local environment (Aksay Aksezer, Demiryontar, Dorrity, Mescoli, 2023, p. 4). The authors emphasise that effective integration requires cooperation between universities, public authorities and regional communities. Recent studies emphasise that the experiences of international students have become a central dimension of the internationalisation of higher education. Contemporary research increasingly focuses on issues such as student wellbeing, social inclusion and institutional support systems provided by universities and host societies (Soong, Maheepala, 2023, pp. 1213-1215). Systematic reviews also indicate that the growing scale of international student mobility requires more comprehensive mechanisms supporting academic and socio-cultural adaptation in host environments (Singh, Jack, 2023, pp. 845-847; Cankaya, 2024, pp. 4-6).

Increasing attention has been devoted to the retention of international graduates. Research shows that the decision to remain in the country or region of study depends on a range of economic, institutional and social factors, including employment opportunities, legalisation procedures and quality of life (Mosneaga, Winther, 2013, pp. 186-188). At the same time, studies on high-skilled migration indicate that labour market conditions and migration regulations significantly shape the mobility decisions of international graduates (Czaika, Parsons, 2017, pp. 603-606). International organisations also emphasise that graduate retention policies are increasingly becoming part of broader regional development strategies aimed at attracting and retaining human capital (OECD, 2025a, pp. 7-9; Kapfudzaruwa, 2024, pp. 495-497).

The Silesian Province, as a region undergoing economic transformation and competing for human capital, provides an important context for analysing the experiences of foreign students. The universities operating in the region are attracting an increasing number of foreigners, but the effectiveness of the region's internationalisation depends not only on the quality of the educational offer, but also on the level of social integration, the efficiency of administrative procedures and opportunities for professional development.

The aim of this article is to analyse the experiences of foreign students studying at Silesian universities and to identify conclusions that are relevant from the perspective of the region's internationalisation.

The study was carried out as part of the project entitled 'Experiences of foreign students at Silesian universities – conclusions for the development of the region's internationalisation', co-financed by the GZM Metropolis as part of the 'Metropolitan Science Support Fund' programme.

2. Methods

The study was quantitative in nature and was designed within the survey research paradigm. According to the methodological approach, survey-type studies serve to systematically analyse the opinions, attitudes and experiences of a specific population using a standardised research tool. They enable both the description of variable distributions and the analysis of relationships between them (Babbie 2020, pp. 253-268). The adoption of this strategy was justified by the need for a multidimensional diagnosis of the experiences of foreign students studying at universities in the Silesian Province.

The design of the research tool was based on an approach to research on intercultural adaptation, which involves analysing the functioning of an individual in a new environment in social and institutional terms (Berry, 1997, pp. 9-10; Ward, Bochner, Furnham, 2001, pp. 42-45). In practice, this meant operationalising students' experiences through indicators of

academic integration, social relations, administrative barriers and migration plans. This approach is consistent with the recommendations of research on international students, which points to the need to combine the academic and social dimensions in the analysis of adaptation (Smith, Khawaja, 2011, pp. 703-705).

The research project was carried out in two stages. In the first stage, a pilot study was conducted, the results of which were published in the article 'Experiences of Foreign Students in Silesia: Key Conclusions for the Internationalisation of Universities and the Region' (Katana, 2025). The pilot study covered 54 foreign students studying at universities in the Silesian Province and aimed to verify the design of the research tool and assess its functionality. In accordance with methodological recommendations for testing questionnaires, the pilot study allows for the identification of ambiguous questions, the assessment of the adequacy of response scales, and the verification of the logical structure of the tool (Babbie, 2020, pp. 294-301; Fowler, 2014, pp. 100-103). Based on the results obtained, corrections were made, including clarifying the response categories and expanding the section on social integration and administrative barriers.

The actual survey was conducted between 7 April and 10 July 2025 and covered 366 foreign students studying at universities in the Silesian Province. The CAWI (Computer-Assisted Web Interview) technique was used, which is recommended in mobile population surveys due to its anonymity, wide reach and organisational efficiency (Couper, 2017, pp. 123-125). Respondents were recruited through universities (distribution of invitations by email) and through social media using the snowball method. The research tool was a standardised questionnaire containing single and multiple choice questions, questions on a five-point Likert scale and open-ended questions. The structure of the questionnaire included thematic blocks on the quality of education, non-academic support, social relations, language and administrative barriers, assessment of the region's openness, and students' migration plans. Based on the responses to 26 items, a scale of the region's openness to foreign students was constructed. The responses were converted into a uniform point system (1-5), where higher values indicated a higher level of perceived openness. The reliability of the scale was verified using Cronbach's alpha coefficient, which reached a value of 0.91. Methodological literature indicates that alpha coefficient values above 0.70 are considered acceptable, while values exceeding 0.80 indicate high internal consistency of the tool (Hair, Babin, Anderson, Black, 2019, pp. 137-139).

Descriptive statistics (means, medians, standard deviations) and non-parametric tests appropriate for ordinal variables were used in the data analysis. The Mann–Whitney U test was used for comparisons between groups, while the chi-square test was used to analyse the relationships between categorical variables. As Field points out, these tests are appropriate for data that do not meet the assumptions of normal distribution and for the analysis of variables measured on an ordinal scale (Field, 2018, pp. 335-338).

3. Research results

The survey involved 366 foreign students studying at Silesian universities. The sample structure shows a slight predominance of males (53.0%) over females (46.2%), with the dominant age group being 20–25 years old (69.7%). In addition, 13.4% were under 20 years of age, 10.7% were aged 26–30, and 6.3% were over 30 years of age. The most numerous nationality was students from Ukraine (42.3%), followed by respondents of Turkish (6.3%), Nigerian (4.9%) and Indian (3.6%) nationality; 6.3% of respondents did not specify their nationality.

The results concerning educational experiences show that the vast majority of respondents rated the quality of education at their universities positively. The share of responses indicating “good” or “very good” ranged from 79.5% (innovative teaching methods) to 91.3% (language competence of lecturers). These results confirm a generally positive evaluation of the educational offer of universities in the region. Detailed results are presented in Table 1.

Table 1.
Evaluation of selected aspects of the quality of education

Aspect of education quality	Negative (Very bad + Bad) %	Neutral (Hard to say) %	Positive (Good + Very good) %
Preparing materials in the language of study	5.4	7.4	87.2
Availability of learning materials	6.3	7.7	86.1
Linguistic competence of lecturers	4.1	4.6	91.3
Innovative teaching methods	5.2	15.3	79.5
Verification of learning outcomes	3.6	12.3	84.2

At the same time, the area of non-academic support proved to be less clear-cut: only 16.4% of students rated the university's support in non-academic matters negatively, while 64.8% expressed the opposite view (i.e. rated it positively), which led to the rejection of the hypothesis of insufficient support. This result suggests that, in terms of the university (including non-teaching aspects), students' experiences are more often positive than negative, which is important as a background for further analysis of the regional component.

A key analytical element of the study is the synthetic scale of the region's openness to foreign students, constructed on the basis of 26 questionnaire items describing different aspects of functioning in the region. Reliability analysis confirmed a high level of internal consistency of the scale (Cronbach's $\alpha = 0.91$). The reliability statistics of the scale are presented in Table 2.

Table 2.
Reliability statistics of the regional openness scale

Indicator	Value
Cronbach's Alpha	0.91
Number of items	26
Scale range	1-5
Mean value of the scale	3.54
Standard deviation	0.59

The distribution of the scale results indicates a moderately positive assessment of the openness of the region. The mean value was $M = 3.54$, the median $Me = 3.62$ and the standard deviation $SD = 0.59$, with a minimum value of 1.73 and a maximum value of 4.81. The variability of the results suggests that although the average perception of the region is moderately favourable, some students experience significantly less favourable conditions.

Verification of the hypotheses allowed for in-depth comparisons between students from European countries and other parts of the world. In the analysis, which included only those who provided their country of origin ($n = 343$), students from Europe rated the openness of the region higher ($M = 3.71$; $Me = 3.77$; $SD = 0.53$) than students from outside Europe ($M = 3.31$; $Me = 3.31$; $SD = 0.57$); the difference was statistically significant ($Z = 6.30254$; $p = 0.000000$). For this difference, the effect size can be estimated as $r = Z/\sqrt{N} \approx 0.34$ ($N = 343$), which corresponds to a moderate (practically significant) effect and means that origin (Europe vs. the rest of the world) is associated not only with 'statistical significance,' but also with a noticeable difference in the assessment of the region's openness. This difference also has a distributional dimension: the median in the European group (3.77) is significantly higher than in the non-European group (3.31), suggesting a shift in the entire distribution of ratings towards a less positive perception of the region among students who are culturally more distant. At the same time, not all indicators of functioning in the region differed significantly depending on origin. An example is the assessment of getting around the region's cities in terms of understanding messages (public transport, accessibility of services). The percentage of 'good' ratings was high in both groups (Europe: 87.3%; rest of the world: 82.8%), and the chi-square test showed no significant differences ($\chi^2 = 1.44270$; $df = 2$; $p = 0.486095$; $n = 343$). The effect size (Cramér's $V \approx \sqrt{(\chi^2/N)} \approx 0.065$) indicates a negligible effect, i.e. practically no differences between the groups in this respect. In interpretative terms, this means that some of the 'infrastructure and information' components may be perceived similarly regardless of origin, while differentiation is more evident at the level of synthetic assessment of openness (and most likely those components that more strongly affect social integration and institutional service). The results also point to the importance of integration issues: although relations with Polish students were generally rated positively, 35.5% of respondents reported social integration problems, while 42.6% indicated language difficulties. This percentage should be read in the context of the openness scale distribution ($SD = 0.59$; $min = 1.73$), as 'integration difficulties'

may be one of the mechanisms generating the lower tail of the distribution of region ratings. The results concerning plans to remain in the region after graduation and factors influencing migration decisions are particularly important for the internationalisation of the region. The study indicated a high interest in taking up employment in the region (70.8%). At the same time, an analysis of the factors influencing the decision to potentially remain shows that the quality of life in the region has the strongest impact ($M = 4.12$; $Me = 4.00$; $SD = 1.01$) and the possibility of finding a job related to one's field of study ($M = 4.03$; $Me = 5.00$; $SD = 1.25$). The importance of programmes supporting the integration and professional development of foreigners was also rated quite highly ($M = 3.72$; $Me = 4.00$; $SD = 1.27$) and the availability of job offers in English ($M = 3.67$; $Me = 4.00$; $SD = 1.42$) were also rated quite highly. It is worth noting the median of 5.00 for 'the possibility of finding a job in the profession', which suggests that at least half of the respondents attributed maximum importance to this factor on a scale of 1 to 5. The relationship between the perception of job prospects in the region and plans to stay was confirmed by a chi-square test. Among those who did not see job prospects in their profession in the region, the highest percentage were those who clearly rejected the possibility of staying (35.7%). On the other hand, among students who saw such prospects, the highest percentages were those declaring that they would stay for several years (39.2%) and permanently (19.6%). The relationship was statistically significant: $\chi^2 = 35.4665$; $df = 6$; $p = 0.000003$. For this table (4×3), the effect size can be described by Cramér's V coefficient ≈ 0.22 , which indicates a small to moderate effect – i.e. not only 'significance' but also a noticeable strength of the relationship in practical terms (in social research with this type of variable, this level of V is interpreted as meaningful in the context of public policies and recommendations).

The results therefore allow us to reconstruct a more precise picture of the internationalisation process of the region 'from the perspective of experience': the university component is rated highly (80-91% positive ratings in key aspects of education quality), while the regional component is moderately positive ($M = 3.54$; $Me = 3.62$), but with significant variability in experiences and clear differences in ratings between students from Europe and outside Europe ($Z = 6.30254$; $p = 0.000000$; $r \approx 0.34$). Most importantly from the perspective of the region's internationalisation, decisions to remain after graduation are strongly linked to the assessment of employment opportunities in the profession and, more broadly, to quality of life and integration and professional support, and the statistically confirmed link between job prospects and plans to remain ($\chi^2 = 35.4665$; $p = 0.000003$) shows that labour market policies and instruments to support foreigners can effectively strengthen the retention of graduates in the region.

The questionnaire also included open-ended questions that allowed respondents to provide additional comments on their experiences of studying and living in the Silesian region. The qualitative responses were analysed thematically in order to identify the most frequently mentioned issues. The analysis indicates that the most commonly reported challenges

concerned language barriers, administrative procedures and social integration. Respondents pointed out that limited knowledge of Polish in everyday situations, particularly in public services or healthcare institutions, may hinder effective communication and access to services. Students also emphasised the need for more opportunities for interaction with local residents and Polish students through integration initiatives. Additionally, some respondents highlighted the importance of career opportunities and stronger cooperation between universities and local employers, which could increase the attractiveness of the region for international graduates. Overall, the themes emerging from the open-ended responses correspond with the patterns identified in the quantitative results of the study.

4. Discussion

The results confirm that the experiences of foreign students in the Silesian Province are complex and multidimensional, which is consistent with the concepts of intercultural adaptation indicating the parallel functioning of academic, social and institutional dimensions (Berry, 1997; Ward, Bochner, Furnham, 2001). The study clearly outlines the asymmetry between the highly rated university component and the moderately rated regional component. While the quality of education and the competence of the teaching staff received very high satisfaction ratings, the experiences related to functioning in the administrative and social space of the region were more diverse.

The insights obtained from the open-ended responses further support the quantitative findings, particularly with regard to language barriers, administrative challenges and the need for stronger social and professional integration of international students.

This result is in line with broader observations on the internationalisation of higher education. Knight (2003) points out that internationalisation is not limited to the curricular or mobility dimension, but requires the integration of the international dimension into the overall functioning of the institution. OECD studies (2025a; 2025b) emphasise that student mobility is increasingly linked to graduate retention policies and regional development. In this context, the results suggest that universities in the region are relatively effective in implementing the academic component of internationalisation, but the full effectiveness of this process depends on the quality of the host environment outside the university structure.

The difference in assessments between students from Europe and outside Europe is particularly significant. The moderate effect of the difference in the assessment of the region's openness indicates that cultural distance may play a real role in shaping perceptions of the host environment. According to Berry's acculturation theory (1997), the greater the cultural and linguistic differences, the higher the likelihood of adaptation difficulties. The results of the study confirm this relationship at the level of perceptions of the region's openness and

integration experiences. At the same time, the lack of significant differences in the assessment of certain infrastructural aspects (e.g., getting around the city) suggests that the barriers are primarily social and institutional in nature, rather than logistical.

The results concerning migration plans are particularly important from the perspective of the region's development strategy. The high percentage of students declaring an interest in staying in Poland after graduation indicates the region's retention potential. At the same time, the analysis of the relationship showed that the key factors determining the decision to stay are the possibility of finding a job related to the field of study and the overall quality of life. This result is consistent with the research by Mosneaga and Winther (2013), which indicate that graduates' migration decisions are strongly linked to their assessment of the local labour market and career development opportunities. This means that the internationalisation of the region cannot be understood solely as a strategy to attract students, but must include instruments to support their transition from the education system to the labour market.

From a public policy perspective, the results suggest a need for stronger integration between universities, regional authorities and labour market institutions. Universities seem to be effectively fulfilling their teaching function in an international environment, while the administrative and integration areas require further development.

The literature on internationalisation emphasises that the effectiveness of this process depends on the coherence of actions at the institutional and regional levels (de Wit 2011; Aksay, Aksezer et al., 2023). In this context, the moderate level of openness of the region and the significant diversity of student experiences point to the need for a more systematic approach to the integration of foreigners in urban and institutional spaces.

It is also worth noting that the high reliability of the region's openness scale allows it to be treated as a potential tool for monitoring the internationalisation process over time. The repeatability of the measurement in subsequent years would enable the analysis of trends and the evaluation of the effectiveness of the interventions implemented.

However, the study has its limitations. Firstly, the CAWI technique was used, which may be associated with the effect of self-selection of respondents. Secondly, the analysis is cross-sectional and does not allow for the assessment of changes over time. Thirdly, despite the relatively large sample size, not all nationalities were represented in equal proportions, which may affect the generalisation of the results.

In summary, the results indicate that the Silesian Province has a strong academic component of internationalisation, but full utilisation of the potential of foreign students as future participants in the regional labour market requires strengthening integration and administrative measures. The internationalisation of the region should be understood as a process that involves not only attracting students, but also creating conditions conducive to their long-term social and professional integration.

5. Conclusion

The study provides empirical grounds for assessing the level of internationalisation in the region from the perspective of foreign students' experiences. The results clearly indicate that the academic component of internationalisation in the Silesian Province is functioning at a high level, as confirmed by both high ratings of the quality of education and the measurement stability of the constructed scale. This means that the region has a strong institutional foundation for attracting foreign students.

At the same time, the moderate level of the region's openness rating and statistically significant differences between students from Europe and outside Europe indicate that the internationalisation process is not uniform and is subject to cultural diversity. The results suggest that the barriers are not infrastructural but socio-institutional in nature, which means that the key challenge is not the availability of resources but the way they are organised and communicated.

The most significant finding is the statistically confirmed link between the assessment of employment prospects and the declared willingness to remain in the region after graduation. This means that the internationalisation of the region should not be analysed in terms of student inflow, but in terms of human capital retention. From the perspective of metropolitan development, it is crucial to transform educational mobility into professional mobility rooted in the region.

In light of these findings, it is reasonable to shift the focus of metropolitan policy from promotional and recruitment activities to structural retention mechanisms. First, it is necessary to institutionally link the higher education system to the regional labour market by creating sustainable student-intern-employee transition paths. This means that an integrated system of internships financed or co-financed at the metropolitan level needs to be implemented in sectors that are strategic for the region's transformation (e.g. new technologies, green economy, medical services).

Secondly, the results justify the need to standardise the administrative experience of foreigners in the region. This is not about general declarations of openness, but about creating a measurable standard of institutional service, including the time required for procedures, the availability of information in English and the transparency of formal processes. Standardising these elements could have a real impact on improving the synthetic assessment of the region's openness.

Thirdly, the differences between students from Europe and outside Europe indicate the need for a segmented approach to integration. Internationalisation is not a homogeneous process; it requires taking into account varying levels of cultural distance. It is therefore reasonable to design integration programmes that are differentiated in terms of adaptation needs, rather than applying universal solutions.

Fourthly, the scale of regional openness constructed in the study can be used as a tool for operationalising internationalisation at the metropolitan level. The cyclical use of this tool would allow a transition from a declarative to a measurable model of managing the internationalisation of the region.

In summary, the Silesian Province has strong academic potential in terms of internationalisation, but the long-term development of the region's internationalisation requires a focus on graduate retention and the quality of socio-institutional experiences. It is these elements, rather than the influx of students alone, that are the key condition for transforming educational mobility into a sustainable development resource for the metropolis.

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INTERNSHIPS FOR APPLIED LINGUISTICS STUDENTS FROM THE PERSPECTIVE OF EMPLOYERS – CHALLENGES, PROBLEMS AND OPPORTUNITIES

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Purpose: The aim of this article is to present the findings of a study on the experiences of employers taking on interns and to attempt to answer the questions whether students undertaking work placements are prepared for them, what competences they should possess to make full use of the opportunities offered by employers, and to what extent universities can collaborate with businesses and institutions hosting interns to optimise the process of organising and implementing work placement programmes in the era of Economy 4.0.

Design/methodology/approach: This paper presents the results of qualitative research in the form of in-depth interviews conducted with 11 employers/work placement supervisors at companies that offer work placements to students, and reflects on the challenges and issues associated with organising such placements.

Findings: An analysis of the respondents' comments enabled us to identify the strengths and weaknesses of the interns in terms of their readiness for work, professional and psychosocial competencies, the problems and challenges faced by employers during the internship, and recommendations for higher education institutions, as well as to highlight areas of tension between different aspects of the respondents' comments.

Practical implications: The results of the research may contribute to the modification of education programmes and internship programmes, and thus to the effective preparation of students for professional work in the labour market conditions of Economy 4.0.

Originality/value: Previous research presented in the literature on this subject has focused mainly on the students' perspective, whilst in the available publications that do take the employers' perspective into account, the findings are based on statistical data or document analysis. There is a lack of in-depth reflection on employers' experiences in a specific professional field. This article aims to fill this research gap.

Keywords: professional practice, professional competences, psychosocial competences, Economy 4.0, translation profession.

Category of the paper: Research paper.

1. Introduction

As the economy transitions towards Industry 4.0, characterised by increasing process complexity, digitalisation and project-based work, the way in which employee competences are defined is changing. It therefore seems appropriate to adapt the training of young people to the evolving demands of the modern labour market. One of the tools facilitating this process is student work placements. These constitute an extremely important component of academic education, significantly influencing students' readiness to enter the labour market seamlessly, whilst enabling employers to recruit potential, career-focused employees.

The research on work placements presented in the literature to date has focused mainly on the students' perspective, whilst the employers' perspective – their needs, the challenges associated with organising work placements, and their level of satisfaction – remains largely under-explored. Furthermore, in the available publications that do take the employers' perspective into account, the results obtained are highly generalised, based on statistical data or on an analysis of documents defining learning outcomes in the context of work placements. The authors focus primarily on the labour market's general expectations of university graduates without specifying particular fields of study, or on the mutual expectations and benefits of cooperation between universities and employers (see Lis-Lemańska, 2013; Cieciora, 2017; Modrzejewska, 2023; Handzel, Kowalczyk, 2023). There appears to be a lack of in-depth reflection on employers' experiences within a specific professional field.

This article aims to fill this research gap. It is the result of the second phase of a research project focusing on work placements for students of applied linguistics. Its aim is to present the findings regarding the experiences of employers hosting interns and to attempt to answer the questions of whether students undertaking work placements are prepared for them, what competences they should possess to fully benefit from the opportunities offered by employers, and to what extent the university can collaborate with businesses and institutions hosting interns to optimise the organisation and programmes of professional placements in the era of Economy 4.0.

2. Labour market transformations in the era of Economy 4.0 – redefining the profession of translator

In the global economy, language competences are undoubtedly an important advantage in the professional environment. Employees who speak foreign languages are of great value to organisations because, according to Konrad Klimkowski, communication competences, including the ability to mediate effectively between languages and cultures, are essential for the

smooth functioning of various organisations: companies, cultural institutions, governmental, non-governmental and international institutions, as well as religious and faith communities (Klimkowski, 2015, p. 163).

In the opinion of Karl-Hubert Kiefer and Paweł Szerszeń, the importance of foreign language competences is revealed in circumstances where at least two conditions are met: 1) there is a cross-border exchange of both tangible and intangible goods, such as banking, transport and medical services, as well as the transfer of rights or information, 2) in communication situations, whether initiating or accompanying such circumstances, when at least one of the participants gives up using their own native language in favour of the language of at least one other interlocutor (Kiefer, Szerszeń, 2015, pp. 129-130).

Klimkowski points out that although knowledge of foreign languages is usually sufficient for employees of an organisation to communicate on a daily basis in the workplace, there are certain types of interactions for which they need the help of specialists, i.e. interpreters, who provide services to support communication and interpersonal cooperation, e.g. in the European Commission, the European Parliament, during scientific conferences or business meetings (Klimkowski, 2015, p. 163).

The fourth industrial revolution, based on information and communication technologies, robotics and intelligent production systems, has significantly influenced the requirements for professional competences in many fields. Klaus Schwab notes that traditional definitions of employee qualifications focus on advanced or specialised education and a set of specific competences within a profession or field. However, due to the accelerating pace of technological change, the fourth industrial revolution will increasingly require employees to constantly adapt and learn new skills and ways of working in different circumstances (Schwab, 2018, p. 65). This means that today's labour market values not so much specific professional qualifications as the competences needed to perform a certain range of tasks.

Klimkowski notes that, like many professions requiring specialist competences, the profession of translator is also undergoing significant changes. Back in the 1990s, translators performed relatively repetitive tasks. Nowadays, when looking for their place in the job market or trying to redefine their activities, translators must demonstrate flexibility and a willingness to undertake a range of activities that support linguistic and intercultural communication, which do not necessarily fall within the scope of traditional translation, e.g. helping clients edit texts and prepare slides for product presentations, participating in such presentations and advising on content, structure, intended communication effect, as well as linguistic correctness – both in their native and foreign languages (Klimkowski, 2015, pp. 165-166). In the reality of Economy 4.0, translators must demonstrate a much broader set of competences than just knowledge of foreign languages.

Based on the literature on the subject, Olena Shelest-Szumilas compiled a summary illustrating changes in employment in the context of the development of the 4.0 economy. The author took into account three areas of change: 1) the nature of work and tasks performed,

2) forms of employment and work organisation, 3) employment structure and competence profiles. Analysing the phenomena and trends identified by the researcher that are causing changes in the labour market, it can be seen that intellectual competences, teamwork skills and the ability to perform cross-cutting tasks are becoming increasingly important. Automation and cooperation with artificial intelligence-based systems are replacing routine, repetitive tasks, leading to the dematerialisation of work and increased standardisation in selected professions. Employee mobility and flexible forms of employment are on the rise, and work is increasingly being performed online, using digital platforms and mobile applications. Relations between employees and employers are becoming less formalised. Employment takes the form of task-based, project-based or casual work, and professional development is no longer linked to a single career path but is shaped by experience gained in various organisations. New professions are emerging and traditional jobs are being transformed, which means that new skills need to be acquired. There is a clear polarisation of employment. On the one hand, the share of the simplest professions in the labour market is increasing, and on the other, those that require very high qualifications. At the same time, the demand for professions with a moderate level of competence is falling. More and more people are choosing to work for themselves, which indicates growing autonomy and individualisation of career paths (Shelest-Szumilas, 2022, p. 41).

In summary, flexibility, readiness to adapt to continuous learning, creativity in problem solving, a change in approach to work organisation, as well as digital skills and the ability to work with technology, and in the case of translators, an understanding of how machine translation works and its limitations, are becoming key for the Economy 4.0.

In the context of employee competences, it is worth referring to Bińczycki, Łukasiński and Dorocki, who have compiled a list of those that they consider to be key for Industry 4.0. The researchers divide competences into four areas: social, cognitive, professional and personality. They consider social communication, the ability to work in a multicultural team and emotional intelligence to be important aspects of social competences. Cognitive competences include creativity and innovation, the ability to think independently, internal discipline, the ability to adapt to emerging changes and mobility in terms of place or country of employment. According to the authors, professional competences include openness to new technologies, the ability to operate modern machines, multitasking and knowledge of foreign languages. Personality-related competences include assertiveness, coping with stress, maintaining a work-life balance, and loyalty to the employer (Bińczycki, Łukasiński, Dorocki, 2023, pp. 85-93).

It seems reasonable to say that in the case of translation work, the above-mentioned characteristics can also be translated into specific professional requirements, conditioned by the building of professional relationships and contacts with clients from different countries, including remotely, and the possibility of using CAT tools or AI technology.

3. Internships for applied linguistics students – future translators

Academic training for translators usually takes place in the field of foreign language philology or applied linguistics. The studies shape the language competences of future translators through courses such as specialised language, specialised translation and, above all, practical language learning. The programme also offers subjects such as translation theory, which provides a theoretical foundation for practical language and translation competences. Most often, young adults' first contact with the realities of the labour market is through student internships.

Katarzyna Klimkiewicz defines student internships as an element of the education programme that can be described as a teaching method aimed at improving the competences of higher education graduates, enabling them to link theoretical issues with the problems of professional life, allowing them to gain experience and preparing them to enter the labour market (Klimkiewicz, 2015, p. 94).

Work placements for students of applied linguistics enable them to gain experience not only in translation, but also in functioning in an authentic institutional, business or cultural environment. In addition to developing key and multifaceted translation competence (see: Pietrzak, 2017, pp. 203-206), internships allow students to familiarise themselves with the specifics of specialist language, the nature of which depends on the profile of a given institution or company. They enable students to come into contact with various fields of translation, such as tourism, medicine, law, technology and literature, and thus encourage them to make an informed choice about their future professional specialisation.

The experience gained during internships allows students to face a variety of challenges typical of the work of a translator, such as terminological, technical or cultural difficulties. In this way, internships prepare students to confront real professional problems. In addition, they stimulate the development of independence, decision-making skills and the ability to act in real-life situations. Cooperation between universities and institutions and companies in the organisation of internships benefits both parties – it provides students with access to practical knowledge and experience, while enabling employers to recruit promising candidates (Klimkiewicz, 2015, p. 96).

The objectives of professional internships for translation students can be systematised in several dimensions. Firstly, an important element is gaining knowledge about the organisation and specific functioning of the company or institution where the internship takes place. Secondly, the opportunity to perform tasks requiring language competences plays a key role, including, among others, handling contacts with contractors, conducting telephone conversations, obtaining information from the media, drafting letters and offers, performing translations and analysing legal documentation. Thirdly, internships enable students to acquire practical skills related to both the specifics of the institution's business operations and the nature of specialised translations.

Another area involves developing an awareness of the cultural conditions of a translator's work, which is particularly important in the context of international organisations. It is equally important to improve self-reflection competences – analysing one's own successes and difficulties encountered while performing tasks – and to develop organisational competences, such as effective planning and rational management of working time. Finally, internships provide an opportunity to develop teamwork skills, which are an indispensable part of preparing to function in complex institutional and project structures.

Students of applied linguistics at the Silesian University of Technology complete a 6-month internship during their studies. First- and second-year students complete their internship in the summer, after the end of classes, for a period of 2 full months, while third-year students complete their professional internship during the academic year for the same period.

When confirming the completion of a student's professional internship, the employer assesses the following aspects of their work:

1. the student's attitude, including: independence, initiative and openness to change, attitude in the face of problems, responsibility, commitment and conscientiousness,
2. social competences and skills, i.e.: ability to work in a team, ability to behave in difficult and stressful situations, communication competences, politeness and kindness, quality of contacts with colleagues, management and external clients, willingness to critically evaluate one's own work,
3. quality of work and organisational competences: quality of tasks performed, timeliness of tasks performed, degree of use of specialist knowledge acquired during studies, planning and organisation of work.

Each of the above areas is assessed on a 6-point scale, from very good to unsatisfactory.

4. Research perspective and methodology

The aim of the study in the project presented here was to ascertain the views of employers collaborating with the university on the organisation of work placements for applied linguistics students, regarding their experiences of this process, their assessment of the students' preparedness to carry out practical professional tasks, the problems they encountered whilst working with interns, the potential benefits of the placements, and their expectations and needs regarding cooperation with the academic community.

In the study, we posed the following research questions:

1. How do employers assess the preparation of applied linguistics students undertaking internships in terms of language, translation, communication, digital and psychosocial competences?
2. What problems and challenges arise during the work placement process from the employers' perspective?
3. What recommendations do employers make regarding ways to improve the effectiveness of professional training for linguistics students?

We situate our study within the interpretative paradigm, giving it an exploratory nature. To carry out the project, we opted for a qualitative model utilising in-depth, semi-structured interviews. This research strategy enables us to elicit interpretations and the meanings attributed to the interviewee's description of the world and their experiences (Kvale, 2012, p. 42). Despite the limitations of the chosen approach, such as the local nature and subjectivity of the knowledge obtained, it should be emphasised that its advantages outweigh the identified shortcomings. The data obtained within this framework are unique and cannot be obtained by other methods, as they result from allowing the research participants to speak freely (Bauman, 2010, p. 103). They therefore constitute a significant source of new knowledge and enable an in-depth analysis of the phenomenon under study. The interviews were conducted in September 2025 with 11 employer representatives, mainly company owners or, in the case of larger enterprises and institutions, individuals designated to supervise students. The selection of interviewees was purposeful; employers who had been taking on applied linguistics students for work placements since the programme's inception in 2019 were invited to participate in the study. The main selection criteria were the length of cooperation with the university and a willingness to participate in the study. Ultimately, the study involved owners or representatives of translation agencies (8), companies in other sectors of business cooperating with foreign partners (2), and a government institution (1).

The interviews, which lasted on average around 45 minutes, were conducted in person or via Zoom. The standard interview script comprised 10 questions and was divided into three sections corresponding to the research questions. However, the order of the questions was flexible, and the scope of the researchers' inquiries depended on the interviewee's engagement. The content of the interviews was recorded, then transcribed and coded. The research findings were obtained through thematic analysis, which assumes an active role for the researchers in the process of knowledge construction and takes into account the subjective and interpretative nature of qualitative research (Braun et al., 2019).

The analysis process was multi-stage and involved: a thorough examination of the empirical data, the inductive (data-driven) generation of codes, the construction of categories, and the identification of themes. Subsequent stages involved reviewing and refining the themes, identifying sub-themes, and developing a coherent analytical narrative that addressed the research questions. During the analysis, we used ATLAS.ti software for coding and organising

the data. We mapped the relationships between themes using hand-drawn concept maps. This combination of tools enabled both the systematic organisation of the material and its in-depth, creative interpretation. The analysis was conducted by two researchers in accordance with the principles of reflective thematic analysis. In subsequent stages, we compared our interpretations and discussed the emerging codes and themes. This collaboration took the form of a dialogue and served to deepen the reflective nature of the analytical process, rather than to achieve coding consensus. This approach constituted a form of researcher triangulation, enhancing the transparency and reliability of the analysis (validation). To convey a full picture of the nature of the narratives, we quote excerpts from the participants' original statements in the article. The statements have been anonymised, and the participants are identified by the symbol R, numbered from 1 to 11.

5. Analysis of the research data obtained. Results and their interpretation.

In the first stage, we obtained 156 codes, from which we identified 14 categories. We then formulated three themes based on these. Analysis of the collected data enabled us to identify the categories described below, which provide answers to the research questions posed.

5.1. How do employers assess the preparation of applied linguistics students undertaking internships in terms of language, translation, communication, digital and psychosocial competences?

5.1.1. Motivation and willingness to learn

According to employers, linguistics students are motivated, ask specific questions and show interest in the practical aspects of the job.

R6: "I think they are very nice, intelligent, willing to cooperate and motivated. So my overall assessment, if I may put it that way, or experience, is positive. And the strengths of the students that are visible are their willingness to work and their willingness to learn. We also pass on a lot of knowledge, for example, about performing and describing certified translations, so here too I see that there are specific questions, you can see that these students are interested in how they are done, and you can also see this willingness to learn something".

R3: "The students are bright, punctual and to the point. We have no complaints".

5.1.2. High level of foreign language proficiency

Almost all employers emphasise the very good language competences of the interns. Here are a few examples:

R3: “Your students are the best-prepared interns we have. I have also noticed that their additional language competences, which they learn from scratch, are at a very good level”.

R1: “Their language competences are definitely very good. The question is how to apply them. We often throw them in at the deep end: they can, for example, interview Piast footballers. And these are people who can cope, who are already prepared linguistically, even with Spanish, much better than, for example, in secondary school. It is clear that people who are interested in foreign languages go into linguistics. The only problem is that they need somewhere to apply this knowledge later on”.

R6: “Language preparation – we don’t see students making any glaring basic mistakes”.

5.1.3. Reliability and meticulousness

Employers emphasise punctuality, accuracy, conscientiousness and even humility in accepting constructive criticism.

R7: “I think we noticed that they approach their tasks very meticulously. We have never had to give anyone a negative review”.

R8: “Most of them are very responsible people who perform their tasks reliably”.

R4: “Our experience with students has been very good overall. They were very reliable, hard-working, eager to work, learn and find out what the job of a translator entails. Their strengths include reliability; they took the work I assigned them seriously and wanted to do it well”.

5.1.4. Communication competences and openness

Employers describe interns as open-minded, willing to talk, well-prepared in terms of interpersonal competences in direct contact with colleagues, which distinguishes them from students of other universities.

R8: “Their strengths are communication competences. Compared to other universities, yes, they are definitely very communicative students who want to work, they don’t slack off (laughter). When it comes to soft competences, such as communication, they are very well prepared”.

5.1.5. Intimidation when dealing with customers

According to the interviewees, students feel insecure in direct relations with customers, especially in difficult situations, and need support and gradual introduction to the realities of the profession. Although communication competences were mentioned in the context of the trainees’ strengths, the interviewees also noted difficulties in this area.

R6: “As for shortcomings and difficulties, I don’t see any. They are a little intimidated when dealing with customers. They have a right to be. But they also receive feedback from us, and we try not to expose them excessively or put them in contact with customers

in difficult situations. Such difficult situations are not yet at the stage where they need to be resolved”.

R10: “Perhaps a lack of ease in communicating with foreign-language customers. In such interactions, face-to-face or over the phone. When it comes to writing text, replying to emails, that’s all fine. However, if a customer comes in and speaks, and now it often happens that it is not a customer who speaks pure English, there is slight resistance and confusion on the part of the students”.

R2: “Contact with the customer – it’s hysteria and panic. A lack of confidence in communicating in a foreign language. A person who chooses to study this should have these predispositions”.

R7: “At the beginning, cooperation and contact with the customer. The problem seems to me to be a bit generational; we also work with young people and it is often the case that these people do not quite feel at ease in such interpersonal contacts and teamwork. They often live in a media-driven world: social media, phones, so anything that requires them to focus on a specific task works great, but working with people is difficult for them”.

5.1.6. Problems with working on formal documents

According to the interviewees, students lack reading comprehension skills in a formal context. They note that filling out formal documents, such as official forms, is difficult for students.

R10: “Filling in an official form is also black magic. They cannot read and understand the instructions on how to fill in the form”.

5.1.7. Good level of basic digital competences

According to the respondents, students demonstrate high basic digital competences, especially in text editing and formatting, which is crucial in the work of a translator. Despite generally high digital competences, many employers report problems with using spreadsheets or more advanced word processing functions. These problems occur mainly at the beginning of the internship and are quickly resolved with the support of the team. Interns also cope well in situations requiring graphic or technical solutions.

R7: “Text editing, text formatting. When it comes to the skills we require, the trainees are doing well. When it comes to text editors or, for example, some graphic solutions, because the client requires, for example, that the form of the document be preserved, we have not had anyone have a problem with this, so I think that digital competences are high”.

R2: “They can use Word reasonably well, and Excel absolutely not”.

R8: “When it comes to shortcomings and difficulties, it is definitely the use of word processing programmes and Excel. I know that these are people focused on translation, but we often have documents with 8000 cells in Excel. For example, a user manual or the coding for a machine. And this has to be translated in Excel so that the company

can use the translation. And this is a big problem. Excel is a tool that is particularly common in technical translations. Machine manuals are usually written in Excel. Word processors and Excel are the basic tools. I assume that not everyone will work as interpreters, so if they want to find a job, they need to learn how to use these tools”.

R6: “Editing text – this can sometimes be problematic, but we are able to resolve it quickly. And it tends to happen at the very beginning”.

An analysis of the interviewees’ comments suggests that students’ competences are generally viewed positively, particularly in terms of motivation, reliability and language competences. At the same time, there is a clear need to improve interpersonal communication competences in direct contact with customers, especially in stressful and unpredictable situations.

5.2. What problems and challenges arise in the internship process from the employers’ point of view?

Based on the interviewees’ statements, we have identified several key challenges that employers face when organising student internships.

5.2.1. Too many internship hours and lack of flexibility in terms of completion dates

Respondents raised concerns regarding the organisational aspects of work placements. The most frequently mentioned issues were the number of placement hours required and the need for greater flexibility in the organisation of placements.

R1: “It would be better if internships were organised during the academic year, i.e. greater flexibility on the part of the university would be advisable”.

R8: “To be honest, we are sometimes surprised by the number of internship hours. It is very high. On the one hand, for organisational reasons on the part of the intern, it is sometimes difficult to reconcile certain matters. Secondly, supporting the intern for 8 hours a day, seven days a week, also makes our work and organisation a little more difficult. Because, obviously, there has to be someone who can help this person if necessary”.

R10: “It would be good if students could work online, as this makes things much easier”.

R 3: “Students often have the same timetable, so you have to arrange it so that as many people as possible can do the internship. Also, they should call in advance. Then it is easier to organise. They have their own desk and computer here. We will be happy to accept them in the future. But it would be good if students had more flexibility in terms of the timing of their internships, then we could take 2 or 3 people at the same time”.

R11: I wonder if such a large number of internship hours is really necessary... With fewer hours, it would be easier to find them a placement”.

R8: “I know where the number of hours comes from, I know the difference between a general academic profile and a practical one. I don’t know if you have any leverage with the ministry (in terms of reducing the number of internship hours)”.

5.2.2. *Premises and staffing constraints*

Despite their willingness to cooperate, employers, especially owners of translation agencies, can only take on a small number of students for internships due to limited capacity to provide workstations and staff supervision.

R6: “We just have to keep an eye on the number of interns so that there aren’t too many of them. This was a problem in the early years, at the beginning of our cooperation. Now we know how many students we can take on and when. There’s no point in exceeding this number, because they might not be able to fill all those internship hours with work. The number of students in a given period is fairly fixed”.

R8: “Logistics. Our office is not very spacious, so we are not able to accept many interns at once”.

5.2.3. *Protection of customers’ personal data and confidentiality of documents*

Due to the fact that we work with confidential documents or documents subject to personal data protection, employers must select the materials made available to interns.

R7: “We are subject to a lot of confidentiality regulations, so we prepare excerpts from documents that do not contain any personal data, so as not to get involved in GDPR training processes and not to sign confidentiality agreements. In fact, the selection of documents that we can make available is quite limited. The issue of data confidentiality and the number of documents that can be translated. Documents related to trade secrets, for example, are probably the biggest organisational challenge”.

R8: “The GDPR is definitely a challenge. It is a significant limitation for us. I can give them licences, legal or technical documents to translate. I can share them with them and there is no problem with that. Medical texts – students will definitely not get those. We would have to put a lot of work into anonymising those texts. Then it would not make sense to prepare such a translation”.

From the respondents’ perspective, the greatest challenges are organisational and structural in nature, rather than substantive. They relate primarily to the number of placement hours, staffing and premises constraints, and legal requirements concerning professional confidentiality and the protection of personal data.

5.3. **What recommendations do employers make to increase the effectiveness of the professional training of linguistics students?**

According to the respondents, students undertaking internships are well prepared in terms of theory, but need support in developing certain competences. One of the recommendations made by the interviewees was to supplement the preparation for professional internships with meetings with representatives of the labour market, who could present their requirements and expectations towards future interns.

5.3.1. *Developing personal and interpersonal competences*

The respondents' comments suggest that students need support in developing their professional interpersonal competences and teamwork abilities.

- R11: "In this regard, the most important competences are openness to new activities. This would be important, and of course interpersonal competences, at least at a basic level. In my opinion, it would also be useful to place emphasis on teamwork".

5.3.2. *Exposure to technical and formal documents*

Employers emphasise the importance of placing greater emphasis on formal and technical documents during academic studies.

- R6: "I think that the University prepares students very well. Perhaps a little more practical, functional and official documents could be used during practical exercises. But that's just from our point of view, because we have the most of them".
- R9: "The demand for technical translation is growing, so if the University of Technology had the opportunity, it would definitely be technical vocabulary, e.g. machine operating manuals, technical specifications. Not many people want to do this. Technical vocabulary, it is worth being well prepared for this – there is money to be made and there is definitely a demand for it".

The research identifies areas for the development of apprentices' competences based on market demand.

5.3.3. *The need for a realistic presentation of the specifics of the translation profession*

During the interviews, the interviewees also note significant discrepancies between students' perceptions of the translator's role and the reality of the job. They emphasise the need to prepare young people for the realities of working as a translator in the business world.

- R7: "Students should already know a little about the work of a translator, because sometimes the expectations of young people clash with reality. Often in private conversations, often unrelated to internships, they think that they sit and translate and that it is easy, simple and pleasant, but this is not always the case. Interns may observe difficult situations when something goes wrong, someone does not arrive, and there is a negative reaction from the customer. When problems arise with a customer, it comes as a surprise to these young people. [...] Sometimes, unfortunately, as interns, they are also given tedious tasks related to archiving documents or tidying up. I think this is valuable in that they also learn at this point that this job is not just about translation and that's it, but that there are also certain procedures for handling documents. Whether it's a matter of GDPR or how long to keep these documents. Unfortunately, it's also a bit of a generational thing, I would say that young people want to get something done and move on. It's not always the case, it's not always possible".

Employers also raise the issue of compliance with regulations in the context of the GDPR or professional secrecy.

5.3.4. *Strengthening cooperation between universities and employers*

Several interviewees also expressed a willingness to strengthen their cooperation with the university, offering to contribute to the educational process by organising meetings and training sessions.

R1: “I could come to you and run a training session on how to implement internships well and effectively”.

R5: “It would be good to organise a mini job fair for students, a meeting for current and former students who already work in various corporations, in various places. Maybe conduct interviews with employers, ask questions about expectations, what the current labour market needs are, and make this knowledge available to lecturers”.

In summary, employers’ comments offer recommendations centred on three key areas: strengthening interpersonal competences, increasing students’ exposure to technical and formal documents, and deepening cooperation between universities and the labour market.

6. Interpretation of the results in the context of thematic analysis according to Braun and Clarke

Based on the above categories, we have identified three themes:

1. “Students – valuable competences capital vs. lack of market experience”

Employers paint a positive picture of students as well-prepared and promising professionals. They highlight their motivation, reliability, communication competences, high level of foreign language proficiency and basic digital skills. It is worth noting that interviewees rate students’ communication competences as high, whilst at the same time highlighting their shyness and communication barriers when dealing with clients, particularly foreigners (cf. Budzanowska-Drzewiecka, Marcinkowski, Motyl-Adamczyk, 2016, pp. 60-62). This points to a discrepancy between communication within a familiar group of colleagues and professional communication, which often requires intercultural interaction involving the negotiation of meanings and spontaneity in the use of a foreign language in business communication. The key challenge is not a lack of knowledge, but a lack of experience in the context of professional responsibility and situational pressure. This can be interpreted as the difference between communication in a safe and predictable situation and market-based communication, which requires greater stress resilience, adaptability and situational flexibility – in other words, competences that form part of the concept of social competences in Industry 4.0 (see Bińczycki, Łukasiński, Dorocki, 2023, pp. 85-93; Shelest-Szumilas, 2022, pp. 39-48).

2. “The transition from perception to reality – areas of tension

It is clear from the interviewees’ comments that, whilst students demonstrate a committed attitude towards their tasks and can boast a good knowledge of foreign languages, their awareness of the realities of a translator’s day-to-day work is limited. Students’ perceptions of a translator’s work are shaped during lectures and on the basis of academic experiences. University courses prepare young people in terms of subject matter and specialist competences, but do not take into account the practical aspects of working within an organisational environment. Tasks requiring non-linguistic skills prove problematic, ranging from the use of tools such as spreadsheets, through the drafting and completion of formal documents, to routine office work such as organising and archiving documentation. The picture of a translator’s daily work presented by the interviewees confirms Klimkowski’s earlier observations regarding the diversity of tasks performed by translators today, who often operate in the labour market as self-employed professionals. This aspect is discussed in greater detail by Katarzyna Klimkowska and Konrad Klimkowski in their monograph *Kształtowanie kompetencji świadczenia usług tłumaczeniowych z perspektywy przyszłych tłumaczy*, in which they highlight a range of competences related to the provision of translation services, covering both interpersonal and service aspects.

3. “The institutional framework for cooperation – between openness and constraints

Employers value their cooperation with the university, as students carrying out the tasks assigned to them during their work placements significantly lighten the workload of staff (cf. Modrzejewska, 2023, pp. 85-86). At the same time, employers point to certain limitations in the organisation of work placements. According to their suggestions, cooperation with the university requires systemic adjustments. Problems include the statutory number of hours, a lack of flexibility in the imposed dates for placements, and staffing constraints within organisations. Professional confidentiality, e.g. GDPR regulations, hinders the integration of trainees into all of the employer’s activities. In the employers’ view, the university should enable students to complete at least part of their placements remotely. This way of carrying out tasks is common in today’s labour market. In their comments, employers recommend that language training should focus on specialist technical language. Although the demand for traditional translation services is falling, translation agencies continue to receive numerous requests for technical translations for industry. One suggestion for planning language training is therefore to develop proficiency in specialist technical language.

The thematic analysis points to clear tensions between students’ competence potential and the realities of the labour market. It highlights the value of work placements as a crucial transitional stage between academic education and professional work.

7. Conclusions, implications and directions for further research

Based on the thematic analysis of statements made by labour market representatives, we have drawn several conclusions regarding the preparation of applied linguistics students for work placements and their performance in the modern labour market.

Applied linguistics students at the Silesian University of Technology are perceived as intelligent, meticulous and eager to acquire new knowledge and skills, thereby developing their professional competences. Thanks to the hard work, commitment, responsibility and diligence of student interns, cooperation with them goes very well, and any difficulties encountered are marginal and relate to isolated cases. According to employers, the characteristics and attitudes listed above bode well for their professional future. Furthermore, high language and communication competences, which form the basis of a translator's work, set linguistics students apart from students at other universities, according to employers. Students' preparation in terms of basic digital skills is also rated highly and enables the effective completion of the placement. The difficulties encountered in this area relate to the use of Excel and the application of advanced word processing functions.

A thematic analysis of the empirical data also reveals certain tensions between students' academic preparation and the demands of the real-world workplace. It is worth noting that, whilst students' professional competences are rated highly, they require support in developing competences such as teamwork and interpersonal communication, particularly in stressful and unpredictable situations. In the opinion of employers, the university should also place greater emphasis in vocational training on practical skills, such as working with authentic official documents.

Another conclusion drawn from the study is the need to ensure that students are given a realistic picture of the translator's profession in today's labour market, as the modern translator's work is increasingly rarely limited to the act of translation itself.

A key finding of the study is the importance of cooperation between universities and employers. Respondents express a positive view of the very idea of work placements and recognise the benefits of having students within their organisations. At the same time, they highlight certain systemic limitations. From the employers' perspective, work placements should be better balanced in terms of duration and the level of support employers can provide. The need to manage the number of interns and their schedules was identified as the most significant organisational challenge. This is primarily due to space constraints and staffing conditions. Another obstacle to organising work placements is limited access to confidential documents, which is regulated by data protection legislation.

An effective way of making students aware of the realities of a translator's work and the changes taking place in the profession within the labour market in the Economy 4.0 is to organise meetings with professionals, as a complement to the teaching process.

In the context of the latest recommendation, we consider it worth noting the comments from employers, which indicate a well-thought-out and progressive approach to organising trainees' tasks, with a focus on a safe induction into the role and the opportunity to learn by comparison, alongside a gradual increase in independence and careful selection of a variety of document types.

R6: "Our practice is such that we start by giving them simple tasks. We send them a document and a template. Translations that were done earlier, but for a different client. Then, in the second stage, they do translations with a reference document. Not necessarily identical, but similar. And the third stage is that they do translations of not very long, not very complicated documents on their own from start to finish. But they don't really need any help, they are able to do it well from start to finish. And interestingly, even though there is no such requirement, they very often prepare these translations for us with all the formatting and in accordance with the rules for certified translations, so I have the impression that for them it is a practical course on how to do certified translations. So, the documents are not repetitive and predictable, although of course there are many of them. However, when we see that they can handle these completely simple things and also do well with the reference ones, we increase the level of difficulty and they do quite well with such simple translations of simple documents".

In one of the statements (see: 5.1.2., R1), the interviewee, whilst praising the trainees' language competences, also expresses concern about their professional future and whether they will be able to make use of their competences. In this section, we would therefore like to offer some of our thoughts on adapting translation teaching to the demands of today's labour market and the employment prospects for graduates in applied linguistics.

Digitalisation, a defining feature of the labour market in the Economy 4.0, including the development of artificial intelligence, is transforming – and indeed replacing – many professions, including that of the translator. As a language specialist and, to a large extent, a mediator between cultures, the translator is compelled to broaden the scope of their work. This point is highlighted by Klimkowski, whom we have cited. Applied linguistics continues to be very popular among prospective students who wish to develop their language competences and acquire professional qualifications that are valuable in the labour market. The role of educators responsible for language teaching should be to prepare language specialists who are flexible in applying their knowledge of foreign languages, not only in interpreting and translation, but also, and perhaps above all, in the fields of media, marketing and business. Those who see their professional future as being linked to foreign language competences will thrive in creative roles (e.g. creating posts, podcasts and newsletters; managing social media profiles for organisations operating in the international market; PR activities), analytical work (e.g. market research, customer feedback analysis) or in roles based on interpersonal relations (e.g. customer relations, recruitment in an international and multicultural workplace,

coordination of international teams, organisation of international events, hosting international conferences, moderating panel discussions). In the teaching process, alongside the development of language competences, soft skills should also be developed and strengthened, as well as the efficient and informed use of digital tools. Employees who can communicate fluently in foreign languages, understand cultural differences and are aware of their impact on business relationships will be a valuable asset to organisations with a global reach.

In summary, the study confirms that students of applied linguistics possess solid linguistic competences and significant potential for development; however, their successful entry into the labour market requires further strengthening of their practical and psychosocial competences. Cooperation between universities and employers, and the systematic incorporation of their experiences into the design of study programmes, can significantly contribute to better preparing graduates for the challenges of the modern labour market.

In light of the findings, we recognise the need for further research aimed at a more in-depth analysis of skills gaps from the comparative perspective of students, employers and the actual requirements of the workplace. It would also be worthwhile to investigate how students perceive the profession of a translator and how this perception changes during their studies and work placements.

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SOURCE ANALYSIS AND CONSIDERATION IN THE FIELD OF THREATS AND MARITIME SAFETY

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Purpose: The purpose of this article is to examine various methods of risk assessment and safety management in maritime shipping. The paper compares both traditional methods and modern technology-based solutions, which are gaining in importance in the context of increasing maritime traffic, port expansion, and threats resulting from a dynamically changing environment, especially in restricted areas with high traffic density.

Design/methodology/approach: The study analyzed numerous scientific publications from Poland and abroad. It focused on comparing different approaches to navigational risk assessment from deterministic to probabilistic and on the applications of modern technologies such as artificial intelligence, AIS data analysis, and computer simulations. Both classic methods, such as Formal Safety Assessment (FSA), and advanced models based on maneuvering space data were taken into account.

Findings: An analysis of the literature shows that there is no single ideal risk assessment method for every case. The best results are achieved with a mixed approach, adapted to the conditions prevailing in a specific water area, the available data, and information about navigational hazards in that area. During the analysis of the methods presented, some loopholes were also identified, particularly in difficult navigation areas such as narrow passages and ports.

Research limitations/implications: One limitation is the lack of uniform access to high-quality AIS data and the cost of implementing modern technological solutions in maritime navigation systems.

Practical implications: The conclusions from the study may be particularly useful in planning port expansions, such as the planned container terminal in Świnoujście or the FSRU terminal in Gdańsk. Projects of this type require a thorough assessment of navigational risks, especially in areas with high traffic volumes and limited maneuvering space.

Social implications: Safer shipping not only benefits the industry, it also protects human life and the environment. The findings of the study can help shape policies that promote environmentally sustainable maritime transport and better port management.

Originality/value: The value of the article lies in its combination of theoretical knowledge with a practical look at new technologies supporting maritime safety. The work is aimed at both researchers and practitioners – engineers, port designers and those responsible for maritime traffic management.

Keywords: Automatic Identification System, Navigational Safety, Navigational Risk Assessment, Formal Safety Assessment, Risk Assessment Matrix, Logic Tree Method.

Category of the paper: Literature review.

1. Introduction

Risk analysis in maritime transport has long been a subject of interest for both researchers and shipping safety specialists. Sources on the examined issue are distinguished by classic deterministic approaches and modern probabilistic methods, which allow for a better understanding of the complexity of navigation systems and doubts related to their functioning. In the past, many detailed studies on risk assessment methods have been carried out, covering various aspects of maritime transport risks (Yang et al., 2017; Shin, 2019; Lim et al., 2018). These include factors that influence risk (Yang et al., 2017), quantification of risks associated with maritime transport (Li et al., 2012), uncertainty analysis (Ozturk, Van Dorp, 2006). These methods have been reviewed in a variety of contexts, including maritime security analysis (Yang et al., 2013), on narrow waterways (Li et al., 2012), collision risk in ship traffic (Ozturk, Cicek, 2019). These studies provide us with different approaches to reviewing potential threats in each area. They also show that the modelling characteristics of maritime transport methods depend mainly on the characteristics of the available data (John et al., 2016), and the main limitation is the lack of specific data (Zhang, Thai, 2016; Hänninen, 2014). Classic approaches to risk analysis are based on detailed modelling of the situation and determining potential threats based on known system parameters. Kristiansen (2013) point out that such methods work primarily in situations where accurate data on shipping processes is available, such as waterway parameters, ship size or expected hydrometeorological conditions. These methods focus on the systematic identification of threats and the assessment of their effects. The basic tool here is scenario analysis, in which probable consequences and possible ways of minimizing the risk are determined for each potential threat. An example is system reliability analysis (Reliability Analysis), which highlights that these methods are most effective when precise data on shipping processes is available, such as waterway parameters, vessel dimensions, or forecasted hydrometeorological conditions. These methods focus on the systematic identification of threats and the assessment of their effects. The basic tool here is scenario analysis, in which probable consequences and possible ways of minimizing the risk are determined for each potential threat. One example is the analysis of system reliability (Reliability Analysis), aimed at identifying critical elements of transport infrastructure, as well as assessing the risks associated with failures, which helps prevent navigation errors and improve safety in transport systems.

A review of available methods for assessing navigation risk and safety shows that research in this area is crucial for science and technology. The methods developed help to identify and minimize threats in maritime navigation. It contributes to the creation of more reliable maritime traffic management systems, the design of safe vessels and environmental protection. It also supports the development of international regulations, such as IMO and SOLAS, by integrating innovative simulation and statistical technologies.

The originality of this work consists in a critical synthesis of existing risk analysis methodologies combined with a novel interpretative framework that explicitly relates modelling effectiveness to the quality and structure of available maritime data. The study moves beyond traditional reviews by identifying systemic constraints in current risk assessment practices and by proposing an integrated approach for analysing navigation safety under uncertainty. This perspective provides a new methodological lens for evaluating navigational hazards in the studied water area with high ship traffic density, particularly in environments characterized by incomplete datasets and dynamic operational conditions.

2. Research Methodology

The analysis was based on publications from the last 15 years, representing essential studies in the field of maritime safety. Both the latest research and older studies, which are still considered the foundations of this field, were taken into account. The selection of literature was not based solely on its relevance, but primarily on its substantive value, impact on scientific development and usefulness in the context of the discussed risk assessment methods and techniques. Thanks to this comparison, it was possible to determine both contemporary trends and proven theoretical foundations.

The scope of the analysis included quantitative methods (e.g. FTA, ETA, QRA), probabilistic approaches, analyses based on data from vessel monitoring systems such as AIS, qualitative techniques (e.g. Formal Safety Assessment – FSA) and simulation analyses and predictive models. Both classical techniques such as fault tree analysis (FTA) and modern methods based on spatial data and stochastic models are discussed. Each source is assessed for its usefulness and consistency in the context of the issues discussed. Key methods, their practical application, advantages, limitations and possibilities of integration with modern technological systems, such as spatial data analysis tools or artificial intelligence technologies, were compared. Based on the collected information, a critical comparison of methods was made, taking into account differences in their approach to hazard identification, risk assessment and implementation of countermeasures. The results of the comparison are presented in tabular form, facilitating comparison and conclusions. The literature review was limited to materials available in English and Polish. Due to the review nature, detailed case studies were not

included, focusing on universal and commonly used techniques. This methodology allowed for a comprehensive comparison of available maritime risk assessment tools, providing a basis for further research and optimization of methods in this area.

2.1. Approaches to risk quantification and navigational safety

Navigational safety is an important element of maritime traffic management, especially in the face of the growing intensity of maritime transport and the development of ports and waterways. Research in this area includes various assessment methods that enable the identification of threats, analysis of potential emergency scenarios and assessment of the effectiveness of risk minimization actions. When considering navigational safety, tools that allow for risk analysis, determining the probability of threats and their potential effects are important. The most frequently used methods include both classical approaches and modern techniques integrating advanced mathematical models and qualitative analyses. The most important methods include:

- Matrix method – used to visualize risk and its classification in simple analyses.
- Logic tree method – allowing the identification of the causes and effects of specific events.
- Simulation method – enabling the analysis of dynamic scenarios in conditions of environmental variability.
- Formal Maritime Safety Assessment (FSA) – a standard recommended by the International Maritime Organization (IMO), integrating qualitative and quantitative approaches to risk assessment.
- Navigation risk model recommended by IALA – including qualitative and quantitative risk analysis in the context of navigation infrastructure.
- PIANC risk assessment model – dedicated to the analysis of security in ports and inland waters.

By using various techniques, it is possible to adapt the security assessment process to the specificity of a given area, available data and the characteristics of potential threats. Below, a detailed analysis of the above methods is presented, highlighting their advantages, limitations and areas of application in navigation practice.

2.1.1. Matrix method

Risk estimation using matrix methods involves determining the categories of consequences and the probability of their occurrence. The advantage of this type of method is that it is easy to use and understand. Thanks to this, it can be used in research where detailed statistical or simulation studies are not required (Bağ et al., 2024). An example of a matrix technique is the ISO Risk Matrix, which is presented in draft of international standard 17776 (ISO, 1999). This standard presents a 5 x 5 risk matrix with consequence and probability categories that are easier for many people to interpret. The ISO 17776 matrix uses 4 types of consequence categories, i.e. people, assets, environment and reputation (Shouman et al., 2021). Figure 1 shows an example of this type of matrix.

Severity Rating	CONSEQUENCE				INCREASING PROBABILITY				
	People	Assets	Environ-ment	Reputation	A	B	C	D	E
					Rarely occurred in E&P industry	Happened several times per year in industry	Has occurred in operating company	Happened several times per year in operating company	Happened several times per year in location
0	Zero injury	Zero damage	Zero effect	Zero impact	Manage for continued improvement				
1	Slight injury	Slight damage	Slight effect	Slight impact					
2	Minor injury	Minor damage	Minor effect	Limited impact					
3	Major injury	Local damage	Local effect	Considerable impact	Incorporate risk reducing measures				
4	Single fatality	Major damage	Major effect	Major national impact					
5	Multiple fatalities	Extensive damage	Massive effect	Major international impact					
					Intolerable				

Figure 1. A matrix technique the ISO Risk Matrix.

Source: Shouman et al., 2021.

In practice, the risks assessed using this methodology include, among others: navigational failures, ship collisions, loading accidents or weather-related hazards. In each case, the key is to assess where specific risks lie in the matrix and then plan actions to minimize those risks.

2.1.2. Probabilistic approaches to navigation risk analysis and management

Probabilistic methods make it possible to consider the uncertainty associated with various factors affecting navigation safety. The use of these models to analyse the parameters of waterways and navigation systems allows for a more precise assessment of the threats associated with manoeuvring vessels in limited water areas (Gucma et al., 2013).

Fault Tree Analysis (FTA) or Event Tree Analysis (ETA) are commonly used to study complex navigation systems. For example, Marek Żukowicz (2015) in his work on FTA, he highlighted the effectiveness of this method in identifying key failure points in maritime traffic control systems. Methods using the logical tree structure enable quantitative analysis of the risk of an accident in a limited area. In practice, three types of logic trees are used to assess the risk of an accident - fault trees (FTA-Fault Tree Analysis), event trees (ETA-Event Tree Analysis) and risk contribution trees (RCT-Risk Contribution Tree) (Bak et al., 2024). As an example, the logic tree method was used to analyse data related to tugboat accidents in restricted waters. The study Remzi Fışkın et al. (2020) was used to understand what factors (e.g. weather conditions, human error, technical condition of tugboats, work organization, etc.) most often contribute to tugboat accidents in ports. Risk factors that have a decisive impact on navigational safety and tips that can help improve the safety of towing operations in ports are presented. The importance of appropriate crew training, fleet modernization and improved management of operational conditions was emphasized, drawing attention to their key impact on improving navigational safety. A decision tree was used to help to identify relationships between various variables, and logistic regression was used to assess the impact of these variables on the probability of an accident.

The example logic tree used to analyse navigation safety in a selected water area consists of various failure scenarios of the navigation system, sensors and other elements such as accelerometers, gyroscopes and other devices essential for safe navigation.

To sum up, event and fault trees are a tool used to analyse the causes of failures in complex systems. Each potential failure event is broken down into smaller, more detailed causes, creating a hierarchy of possible problem sources. This helps identify critical points in the system that could lead to serious damage, enabling more effective risk management and implementation of preventive actions.

2.1.3. Formal Maritime Safety Assessment (FSA) as a risk assessment tool in maritime navigation

Formal Maritime Safety Assessment (FSA), developed by the International Maritime Organization (IMO) (MSC/Circ.1023 & MPEC/Circ.392) is a key risk assessment methodology used to make regulatory decisions in maritime safety. FSA consists of five stages: identification of hazards (a list of all relevant accident scenarios with potential causes and outcomes), assessment of risks (evaluation of risk factors), risk control options (devising regulatory measures to control and reduce the identified risks), cost benefit assessment (determining cost effectiveness of each risk control option) and recommendations for decision-making (information about the hazards, their associated risks and the cost effectiveness of alternative risk control options is provided). This methodology is particularly helpful in developing IMO regulations, enabling effective risk identification and proposals for actions to improve safety. FSA is also used in planning the development of port infrastructure and in the implementation of navigation decision support systems, especially in the context of modernization of waterways.

An example of such an application is the research published by M.B. Zamana et al. (2014) on the use of the Formal Safety Assessment (FSA) method in analysing the risk of ship collisions, based on data from the AIS (Automatic Identification System). The aim of this research was to develop a collision risk assessment model using AIS and GIS data, especially in the context of calculating collision probabilities in strategic maritime regions such as the Strait of Malacca. This study considers factors such as maritime traffic density, as well as various navigation conditions that may affect the likelihood of collisions, such as overtaking situations or head-on collisions.

The Strait of Malacca is one of the busiest sea routes in the world. Figure 2 illustrates the density of maritime traffic and the areas that have been analysed in the context of assessing navigational safety and risk. The use of FSA in these studies enables the identification of threats, risk assessment, and the proposal of actions aimed at reducing the number of collisions in selected sea areas.



Figure 2. Maritime traffic density around the Strait of Malacca.

Source: Zamana et al., 2014.

The use of Formal Safety Assessment (FSA) in risk analysis, including ship collision risk assessment using AIS data, offers both advantages and limitations. This method primarily enables accurate hazard identification, risk assessment, and the development of risk minimization strategies, which support regulatory and operational decision-making. It can be applied in various contexts, from designing regulations and modernizing infrastructure to implementing navigation decision support systems. The use of real data, such as AIS, increases the accuracy of results, enabling more precise threat forecasting. It also incorporates cost-benefit analysis, which helps identify the most effective and cost-efficient preventive actions.

Unfortunately, its complexity requires advanced knowledge in the field of risk analysis, which may constitute a barrier to its wide implementation. For example, to conduct a complete risk analysis in the Strait of Malacca area, researchers had to consider many variables such as traffic density, different weather conditions and marine topography. The study required advanced expertise and extensive resources. Zaman & Santoso (2014) indicate the need for complex analysis and the introduction of appropriate mathematical models, which may require a lot of time and experts. The effectiveness of the FSA application depends on the quality and availability of data. In an area where marine monitoring infrastructure is limited, e.g. AIS data may be incomplete or out of date. In such cases, risk assessment may be difficult, which reduces the effectiveness of decisions made. An additional challenge is appropriate technological support, including the use of advanced computer systems for data processing and analysis.

Formal Safety Assessment (FSA) is an effective tool in maritime risk assessment, enabling decisions to be made based on detailed analysis of threats and impacts. Although this method has many advantages, such as systematicity and versatility, its implementation may be expensive and time-consuming, and requires advanced data processing and appropriate technical resources.

2.1.4. Navigation risk model recommended by IALA (qualitative risk assessment and quantitative risk assessment)

The recommendations of the International Association of Navigation Marking Services (IALA) can be used to assess the level of navigation risk for both existing and planned ports or waterways. They become useful when designing water bodies, such as expanding infrastructure or changing traffic organization (Bak et al., 2024). The IALA guidelines should be highlighted Qualitative Risk Assessment i Quantitative Risk Assessment (IALA, 2009).

The Port and Waterway Safety Assessment Toll (PAWSAT) is used for qualitative risk assessment. This method was developed for the US Coast Guard, it enables the identification of main safety threats, estimating the level of risk and determining the consequences of accidents. The methodology includes a general risk model for waterways. It aims to consider all factors that affect safety.

The tool for quantitative risk assessment is the IWRAP MK II computer program, which was developed by the Canadian Coast Guard, DTU (Technical University of Denmark) and MSCW (Marine Simulation Center Warnemunde). The created model considers the geometry of routes, traffic intensity and ship parameters. The program builds a model, and then determines the average annual number of possible collisions and entries in the created water area.

IWRAP MK II (International Waterway Risk Assessment Program) software enables the assessment of the frequency of ship collisions and groundings on a given waterway based on data from the Automatic Identification System (AIS) in a selected water area. The app can compare different shipping routes by assessing the relative frequency of collisions or groundings. The advantage of the program is that the analysis are carried out based on actual data obtained from AIS, and the accuracy of the results depends on the amount of data entered by the user. IALA IWRAP MK II has a wide range of applications in research work including analysis of ship traffic streams in a selected water area, analysis of the width of ship traffic lanes and the location of hydrotechnical structures and navigation infrastructure, determining areas with the highest intensity of sea and inland ship traffic (Anczykowska et al., 2015). It is worth paying attention to several key points related to its use. On the one hand, the effectiveness of the method lies in its ability to accurately identify threats and help make regulatory decisions based on a sound risk analysis. On the other hand, limitations of this method, such as data quality requirements and the need for specialized knowledge, may hinder its widespread implementation, especially in less developed regions.

2.1.5. Application of the PIANC risk assessment model in the context of navigation safety

The PIANC risk assessment model is used to analyse and assess risks in water infrastructure projects, such as the construction of ports, terminals and waterways. This method is based on a systems approach that integrates both environmental and technical risk assessments. Key elements of the PIANC model include:

- Qualitative and quantitative analysis – risk assessment is divided into stages: qualitative analysis (identification of potential threats and their effects) and quantitative analysis (modelling the probability and consequences of events).
- Use of probabilistic tools – the method includes techniques such as modelling structural re-liability or simulating emergency scenarios.
- The "Working with Nature" principle – promotes an approach that integrates infrastructure development with environmental protection (PIANC, 2014).

The navigation risk management procedure is presented below (Figure 3).

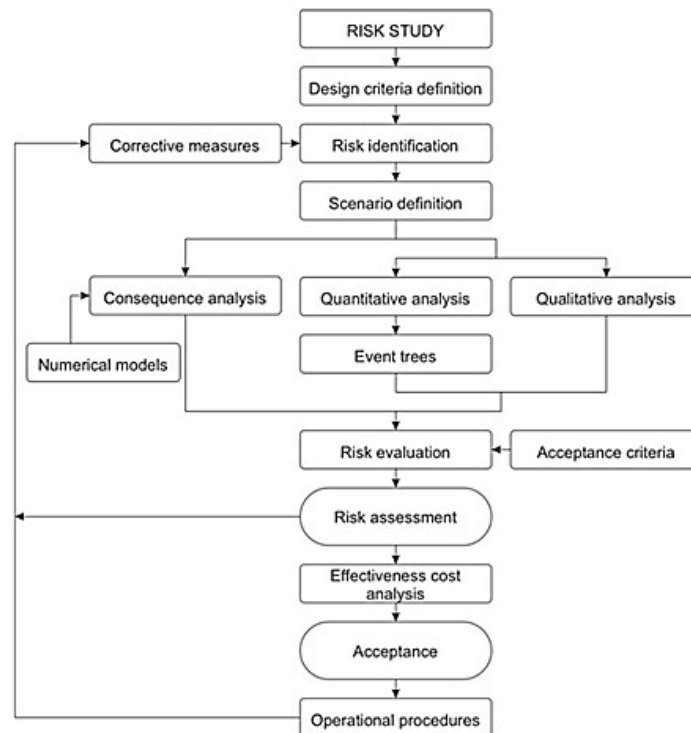


Figure 3. Navigation risk management procedure.

Source: PIANC, 2014.

The PIANC method is a logical and systematic procedure that focuses on identifying all events that may result in a hazardous situation related to the navigation, manoeuvring, mooring and unberthing of ships in canals, as well as those related to water areas. Risk is defined here as the frequency of occurrence of a negative event, i.e. accident, incident, damage. It is calculated as the product of frequency and consequence, which is compared to the acceptance or rejection criteria. A decision must be made as to whether the risk is acceptable without taking any action or whether mitigating measures should be taken to reduce the risk to an acceptable level. Risk management comes down to minimizing losses and maximizing the safety, service, operability and any other economic or social benefits of the project. This model aims to identify a dangerous event and prevent its occurrence, and at the same time minimize damage if it does occur. Risk analysis is defined as part of the risk management process, which aims to systematically use all available information to determine the frequency with which various incidents may occur, as well as the scale of their consequences.

One of many examples is the Port of Geelong, which handles over 600 ships annually, using the PIANC model to use the TideCaster system, integrating numerical forecasts and local environmental data. This enabled, among other things, safe reception of larger ships, optimized traffic management, also considering changing tidal conditions and gradual increase in ship drafts, which was verified using high-precision GPS systems (PIANC Australia & New Zealand, 2018-2023).

2.1.6. Conditions for the use of methods used in the assessment of risk and safety of maritime navigation

Over the years, it has evolved in maritime transport to become an essential aspect of the approach used by practitioners or managers to assess the acceptability of risk in transport projects. In the past, numerous studies have been carried out in the field of navigation risk assessment, using both deterministic and probabilistic methods. In particular, the latter have evolved to take into account more complex scenarios, such as the stability of a ship after damage or the analysis of traffic in ports. Their development is based on historical data, simulations and models, enabling a more universal and precise assessment of threats in complex maritime systems, such as ports and ocean traffic. The appropriate choice of risk assessment method depends on the specificity of the system being analysed, as well as on the available data. Classical deterministic approaches are more suitable for local analysis where detailed data on hydrographic and navigation conditions are available. In turn, probabilistic methods are better suited for global analysis or in cases where data are incomplete or subject to high uncertainty. These methods have many applications in specific contexts and can effectively assess risk in a variety of settings based on available data (Vassalos, Mujeeb-Ahmed, 2021).

2.1.7. Application of Automatic Identification System (AIS) in navigation risk analysis and improvement of navigation safety

The AIS system provides precise data on the position, speed, course and identification of ships. This information is crucial for real-time identification of potential threats and long-term analysis. The literature highlights the use of AIS in many key areas. Huang et al. (2019) conducted an analysis of the risk of manoeuvring ships in approaches to ports, using data from the AIS system to study the movement trajectories of vessels. Thanks to this, they identified key critical points where the risk of collision is particularly high. Research has shown that AIS data can be used to generate dynamic risk maps to assist ship captains and the Maritime Traffic Control System (VTS) in decision-making. The study Lianbo Li et al. (2018) on ship collision risk assessment also use AIS data to analyse potential hazardous situations, such as reducing the distance between two ships, in real time. In this case, the VCRO (Vessel Collision Risk Index) model was used, which assesses the risk of collision based on AIS data. Historical AIS data is useful for identifying traffic patterns and accidents. They presented an example of such an application Goerlandt & Montewka (2015), who used the data to spatially analyse the risk of collisions in high-traffic areas.

Models based on AIS data also enable the determination of optimal routes for ships in real time, considering hydrometeorological conditions and the movement of other vessels. Zhou et al. (2024) used this approach to analyse global maritime accident trends, which enabled the development of dynamic risk reduction strategies in real time.

The global use of AIS data in risk analysis and improving maritime safety in recent years has led to significant innovations in predictive modelling and strengthening security measures. For example, modern approaches based on AIS data enable mapping vessel behaviour, analysing traffic density and predicting collision risk. A review of available research highlights the use of ship trajectory clustering (which means data analysis consisting of grouping the paths of moving vessels) and Bayesian networks in the assessment of navigational risks, including the detection of anomalies in ship traffic. These methods are particularly useful in complex marine environments such as high-traffic ports (Perkovič et al., 2024).

Liu J. et al. (2023) developed a safety analysis method that is based on a network model combining the causal factors of ship collisions with their mutual dependencies. The aim of the study was to determine which factors have the greatest impact on the risk of accidents. The study looked at 300 collision cases in Chinese waters, identifying 98 key factors that include aspects such as observation errors, inappropriate manoeuvres, miscommunication and inappropriate responses to changing navigation conditions. The study also considers other elements, such as weather conditions, technical failures, as well as human factors, which in combination may lead to an increased risk of collision. The use of the network model allowed for precise identification of their mutual dependencies. This allowed for a more precise determination of the role of individual factors, also considering those that, although less likely to cause accidents, have a large impact on their frequency.

Another example of the use of AIS data is a study conducted by Liu Z. et al. (2023) in which a selected sea area was analysed to identify zones with an increased risk of collision. The work identified key factors influencing the risk of collision, such as traffic density, vessel speed and mutual ship trajectories. Moreover, the effectiveness of the developed method was assessed compared to previously used approaches, demonstrating its higher precision in forecasting high-risk situations. Figure 4 shows the maritime traffic analysis area against the background of the map of the eastern China region. A map is visible showing vessel traffic density or potential collision risk, marked with colour intensity (shades of orange and red).

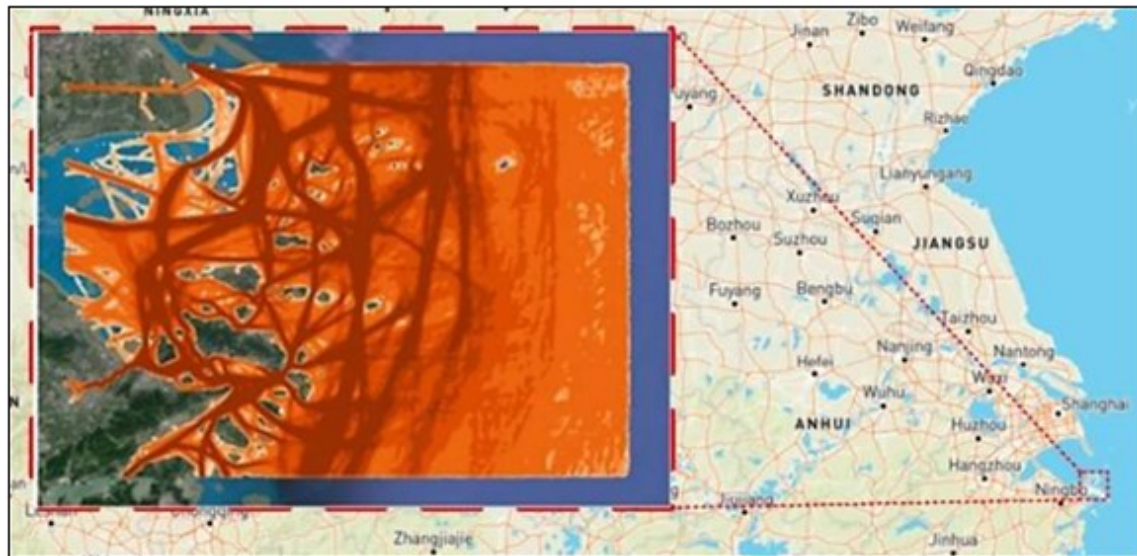


Figure 4. Maritime traffic analysis area against the map of the eastern China region.

Source: Liu, 2023.

2.2. Artificial intelligence in navigation risk analysis

Artificial intelligence is increasingly gaining importance in the risk modelling process, especially in areas requiring the analysis of large data sets and the identification of complex relationships. Chen et al. (2019) proposed probabilistic ship collision models, where, using ML algorithms, they were able to accurately predict the probability of events based on many variables, such as ship type, weather conditions and traffic intensity. Recognizing patterns in AIS data and other information sources allows for early detection of anomalies in ship traffic, which can indicate potential threats. Xue Yang et al. (2017) developed a framework for analysing the risk of ship activity, using AI to identify dangerous manoeuvres in ports. Systems such as Decision Support Systems are used in decision support systems for ship captains and VTS operators. Luo & Shin (2019) suggest that the integration of AIS data with AI algorithms can significantly improve the effectiveness of early collision warning and increases coordination in crisis situations. Artificial intelligence (AI) with AIS data supports real-time decision-making, which increases the effectiveness of predictive maintenance and the automation of safety procedures. AI-based systems analyse huge amounts of AIS data to detect potential threats and optimize ship routes. These types of solutions are used in smart-navigation technologies that improve maritime traffic management and minimize the risk of accidents (Perković et al., 2024).

Mostefa Mohamed-Seghir et al. (2021), in their research, discussed the use of artificial intelligence in preventing ship collisions. The use of AI to predict the risk of collision and optimize ship movements in real time was aimed at improving the safety of maritime navigation. They presented a model for ensuring safe navigation of ships in collision situations. This model considers parameters such as ship manoeuvrability, visibility conditions and the movement of objects in a collision situation. Techniques used - ACNN neural network (Anti-

collision Neural Network) the ACEA algorithm (Anti-collision Evolutionary Algorithm) – made it possible to determine the optimal trajectory of the ship, while ensuring minimum fuel consumption. The results showed that the ACEA technique is more effective in terms of energy savings, but ACNN provides faster computational time. The proposed methods can be used in decision support systems on ships and in applications related to robot movement. Using these methods, navigation systems can effectively avoid collisions while considering both safety and energy efficiency in real time.

2.3. Specificity of restricted water areas in the context of navigational safety

Limited water areas, such as narrow waterways, port channels or terminal approach waters, pose a particular challenge in managing navigation risk. Characteristic features of limited water areas include limited manoeuvring space, variable hydrometeorological conditions, and intense ship traffic. These features require precise planning and implementation of advanced risk analysis and management methods. This involves the need to consider several specific factors, i.e. hydrographic parameters (depth of waterways, width, presence of underwater obstacles and seabed configuration), the intensity of ship traffic, the presence of deep draft vessels and the variety of vessel types (e.g. container ships, ferries, passenger ships). Factors such as strong currents, variable winds, tidal variability and limited visibility due to fog or precipitation also influence it. Research work present a comprehensive risk analysis methodology for vessels crossing narrow waterways, considering an integrated approach to hydrographic, environmental and manoeuvring parameters. The research methodology is based on the analysis of ship movement trajectories, simulation models and assessment of safety criteria.

In order to estimate the safety of navigation on the fairways, it is necessary to determine the probability of an accident and its consequences (Gucma et al., 2022). In limited water areas, such as fairways, the risk is the possibility of damage occurring within a certain period of use (Chen et al., 2019) and is expressed as the product of the probability of an accident and the losses resulting from the accident. There are many methods that allow for a detailed assessment of navigation risk (Dhillon, 2022; Huang et al., 2019; Kite-Powell, Ozturk et al., 2019; Ozturk, Cicek, 2019; Patrician, 1998; PIANC, 1997; Rausand, 2013). In maritime transport, the Formal Safety Assessment (FSA) developed by the International Maritime Organization (IMO) is used to assess safety (PIANC, 1997).

Construction or modernization of waterways in a limited area and in the event of a change in the conditions of safe operation, the basic principle is to identify the threat (Chen, 2019; Gućma et al., 2020). Currently, two approaches are used to design the parameters of waterways and to determine the safe operation of ships on waterways, i.e. empirical methods and simulation methods (Rausand, 2013).

Deterministic or probabilistic methods make it possible to determine safe widths of ship manoeuvring areas (Rausand, 2013). These types of methods include, among others: PIANC (PIANC, 2014), CIRM (Gucma et al., 2015), Spanish (Pueros Del Estado, 2007), Japanese

(Japan Institute of Navigation, 2003) Canadian (Canadian Coast Guard, 1999) & USA CA (USACA, 2006, 2008). The selection of an appropriate empirical method is determined by criteria, i.e. the type of waterway, the manoeuvres performed on it, as well as its reliability and cost-effectiveness.

The simulation methods that are currently used are based on the construction of a non-autonomous real-time model, where the ship's movement is controlled by a navigator with unspecified qualifications. For this purpose, Full Mission Bridge Simulators (FMBS) are used. Unfortunately, the research methodology requires significant workload in connection with the construction of simulation models of ships and water areas, as well as conducting many real-time simulation experiments with an appropriately large number of manoeuvres performed by qualified navigators.

2.4. Integration of Human Reliability Analysis (HRA) and Organizational Safety Culture

In areas with high maritime traffic density, such as the Baltic Sea, and in particular in areas such as traffic separation schemes (TSS), port approaches, pilotage areas, and narrow waterways, navigation operations are characterized by strong temporal and functional coupling. Decisions are made by the navigator under time pressure, while processing multiple sources of information (ARPA, AIS, ECDIS, VHF) and under high cognitive load.

Research clearly shows that in such conditions, maritime accidents are rarely the result of a single “human error.” Much more often, they are the result of interactions between people, technology, procedures, and organizational conditions, which is consistent with modern models of systemic accidents (Reason, 1997; Leveson, 2011). Analyses of collisions in confined waters show the recurrence of factors such as ineffective communication, deficiencies in Bridge Resource Management (BRM), inadequate planning, and imperfections in organizational oversight (Abramowicz-Gerigk, 2019).

A key step in the development of human factors analysis is to take into account the concept of human performance variability. According to the Safety-II and resilience engineering approaches, people constantly adapt their actions to current conditions, and this adaptability is the main reason why systems usually function correctly (Hollnagel, 2017). Performance variability only becomes a problem when it overlaps and resonates with other variabilities in the system, e.g., with a simultaneous increase in traffic intensity, deterioration of visibility, VHF communication overload, and crew fatigue. In such conditions, even routine activities can lead to dangerous situations. Functional Resonance Analysis Method (FRAM) One of the most commonly used tools for analyzing performance variability is FRAM – Functional Resonance Analysis Method (Hollnagel, 2017; Hollnagel, 2012). This method describes operations as a set of related functions, analyzes how the variability of one function affects others, allows the identification of conditions conducive to “functional resonance”.

The application of FRAM in the analysis of maritime collisions and port operations confirms its usefulness in areas with high traffic density (Patriarca et al., 2020). Performance variability is a natural link between human factors and organizational safety culture, as it is the organization that sets the boundaries of safe adaptation.

The primary formal tool for safety management in shipping is the Safety Management System (SMS) implemented in accordance with the ISM Code (IMO, 2018). Although ISM provides a consistent organizational framework, numerous studies indicate that its effectiveness depends on the quality of implementation rather than the mere existence of procedures. Scientific publications show that key elements of safety culture in shipping include:

- leadership and management commitment,
- a culture of reporting and learning,
- the relevance of procedures to “real work”,
- competence and training management,
- fatigue management (Teperi et al., 2019; Arslan et al., 2016).

2.5. Practical use of the results of the analysis of methods and models for maritime assessment and safety

The practical use of the analysis of maritime navigation risk and safety assessment methods may become crucial in future port expansion projects, such as those implemented in Świnoujście and Gdańsk. In the context of the development of container terminals, it is important to conduct a detailed assessment of navigational safety on the waterways leading to these terminals. Risk analysis, using both methods, will enable the identification of potential threats related to ship traffic, including collisions and other navigation incidents. The practical application of these methods allows the development of effective risk minimization strategies, which is particularly important in areas with high maritime traffic. As part of planned investments, such as the construction of new quays or fairways, the assessment of navigational safety is important to ensure safe and effective ship operation. The implementation of these analysis will also enable the adaptation of port infrastructure to change operational conditions, ensuring adequate manoeuvring space and minimizing the risk of congestion or collisions.

In the port area of Świnoujście, the expansion of the container terminal required the use of simulations of the movement of large vessels and an analysis of the impact of the depth of the waterway on their manoeuvring ability. In the analysis of the expansion of the port in Gdańsk, probabilistic models for assessing the risk of collision and grounding were used, using AIS data and historical navigation events (Gucma et al., 2022).

Modern technologies that support risk management are becoming more and more important. The best example of this is VTS systems (Vessel Traffic Services), which integrate AIS data with other sources, enabling dynamic traffic management. In addition, the previously mentioned developing artificial intelligence helps predict potential events, such as units passing too closely or the risk of leaving the track.

3. Future research directions in risk analysis in maritime transport

Research on risk management in maritime transport is constantly evolving, adapting to new challenges related to increasing ship traffic, changing environmental conditions and the development of new technologies. Modern research increasingly indicates the need to integrate traditional risk analysis methods with modern approaches based on advanced technology. Development based on balance is becoming one of the key challenges in risk management in maritime transport. Liu & Frangopol (2018) highlighted the need to integrate risk with environmental impact assessment. In the context of maritime transport, this means that risk analyses should consider not only technical and operational issues, but also the impact on the natural environment, as well as the sustainable development of the maritime transport industry. Research should focus on the impact of marine accidents on the marine environment, research should focus on developing models that combine classic risk analysis with the assessment of potential impacts on the marine environment, but also new capabilities of artificial intelligence. Modern research should also enable the implementation of solutions that reduce the risk of maritime accidents while minimizing the negative impact on the natural environment. An example may be the development of ships powered by alternative fuels or traffic management systems that allow for the optimization of routes and reduction of pollutant emissions. The risk analysis should also consider aspects of sustainable port development, including water resources management, impact on marine flora and fauna, as well as the reduction of noise and other negative effects of port activities. It is also noted that the use of Big Data analysis in risk management in maritime transport has become the subject of intensive research. Luo & Shin (2019) emphasize the need to further develop big data analysis methods to better understand maritime accident patterns and their causes. The current approach to risk analysis, particularly in the context of maritime accidents, is increasingly dependent on the ability to process large amounts of data in real time. Vessel traffic monitoring systems (AIS and VTS) provide enormous amounts of information that can be used to identify risk patterns. The use of appropriate algorithms may enable the prediction of potential accidents based on the analysis of the behaviour of navigation units in various conditions. The collection and analysis of weather data can be crucial in predicting the risk of collisions or other hazards associated with manoeuvring ships. The use of big data methods in real time allows for preventive actions to be taken. Forecasting models based on the analysis of data from AIS, port sensors or satellites significantly shorten the response time to dangerous situations. It is worth adding that the use of historical data on maritime accidents allows the development of preventive risk management strategies. Using artificial intelligence to analyse past accident patterns will help improve future prevention.

4. Results

Literature analysis shows that information received from AIS has become a key tool in navigation risk analyses. They enable monitoring the situation in real time, identifying threats and making decisions about course changes in the event of impending collisions. The use of this data in risk analysis enables better prediction and prevention of incidents in maritime waters. Another conclusion that comes to mind is the role of computer simulations in risk assessment. Mathematical models allow the generation of many possible collision scenarios and other navigation events, which allows for risk assessment in various conditions and on various sections of waterways.

Another key insight is the need to integrate new technologies, such as artificial intelligence and automated systems, in the navigation risk assessment process. New AI technologies enable more precise monitoring of the situation on the fairways and quick decision-making in response to changing navigation conditions. One significant limitation is the availability of accurate AIS data, which may be limited to selected areas or time periods. In regions with weaker marine monitoring infrastructure, this data may be incomplete or outdated, which affects the accuracy of risk analysis performed. Although new technologies such as artificial intelligence offer promising opportunities, their implementation in navigation systems requires large investments in infrastructure and specialized training for personnel responsible for monitoring navigation safety.

Research should be focused on further development of AIS data analysis algorithms and their integration with other monitoring systems. This would help in obtaining more accurate and faster results in risk analysis. Another important direction of research should be the development of more advanced methods for optimizing shipping routes aimed at minimizing the risk of collisions and improving the efficiency of maritime transport. The development of artificial intelligence in risk assessment has the potential to contribute to more precise threat forecasting and faster decision-making in real time.

It is also suggested to study the impact of changing atmospheric and hydrological conditions on navigation safety, which will support the development of more flexible risk assessment models in the face of a changing climate.

A summary of the advantages and disadvantages of various navigation safety assessment methods, presented in the table, allows for a comprehensive comparison of the techniques used. Each method has its strengths, such as analysis accuracy, predictive capabilities and practical application in specific conditions, but also limitations, such as computational complexity or limited access to data. By taking these aspects into account, a method suitable for specific needs and operational conditions can be effectively selected, thereby increasing the effectiveness of navigation safety systems. Attention should also be paid to the variety of available methods for assessing navigational risk and safety, which vary in accuracy, complexity and practical

application. (Table 1). The selection of an appropriate method depends on the specificity of the analysed area, data availability and the goals to be met by the monitoring system. Each method, despite its limitations, makes a significant contribution to improving the effectiveness of navigational safety activities.

Table 1.

Juxtaposition of methods for assessing maritime navigation safety

Methods for assessing the safety of maritime navigation	Advantages	Disadvantages	Application
Matrix method	- Simple and intuitive. - Easy to use (in case of limited data). - Visualization using a table allows you to quickly assess the situation.	- Limited accuracy when analysing complex systems. - Failure to consider the dynamics of variables over time.	Risk assessment in simple operations such as shipping route planning or local hazard analyses.
Logical tree method	- Allows you to analyse the causes and effects of events. - Good for identifying potential system failures. - Useful in decision analysis.	- Focuses on one-off events, ignoring the complexity of dynamics. - Requires detailed input.	Identification of the risk of failure of navigation devices and communication systems.
Simulation method	- Analysis of complex scenarios in dynamic conditions. - Enables you to predict the consequences of various decisions in real time. - Accounts for uncertainty in mathematical models (e.g. Monte Carlo simulations).	- High technical and computational requirements. - Highly dependent on the quality and quantity of input data.	Analysis of collision scenarios, optimization of shipping routes, assessment of the impact of environmental variables on safety.
Formal Safety Assessment (FSA)	- Standard recommended by IMO (International Maritime Organization). - A comprehensive approach including threat identification, risk assessment, and risk minimization strategies. - Allows you to combine qualitative and quantitative analyses.	- Time-consuming and expensive - Requires advanced technical knowledge and large data resources.	Comprehensive security assessment of operations in ports and shipping lanes, analysis of maritime security policies.
Navigation risk model recommended by IALA	- It considers both qualitative and quantitative assessment. - Suitable for analysing the safety impact of navigation infrastructure. - Supported by the international organization IALA.	- May require advanced knowledge and specialized software. - Time-consuming data collection process.	Assessment of the impact of infrastructure such as lighthouses and buoys on navigational safety.
PIANC risk assessment model	- Detailed risk analysis on inland waters and ports. - Takes into account the specificity of local hydrographic and navigation conditions. - Adapted to the needs of planning and development of water infrastructure.	- It mainly focuses on specific aspects of risk, which may limit its use in global analyses. - Requires local hydrographic and navigation data.	Risk assessment in port and water infrastructure projects, optimization of shipping development plans.

Source: Own work based on the analysis of methods and tools for maritime safety assessment.

As a result, matrix and logic tree methods are simple to use but limited in precision, while simulation and FSA methods offer more advanced and comprehensive analysis but require more resources and advanced technology. IALA and PIANC models are used in specialized analyses related to infrastructure and local navigation conditions.

5. Discussion

The conducted literature analysis on methods that ensure maritime safety is crucial for the practical implementation of these methods in navigational safety management. The article compares deterministic and probabilistic approaches, but the comparison is largely descriptive. From a practical point of view, this is important. Reference should be made to those methods that have clearly defined criteria, such as input data requirements, the ability to take uncertainty into account, computational cost, interpretability of results, and suitability for water bodies subject to spatial or organizational constraints. Deterministic approaches are generally simpler to implement and less computationally demanding, while probabilistic methods allow for a more realistic description of the variability of traffic and environmental conditions, resulting in greater complexity. Most of the methods currently used to assess navigational hazards, especially in confined waters, are based on data from the AIS system, which, although made available by some national administrations, often contain millions of vessel positions, and databases containing information on ship traffic in a selected area over several years, with sufficient position density, can exceed one billion records. The accuracy of this data varies, as described by Wawruch, R. (2018) - description of errors and AIS data reliability or by Harati-Mokhtari, A., Wall, A., Brooks, P., & Wang, J. (2007). - Analysis of errors in static and dynamic data. Despite the wide range of tools available, including collision risk analysis, probabilistic models, and computer simulations, their practical application requires adaptation to the specific conditions of each area, such as maritime traffic intensity, geographical characteristics, and port infrastructure. The practical application of the methods discussed in the article in port expansion projects, such as those in Świnoujście and Gdańsk, can significantly improve shipping safety. The use of AIS data and advanced mathematical models enables precise monitoring of conditions on the fairways, identifying potential threats, and developing effective collision avoidance strategies. However, it is worth noting that despite mentioning human factors, most analyses focus mainly on technical aspects. Variability in human performance, decision-making under time pressure, and the influence of organizational safety culture are rarely systematically included in risk assessment models. Meanwhile, many maritime incidents are caused by human error and organizational conditions, so greater consideration of the human reliability analysis perspective could significantly increase the application value of the methods discussed. The implementation of such tools in real conditions allows for optimizing the

development of port infrastructure, taking into account changing operational conditions and ship traffic. However, as research in this area indicates, there is still a need for further improvement in risk analysis methods and the integration of new technologies, such as artificial intelligence or automated systems, which can significantly enhance the efficiency of maritime traffic management in real time. It is also important to note that the effective implementation of these methods requires cooperation between various institutions, including ports, maritime administrations, and navigation companies. The conducted research shows that the integration of theoretical approaches with real data and technologies can contribute to a significant improvement in navigational safety, thereby minimizing the risk of accidents at sea. A review of the literature indicates that hybrid approaches are the most effective, but there is no systematic synthesis of these approaches in the literature. Based on the analyses conducted, typical combinations of methods can be identified, such as AIS-based traffic monitoring combined with probabilistic modeling and computer simulations, supplemented by decision support systems within VTS services. Such “packages” are particularly useful in port areas and waters with high traffic intensity, while simpler hybrid configurations may be sufficient in less complex conditions.

6. Conclusions

The topicality and originality of the issues raised regarding maritime safety methods are crucial, especially in the context of dynamically growing maritime traffic, the development of large ports and new threats related to technology and climate change. Research focuses on increasing navigation safety and reducing operational risk. Literature analysis indicates that innovative approaches, such as the integration of environmental data with random variable models, constitute a unique contribution to the development of this area and respond to current challenges. The analysis showed that there are many different risk assessment methods that can be used in the context of navigation safety. Risk assessment methods in navigation safety can be divided into deterministic methods and probabilistic methods, which differ in their approach to analysis and application in different contexts. An important conclusion is that effective navigation safety management requires a combination of both approaches, adapted to the specificity of a given situation and available data. In practice, a hybrid approach is often used that combines both approaches to obtain a more complete risk picture and effectively manage security. Increasing attention is being paid to improving navigational safety, which has led to the emergence of various tools and methods for assessing navigational safety. The literature analysis included an extensive review of foreign and domestic literature. The methods and tools used to assess maritime safety were thoroughly assessed and analysed. A review of the available literature provides a better understanding of the use and integration of method parameters in

individual risk assessments. Moreover, the information obtained from the analysis of available methods and tools for safety assessment allowed the identification of circumstances, trends and shortcomings of these techniques. It also allowed us to know what should be considered when estimating navigation risk on waterways. These include primarily:

- specificity of the reservoir,
- relatively heavy traffic,
- relatively high traffic intensity,
- many variables depending on current meteorological and hydrological conditions,
- specific manoeuvring of the ship, different knowledge of standard phrases used for communication at sea by those in charge of vessels on the move.

The results of the systematic literature review also indicate a gap in the literature regarding navigational safety assessment. All methods of risk assessment to ensure navigational safety discussed above have their advantages and disadvantages. Due to the large number of parameters, features, complexity of the marine environment (its nature), uncertainty and lack of information, there is no common ground to define risk. The most important aspect is the selection of a navigation safety estimation method that considers the most unlikely event scenario, while maintaining realistic assumptions regarding possible crisis situations.

In summary, the selection of appropriate and consistent safety risk assessment methods generally depends on each unique situation and area in which navigation is to be carried out.

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TRANSPORT EXCLUSION AND QUALITY OF LIFE IN NORTHERN PROVINCES: DIAGNOSIS AND MONITORING

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Purpose: The paper investigates the impact of transport exclusion on the quality of life for residents in the northern provinces of Poland, aiming to diagnose the problem, analyze leading causes, and present proposals for countermeasures. Improving quality of life through sustainable development and enhanced transport accessibility is a central focus for local government units.

Design/methodology/approach: The study employs an interdisciplinary approach, integrating economic, sociological, psychological, and ecological perspectives. It utilizes both subjective and objective quality of life indicators, with a standardized total and partial utility analysis applied to statistical data from public transport, infrastructure, and demographic sources. Four northern Polish voivodeships are compared using multidimensional indicator systems to measure transport development and exclusion.

Findings: Results reveal significant disparities in transport infrastructure and exclusion across the selected regions. The Pomeranian Voivodeship demonstrates the highest utility values (up to 6.83 in 2021), indicating superior transport infrastructure and accessibility, while Warmian-Masurian consistently records the lowest utility scores (as low as 1.99), reflecting higher transport exclusion. Key factors identified include road network density, railway lines, cycling infrastructure, and public transport services, which all contribute to regional differences in quality of life.

Research limitations/implications: Limitations include the availability and granularity of statistical data, and the challenge of integrating diverse indicator systems. Future research could expand the analysis to other regions or further refine the utility methodology for improved comparability and actionability.

Practical implications: The research suggests the need for targeted infrastructure investments, modernization of district and municipal road networks, expansion of public and alternative transport modes (rail, bicycle), and development of Park & Ride systems. Regions with inadequate infrastructure require interventions to reduce transport exclusion and improve mobility, impacting both local economies and residents' everyday lives.

Social implications: Enhanced transport infrastructure and accessibility support social inclusion, increase public safety, and improve access to education, employment, and services. The research informs public policy and strategic planning, potentially improving quality of life and supporting sustainable social development.

Originality/value: The paper introduces a repeatable, utility-based methodology for regional diagnosis of transport exclusion, providing actionable insights for policymakers, urban planners, and researchers to optimize regional development.

Keywords: quality of life, transport, sustainable development, usability.

Category of the paper: Research paper.

1. Introduction

The primary goal of local government development is to improve the quality of life of society, but this quality must be considered in close connection with the principles of sustainable development. Quality of life is a multidimensional area of scientific research, encompassing both objective aspects, such as economic, infrastructural, and environmental conditions, as well as subjective aspects related to individual well-being and life satisfaction. Therefore, analyzing quality of life requires an interdisciplinary approach, integrating economic, sociological, psychological, and ecological perspectives. The use of appropriate indicators and analytical methods is crucial for the accurate interpretation of research results. However, the large number of indicators, as well as the complexity and limited availability of some data, remain challenges. To address this challenge, approaches such as total and partial utility analysis are used, which enable a transparent and comprehensive presentation of sustainable development research results. This enables the effective use of data to formulate public policies and development strategies at the local and regional levels.

Implementing strategic national and international policy goals determines regional development at the voivodeship level. Sustainable development priorities should be aligned with strategic documents such as the Europe 2020 Strategy, the Poland Sustainable Development Strategy until 2025, the Poland 2030 Strategy, and the National Environmental Policy. Another key factor affecting quality of life is transportation exclusion (Pucher, Buehler, 2012), which limits social and economic mobility and hinders access to education, the labor market, and public services. Therefore, eliminating transportation barriers should be a priority for local government policy, thus supporting sustainable socioeconomic development and improving residents' quality of life.

2. Quality of life and communication exclusion

The issue of quality of life is widely discussed in the scientific literature and is the subject of analysis in various research contexts. This topic has been approached, among others, from an economic perspective, examining the impact of income, employment, and living standards on the well-being of individuals and communities. Psychology has focused on subjective indicators such as life satisfaction, happiness, and fulfillment. Meanwhile, sociology and the social sciences have emphasized the role of interpersonal relationships, social capital, and demographic structures as significant determinants of quality of life (Komornicki, 2020). Reflections on the existential dimension of well-being have also been undertaken in theology, philosophy, and the humanities. Meanwhile, mathematical, medical, and technical sciences have provided tools for quantifying and modeling changes in quality of life.

Despite the extensive research on quality of life, a clear and universally accepted definition of this concept has yet to be developed. Differences in interpretation stem from the adopted theoretical frameworks – some concepts emphasize hedonistic aspects and happiness, others emphasize the availability of resources and material conditions, and others emphasize the fulfillment of basic human needs (Lucas, 2012). However, a common element of these approaches is the belief in universal methods and tools enabling quantitative and qualitative assessment of the quality of life. This analysis most often utilizes sustainable development indicators, which, when monitored over time, allow for assessing the dynamics of socio-economic and environmental changes. Transport exclusion is a social phenomenon that can significantly impact the quality of life of individuals and social groups. Quality of life refers to the subjective assessment of an individual's life, considering health, financial conditions, access to education, work, social services, and the ability to participate in social life (Kowalski, 2021). On the other hand, transport exclusion refers to difficulties in fully and effectively participating in communication processes, including a lack of access to technology and problems with understanding or communicating information.

Transport exclusion in the context of transport refers to difficulties in accessing means of transport, both public and private, which affect the mobility of people and goods. This phenomenon particularly affects people in rural areas, less developed regions, or so-called transport "dead zones" (Zielińska, 2021), whose infrastructure is insufficient or underdeveloped.

Transport infrastructure in the context of sustainable development in selected cities in the northern voivodeships.

Podlaskie Voivodeship, one of Poland's 16 voivodeships, is located in the northeastern part of the country and borders Belarus and Lithuania. This region is critical regarding nature, sustainable development, and ecological and economic integration. Podlaskie Voivodeship has an area of 20,187 km², constituting approximately 6.5% of Poland's total area. The voivodeship

is inhabited by approximately 1.2 million people (as of 2021), making it one of the least populated voivodeships in Poland (Ślupik, 2016). Podlaskie Voivodeship is well connected to other regions of Poland thanks to a network of national and voivodeship roads, the A2 motorway, and the S8 expressway. Further infrastructure investments are planned to improve transport in the region. The voivodeship is well connected by rail, with significant connections to Warsaw, Gdańsk, Olsztyn, and neighboring countries (Belarus, Lithuania). Air transport: The airport in Białystok (Kryniewice airport) serves domestic and international connections, although air traffic in the region is less intense than in other parts of Poland (Kopeć, 2014).

The Pomeranian Voivodeship is located in the northern part of the country, on the Baltic Sea. It is a region of significant economic, tourist, and cultural importance, with a well-developed transport infrastructure and a strong economy based on services, industry, tourism, and agriculture (Bąk, M., 2019). It borders the Kuyavian-Pomeranian Voivodeship, the West Pomeranian Voivodeship, and the Warmian-Masurian Voivodeship. It has access to the Baltic Sea to the north and west. The Pomeranian Voivodeship has a population of approximately 2.4 million (as of 2023), making it one of the most populous voivodeships in Poland. The Pomeranian Voivodeship has a well-developed road network, including the A1 and A6 motorways and the S6 and S7 expressways. The A1 connects Gdańsk with Łódź and southern Poland, enabling efficient communication with other regions of the country. Pomerania has a well-developed railway network, with main connections between Gdańsk, Gdynia, Sopot, and other large cities in Poland. The Gdańsk-Warsaw railway line is one of the key connections (Letkiewicz, Szulc, 2022). Gdańsk Lech Wałęsa Airport is one of the largest airports in Poland, serving domestic and international connections. Gdynia also has an airport, although of lesser importance. The ports in Gdańsk and Gdynia are crucial for transporting goods in the region and global trade. Gdynia is also a center for passenger shipping.

The Warmian-Masurian Voivodeship, located in the northeastern part of Poland, is one of the most beautiful regions of the country, known for its natural wealth, numerous lakes, and green areas (Nowak and Wiśniewska, 2022). This region combines agricultural, industrial, and tourist traditions, emphasizing sustainable development and environmental protection. The Warmian-Masurian Voivodeship has an area of 24,192 km², making it one of the largest voivodeships in Poland (approximately 7.7% of the country's area). It borders the following voivodeships: Pomerania, Masovia, Podlaskie, and the Kaliningrad Oblast of the Russian Federation. The Warmian-Masurian Voivodeship is inhabited by approximately 1.4 million people (as of 2023), making the region relatively less densely populated than other voivodeships in Poland.

It's worth noting that the voivodeship is connected to other parts of Poland via a network of national roads, including the S7 expressway (Warsaw-Gdańsk). The region also boasts a network of regional roads connecting smaller towns with larger cities. The Warmian-Masurian Voivodeship has a railway network connecting Olsztyn with other Polish cities,

including Warsaw, Gdańsk, Bydgoszcz, and Poland's eastern border. Olsztyn-Mazury Airport is the main airport in the region, serving both domestic and international connections. It is also a major passenger transport hub for tourists.

The West Pomeranian Voivodeship is located in the country's northwestern part, on the Baltic Sea. This region is strategically vital to Poland economically, touristically, and culturally. It is characterized by an extensive transport infrastructure, a strong maritime sector, and a dynamically developing economy. The West Pomeranian Voivodeship has an area of 22,892 km², constituting approximately 7.4% of Poland's total area. It borders Germany to the west, the Pomeranian Voivodeship to the east, and the Lubusz and Lower Silesian Voivodeships to the south. In the north, the region has access to the Baltic Sea. The West Pomeranian Voivodeship has a population of approximately 1.7 million (as of 2023). The West Pomeranian Voivodeship has a well-developed road network. The A6 motorway and expressways (S3) connect the voivodeship with other parts of Poland and Germany. West Pomerania also has a well-developed railway network, connecting Szczecin with other Polish cities, including Warsaw, Wrocław, and Poznań. There are also international connections with Germany (Kogut-Jaworska, Wankiewicz, 2018). Air transport: Szczecin-Goleniów Airport is the main airport in the region, offering domestic and global connections.

Additionally, the airport in Świnoujście serves smaller regional connections. The ports in Szczecin, Świnoujście, and Kołobrzeg are crucial for the maritime transport of goods and passengers. The primary tool for defining detailed goals and actions, aimed primarily at achieving fully sustainable development, but also helping to develop appropriate patterns, is development strategies. All of the surveyed voivodeships have adopted development strategies:

- Podlaskie Voivodeship Development Strategy 2030,
- Pomeranian Voivodeship Development Strategy 2030,
- Warmian-Masurian Voivodeship 2030. Socio-economic Strategy,
- West Pomeranian Voivodeship Development Strategy 2030.

This defines the concept of the voivodeships' functioning over several to a dozen or so years (Chen, 2021). The overarching development goal at every level of local government is a high quality of life, and the implementation tool is a strategy that forms the basis for regional development policy. Quality of life can be considered the result of actions undertaken by local government authorities (Augustyn, 2020). The Podlaskie, Pomeranian, Warmian-Masurian, and West Pomeranian voivodeships were selected for analysis because they represent diverse infrastructural, geographic, and socio-economic conditions in northern Poland. These regions encompass highly urbanized and economically well-developed areas (e.g., Pomerania, West Pomerania) and areas with lower population density and limited transport services (e.g., Warmian-Masurian, Podlaskie). This allows for identifying differences in the level of transport exclusion and assessing the impact of transport infrastructure on residents' quality of life in the context of sustainable development.

3. Sustainable development indicators as a tool for examining the quality of life in the aspect of communication exclusion

The concept of sustainable development is associated with constant challenges, activities, and constantly changing processes. Achieving this goal requires effective management and monitoring of ongoing activities. Implementing strategies, development plans, and programs allows for achieving sustainable development goals.

Indicators are a key tool in assessing progress, enabling the monitoring and analyzing ongoing tasks. Concepts such as indicator, measure, variable, characteristic, or category describe, estimate, and define selected phenomena. There is no accepted definition of an indicator in the literature – it is often used interchangeably with a measure (Andrews, Caldera, Johansson, 2013). Furthermore, there are inconsistencies in distinguishing the concepts of an indicator and an index. An indicator, expressed as an absolute or relative number (e.g., the percentage ratio of the analyzed values to the adopted base), describes the level of a given phenomenon and is an essential element of statistical analysis.

The use of indicators as information carriers has become widespread due to their multidimensionality, availability, unambiguity, and the possibility of comparing data. Many indicators and their sets are used to assess the development of voivodeships in the context of sustainable development (Razmjoo et al., 2021).

However, it is worth considering the readability and ease of analysis of many indicators used to monitor the quality of life (Kaniowski et al., 2025). An overly complex analysis can pose a challenge for local government employees. Therefore, research should focus primarily on developing indicators that will find practical application in the management of local government units (Xinyi Wang et al., 2021).

2.1. Usability as a tool for measuring communication exclusion as an element of quality of life

A system for monitoring the implementation of activities defined in development strategies should be a key management tool, enabling effective planning, optimal resource allocation, systematic evaluation, and adaptation of undertaken actions to dynamically changing socio-economic conditions. This process should be based on a standardized and repeatable methodology, ensuring high-quality analysis and comparability of results (Dol, Haffner, 2010).

The total and partial utility method enables a transparent and unambiguous assessment of the degree of implementation of the analyzed activities. With a properly selected set of indicators, this method is highly readable, and the interpretation and presentation of results become more transparent and objective.

Using sustainable development indicators within this method allows for determining the total utility of the analyzed voivodeships. Precise classification of the functions of individual indicators is crucial. They can serve as:

- stimulants (an increase in their value indicates a positive phenomenon),
- destimulants (an increase in their value is unfavorable). This analysis utilizes stimulants (stimulants) and destimulants (regressors), enabling a precise assessment of the impact of individual factors on the development of the analyzed territorial units. Partial utility determines the relative value of a given sustainable development indicator for the analyzed city about the value of that indicator in other towns (Alpopi, Iacoboaia, Stănescu, 2011). Its value is calculated individually for each indicator according to a specific mathematical formula:

$$U_{ij} = \frac{C_{ij} - C_j^0}{C_j^1 - C_j^0} \quad (1)$$

where:

U_{ij} - partial utility of city i relative to indicator j ,

C_{ij} - value of sustainable development indicator j for voivodeship i ,

C_j^0 - the lowest (for a sustainable development stimulant) or the highest (for a sustainable development destimulant) value of sustainable development indicator j among the surveyed voivodeships,

C_j^1 - the highest (for a sustainable development stimulant) or the lowest (for a sustainable development destimulant) value of sustainable development indicator j among the surveyed voivodeships.

The partial utility value takes values from the range $[0, 1]$, where zero corresponds to the lowest level achieved by the voivodeship in a given indicator, and 1 indicates the highest – i.e., the reference value among the analyzed units. Therefore, a higher partial utility value indicates a better level of implementation of a given aspect of sustainable development.

The total utility is calculated using the following formula:

$$G_i = \sum_{j=1}^n U_{ij} \quad (2)$$

The value of total utility depends not only on the values of the partial utilities, but also on the Number of indicators analyzed, as the highest possible value of total utility is equal to the sum of the indicators considered.

The total utility value depends not only on the values of the individual partial utilities, but also on the Number of indicators considered. It should be noted that the maximum value of total utility equals the sum of the values of all analyzed indicators.

This study calculated total and partial utilities for five indicators related to environmental governance, which undoubtedly contribute to improving the quality of life. A detailed list of indicators and their calculated utilities is presented in the table.

Indicators that best illustrate changes in transport exclusion regarding quality of life were selected for this study. The availability of current statistical data also determined the selection of these indicators. Among the destimulating indicators are: Fatalities per 100,000 inhabitants. Vehicles [person], while the stimulants were defined as: Total public roads per 100 km² [km], Passenger transport per capita [person], Number of passenger cars [pcs], Total railway lines per 10,000 population [km], Share of county and municipal roads with dirt surfaces in the total length of these roads [%], Bicycle paths per 10,000 population [km], Length of public transport lines per 1000 inhabitants [km], Number of Park & Ride parking lots [pcs].

Table 1.

Total and partial utility values of the surveyed voivodeships in 2020-2023

Voivodeship /indicator	Podlaskie	Pomorskie	Warmińsko-mazurskie	Zachodnio-pomorskie
2020				
Total public roads 100 km ² [km] - S	1	0,84	0,09	0
Passenger transport per capita [person]- S	0,07	0,89	0	1
Number of passenger cars [pcs] S	0	1	0,48	0,93
Total railway lines per 10 thousand population [km] - S	0,45	0	1	0,68
Fatalities per 100,000 vehicles [person] - D	0,77	0,54	0	1
Share of district and municipal roads with dirt surfaces in the total length of these roads [%] - S	1	0,34	0,45	0
Bicycle paths per 10,000 inhabitants [km] - S	1	0,96	0	0,85
Length of public transport lines per 1000 inhabitants [km] - S	0,60	1	0	0,40
Number of parking lots in the Park & Ride system [pcs.] - S	0	1	0	0,2
Total utility	4,89	6,57	2,02	5,06
2021				
Total public roads 100 km ² [km] - S	1	0,77	0,11	0
Passenger transport per capita [person]- S	0,49	1	0	0,89
Number of passenger cars [pcs] S	0	1	0,51	0,95
Total railway lines per 10 thousand population [km] - S	0,53	0	1	0,71
Fatalities per 100,000 vehicles [person] - D	0,18	1	0	0,65
Share of district and municipal roads with dirt surfaces in the total length of these roads [%] - S	1	0,26	0,43	0
Bicycle paths per 10,000 inhabitants [km] - S	1	0,80	0	0,88
Length of public transport lines per 1000 inhabitants [km] - S	0,67	1	0	0,50
Number of parking lots in the Park & Ride system [pcs.] - S	0,04	1	0	0,18
Total utility	4,91	6,83	2,05	4,76
2022				
Total public roads 100 km ² [km] - S	1	0,63	0,15,	0
Passenger transport per capita [person]- S	0,54	1	0	0,87
Number of passenger cars [pcs] S	0	1	0,51	0,96
Total railway lines per 10 thousand population [km] - S	,0,55	0	1	0,69
Fatalities per 100,000 vehicles [person] - D	0,19	1	0	0,84
Share of district and municipal roads with dirt surfaces in the total length of these roads [%] - S	1	0,05	0,45	0
Bicycle paths per 10,000 inhabitants [km] - S	0,79	0,61	0	1

Cont. table 1.

Length of public transport lines per 1000 inhabitants [km] - S	0	1	0	0,33
Number of parking lots in the Park & Ride system [pcs.] - S	0	1	0,03	0,17
Total utility	3,52	6,29	1,99	4,86
2023				
Total public roads 100 km ² [km] - S	1	0,45	0,13	0
Passenger transport per capita [person]- S	0,18	1	0	0,92
Number of passenger cars [pcs] S	0	1	0,50	0,96
Total railway lines per 10 thousand population [km] - S	0,7	0	1	0,67
Fatalities per 100,000 vehicles [person] - D	0	1	0,40	0,46
Share of district and municipal roads with dirt surfaces in the total length of these roads [%] - S	1	0	0,48	0,03
Bicycle paths per 10,000 inhabitants [km] - S	0,83	0,63	0	1
Length of public transport lines per 1000 inhabitants [km] - S	0,33	0,67	0	1
Number of parking lots in the Park & Ride system [pcs.] - S	0	1	0,08	0,46
Total utility	4,04	5,75	2,59	5,5

The analysis was based on the most complete statistical data available for years. Table 1 lists nine indicators, so the hypothetical highest total utility value is 9; none of the analyzed voivodeships achieved this (maximum) value. Significant disparities exist between the analyzed cities (1.99-6.83). The highest total utility value was observed in 2021 in the Pomeranian Voivodeship (6.83). The lowest utility values were observed in the Warmian-Masurian Voivodeship in 2022, reaching 1.99. In the remaining voivodeships, utility values ranged between the Podlaskie Voivodeship (4.91-3.52) and the West Pomeranian Voivodeship (5.5-4.76).

To comprehensively analyze the obtained results, it is necessary to relate the total utility values of individual voivodeships to a reference value, referred to as the reference vector. This vector serves as a reference point, representing the highest possible rating a given voivodeship could achieve within the adopted set of criteria. Its numerical value is defined by the sum of the maximum ratings assigned to each analyzed indicator. This comparison allows for determining the degree of compliance between actual results and the ideal model and identifying areas requiring intervention to optimize the analyzed parameters further. In the case of the analysis of nine indicators, the benchmark vector is 9.

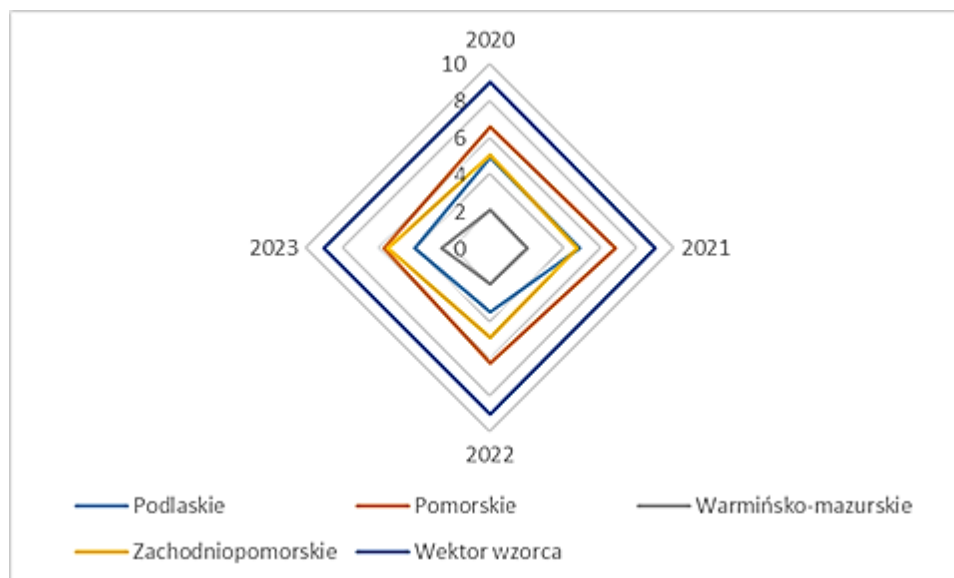


Figure 1. Total utility value compared to the benchmark vector.

Source: own study

The Pomeranian Voivodeship exhibits the highest values, close to the 6-7 range, which places it closest to the benchmark and indicates its relatively highest quality for the analyzed parameter. Values in the West Pomeranian Voivodeship range around 4.7-5.5, while the Podlaskie Voivodeship exhibits lower values, ranging from 3.5-4.9. The lowest values were recorded in the Warmian-Masurian Voivodeship, where values were around 2.

Analysis of time trends indicates that the Pomeranian Voivodeship remains at the highest level for most years, although a slight decline was observed in 2023. The West Pomeranian Voivodeship is characterized by an initial decrease in values in 2021, followed by an increase. The Podlaskie Voivodeship recorded a decline in 2022 with a subsequent rebound, while the Warmian-Masurian Voivodeship maintained relatively stable and low values, with a slight increase in 2023.

In summary, the Pomeranian Voivodeship stands out as the best in terms of the analyzed indicator, consistently achieving the highest results throughout the study period. The remaining voivodeships show lower values and a significantly greater distance from the adopted benchmark, which may indicate the need for further action to improve their results.

Voivodeships characterized by low road infrastructure usability, such as the Warmian-Masurian Voivodeship and the West Pomeranian Voivodeship, require priority modernization of their district and municipal road networks. Asphaltting existing dirt surfaces is particularly important, significantly improving road accessibility and user comfort. Furthermore, increasing the density of the public road network per unit area will shorten distances to key service points, positively impacting residents' mobility in these regions. In parallel, passenger and public transport options should be developed, especially in voivodeships with low per capita ridership, such as Podlaskie and Warmińsko-Mazurskie. Expanding urban and inter-municipal transport connections, particularly in rural and peripheral areas, along with the introduction of more

frequent services, better connections with other modes of transport, and modern information solutions, such as mobile apps with timetables, is a necessary step towards increasing the attractiveness of public transport. Increasing the availability of discounted tickets and promotions is also essential to encourage residents to use these services.

Voivodeships with high road fatality rates should focus on intensifying preventive and educational initiatives aimed at all road users, including drivers, pedestrians, and cyclists. Safety campaigns and training, along with modernizing dangerous road sections by introducing additional signage, speed bumps, lighting, and safety barriers, aim to reduce the number of accidents and fatalities. Considering increased traffic police patrols and implementing monitoring and automatic enforcement systems is essential to the safety improvement strategy.

In the context of developing cycling infrastructure, regions with a low number of cycle paths per 10,000 inhabitants, such as the Warmian-Masurian Voivodeship, should plan and implement a network of safe, coherent, and well-marked cycle routes that will connect residential areas with places of work, education, and recreation. Introducing bicycle subsidy programs and promoting cycling as a healthy and ecological transport alternative can significantly increase the share of this mode of transport. Integrating cycling infrastructure with public transport, for example, by installing bicycle racks at stations and stops, further enhances the functionality of the transport system. Expanding the Park & Ride (P&R) system is a key element in improving urban mobility. Voivodeships with a few P&R parking lots should plan the location of new parking lots on the outskirts of cities and at transportation hubs to encourage drivers to leave their cars and use public transportation. Facilitating the integration of public transportation tickets with P&R services and introducing real-time information systems on parking space availability are critical solutions supporting this system. Promoting Park & Ride as an ecological way to reduce car traffic in city centers can improve residents' quality of life.

Voivodeships with a low ratio of railway lines per 10,000 inhabitants should consider investing in revitalizing and expanding local railway lines, which can provide a fast and environmentally friendly alternative to car transport. Supporting the integration of rail with other modes of transport, such as buses, bicycles, and cars, by creating multimodal transfer hubs allows for efficient transport infrastructure. Establishing a system for regular, annual monitoring and analysis of infrastructure utility indicators in individual voivodeships is also essential. Such activities will enable the rapid identification of trends and areas requiring intervention and the optimization of financial allocation for infrastructure development and safety improvements.

Finally, supporting interregional cooperation, particularly promoting the exchange of experiences and best practices, as exemplified by the Pomeranian Voivodeship, can contribute to the more coherent and effective transport infrastructure development. Joint planning and implementation of transport projects fosters the harmonization of activities and the exploitation of regional synergies.

4. Conclusions

The analysis of partial and total utility for nine indicators related to transport exclusion allowed us to assess the degree of sustainable development of public transport and road infrastructure in selected voivodeships of northeastern and northwestern Poland in 2020-2023. The results indicate significant variation in the level of utility between the studied regions. The highest values of total utility were observed in the Pomeranian Voivodeship, which in 2021 reached a value of 6.83, closest to the benchmark value (9). Pomerania stands out for its favorable indicators regarding the length of public transport lines, the number of passenger cars, and the availability of the Park & Ride system, which indicates effective transport infrastructure management. In contrast, the Warmian-Masurian Voivodeship consistently recorded the lowest utility values (e.g., 1.99 in 2022), which may indicate significant transport exclusion and insufficient infrastructure and public transport development. The conclusions from the conducted research allow us to formulate several key observations:

- A high value of total utility is closely linked to a well-developed public transport infrastructure and low traffic hazards (destimulants).
- There is a clear need to redress regional disparities through investments in public transport, improved road accessibility, and the development of alternative modes of transport (bicycles, rail).
- Continuous monitoring of utility indicators can effectively manage regional development, enabling data-driven decision-making.

In summary, the analysis results confirm the thesis that the varying levels of transport infrastructure development in Poland impact the quality of life of residents and the degree of their transport exclusion. They also point to the need for a coherent, long-term transport policy based on indicator-based assessment of the effectiveness of public actions.

This method can therefore be an effective diagnostic tool for public policymakers, urban planners, and researchers of regional development.

5. Summary

Improving the quality of life remains the primary development goal of local government units, and its growth must be consistent with the principles of sustainable development. However, the lack of access to efficient means of transportation limits residents' social and economic functioning. This article aims to analyze the impact of transport exclusion on residents' quality of life in northern Poland's voivodeships. A diagnosis of the problem, its leading causes, and possible countermeasures are presented. The accessibility of public

transport is identified in the context of the region's demographic and geographic conditions, and proposals for transport policies aimed at improving the situation are presented.

As information carriers, indicators play a key role in analyzing and evaluating various aspects of voivodeship development. Their popularity stems from multidimensionality, accessibility, clarity, readability, and the ability to compare results across spatial and temporal contexts. Numerous indicators and comprehensive indicator systems exist that allow for assessing the degree of implementation of sustainable development objectives for local government units.

However, the growing number of indicators in use poses challenges related to their analysis, interpretation, and use in decision-making processes. Public and local government officials responsible for planning and monitoring city and district policies often encounter challenges related to analyzing large data sets and processing multidimensional indicators. Therefore, a key research issue is the selection of appropriate indicators and the development of tools enabling their practical use. The system for monitoring activities included in development strategies should serve as an advanced strategic management tool, enabling effective planning, rational allocation of financial resources, and ongoing assessment and optimization of undertaken activities in the context of dynamically changing socio-economic conditions. Using a standardized and repeatable evaluation methodology is crucial, ensuring consistency of analyses and enabling comparison of results over time and across space.

One approach used in the analysis of indicator data is the total and partial utility method, which transparently allows for the assessment of the degree of achievement of established strategic goals. Its use becomes particularly important when the analyzed set of indicators is extensive and multidimensional, as it allows for aggregating results and their more straightforward interpretation. The transparency and clarity of this method support decision-making processes, contributing to more effective management of the development of local government units.

Partial utility refers to the relative value of individual indicators about a specific voivodeship and its position relative to other units. This approach allows for identifying strengths and weaknesses in the analyzed area and identifying priority areas for intervention. As a result, implementing sustainable provincial/city policies can be more effective and tailored to actual socio-economic needs, particularly when monitoring the quality of life in local government units and verifying planning and strategic assumptions.

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IMAGE OF NATIONWIDE ASSOCIATION OF OCCUPATIONAL HEALTH AND SAFETY WORKERS (OSPSBHP)

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Aim: Identification of the brand image of the Polish Association of Occupational Health and Safety Service Employees (OSPBHP).

Design and methods: A survey was conducted on a sample of 78 people. Quantitative and qualitative text analysis was used to analyze the results. The quantitative analysis examined the frequency of occurrence as well as associations and connections between attributes.

Conclusions: It was found that when analyzing the image of the OSPSBHP brand, two of its dimensions were found. First of all, it is the first professional organization based on knowledge in the field of occupational safety, acquired through experience and training. Secondly, it enables cooperation between associated people who can count on mutual help and support. These contacts are professional in nature, but they can also take on a more personal dimension - transform into friendship. Taking into account the association analysis, OSPSBHP is a professional knowledge-based organization.

Practical implications: Information was obtained about the attributes that create the image of the OSPSBHP brand, i.e. the recipients' idea of it. On this basis, it can be suggested to take actions within the marketing mix aimed at creating an attractive image of the examined brand.

Limitations: Small sample size in the empirical study, as well as the limitations of the survey questionnaire. The structure of the sample was not examined.

Contribution: Innovative measurement of the OSPSBHP brand image based on an original methodology. Conclusions from quantitative and qualitative text analysis.

Keywords: image, association, occupational health.

Category of the paper: Research paper.

Introduction

In contemporary discourse, increasing emphasis is placed on the understanding of organizations as aggregations of the interests of multiple stakeholders (Kotas, 2014). Through their influence, stakeholders determine the scope and direction of organizational activities

(Mitchell, Agle, Wood, 1997). As noted by M. Kotas (2014), a critical determinant of success for non-governmental organizations (NGOs) is the degree of satisfaction among stakeholders within their environment. The establishment of an effective system of marketing communication between NGOs and stakeholders constitutes a fundamental prerequisite for organizational effectiveness (Bryson, 2004). A particularly significant instrument in this process is the brand image of the organization (Scott, Lane, 2000). Unlike commercial entities, NGOs are subject to distinct conditions in shaping their image. According to Sondej (2016), they must convincingly demonstrate to their environment that they effectively pursue socially significant goals while refraining from profit orientation. Kwaśnicki (2005) further emphasizes that NGOs are compelled to reconcile the differing rationalities ascribed to the market, the state, and society.

As Jasiecki (2004) observes, the concept of “brand” is employed in three principal senses (SJP, 1979). The first is cognitive and descriptive in nature, referring to the trademark identifying the producer. In the second sense, a brand is understood evaluatively, eliciting associations and emotions. The third interpretation relates to the broader climate, atmosphere, and social image attached to the brand. The notions of brand identity and brand image are inherently abstract, encompassing a set of characteristics and perceptions attributed to the brand. These function within the mind of the creator of the marketing message (identity) as well as within the mind of its recipient (image) (Lotko, Lotko, 2020).

Empirical studies (Przewłocka, Adamiak, Herbst, 2013) demonstrate that social engagement is strongly correlated with public perceptions of NGOs. The more favorable the image of such organizations, the greater the propensity of society to engage in philanthropy and volunteering. Moreover, this relationship is reciprocal: higher levels of civic engagement and more frequent interactions with NGOs translate into more positive evaluations of their activities. This underscores the strategic importance of building and managing organizational image. Against this backdrop, the present study addresses the following research question:

RQ: *What is the brand image of the selected professional association – the National Association of Occupational Health and Safety Service Employees (OSPSBHP)?*

Consequently, the aim of the analysis was to identify the brand image of OSPSBHP.

Research Methodology

To identify the scope and significance of the research problem, a literature review was conducted using the Google Scholar database. The following search phrases were applied:

- “occupational health and safety association brand”,
- “occupational health and safety association image”,

- “NGO brand”,
- “NGO image”.

The literature search was carried out in March 2024. For the purpose of analysis, results from the first two pages generated by the search engine were selected. The results of these studies were then analyzed. Based on these findings, the significance of the problem addressed was determined. They also identified a research gap, which this study sought to fill.

In order to identify brand image attributes – that is, the way the brand is perceived by consumers – an empirical survey was conducted on a sample of 78 respondents. The study took place during the International Trade Fair for Work Protection, Fire-Fighting, and Rescue (SAWO) in Poznań, held between 22 and 24 April 2024. Participants were asked to list three attributes (features, associations, values) of the brand, ordered according to the strength of association. They completed the printed survey questionnaire directly.

The collected data were analyzed both quantitatively and qualitatively. The quantitative analysis involved frequency analysis as well as association and linkage analysis. Specifically, (1) the frequency of occurrence of individual associations and (2) the structure of sequences—that is, the order in which associations appeared across data records—were examined. Statistical analysis was carried out using the Statistica 13.0 software package, employing the Sequence, Association, and Linkage (SAL) analysis tool within the Data Mining module. A cloud of tags was generated using the Word Art software.

Brand Image

A brand constitutes one of the key intangible assets (Diaz-Soloaga, Fernandez-Blanco, 2017; Saxena, Dhar, 2021). It performs an identificatory function, promises benefits, and, above all, shapes image (Michalski, 2003). It creates messages, associations, and emotions (Kotler, Armstrong, 2008; Kall, 2002, 2006). A brand is recognized as a symbolic, emotional, and transient construct, subject to subjective interpretation (Sułkowski, 2012; Escalas, Stern, 2013; Hammerl et al., 2016).

The notion of brand image derives from the Latin language, meaning model, prototype, reflection, or representation (Kotas, 2014; Dębski, 2009). Building a desirable brand image is regarded as a central objective of marketing communication activities (Czubała et al., 2006; Lotko, Lotko, 2020). The brand image serves multiple functions: identificatory (enabling the recognition of benefits), simplifying (facilitating choice), risk-reducing (ensuring the expected benefits are delivered), and loyalty-shaping (Altkorn, 1999; Aaker, 2010).

As early as the 1980s, the brand image began to be strongly linked with consumer behavior (Saxena, Dhar, 2021). Findings from empirical research have highlighted the growing importance attributed to brand image (Ogba, Tan, 2009). It has been demonstrated that

a properly shaped brand image positively influences perceived value, satisfaction, and ultimately, consumer loyalty. Studies conducted in this field have consistently shown that image constitutes a critical component of brand equity (Hsieh et al., 2004).

The brand image is inherently subjective (Altkorn, 1999; Czubała et al., 2006). As noted by Łuczak (2011), it comprises two components: cognitive and affective. In the case of non-governmental organizations, the cognitive component stems from knowledge about the organization's activities, familiarity with individuals involved in its operations, as well as the transparency and ethical assessment of its conduct. The affective component, by contrast, is predominantly linked to the characteristics of the recipient's profile. For this reason, individuals may perceive the image of the same organization in markedly contrasting ways. M. Kotas (2014), drawing on J. Altcorn (1999), observes that a discrepancy typically exists between the desired and the actual image. This gap most often arises from a misalignment between identity attributes and stakeholder expectations, discrepancies between declared and actual behavior, ineffective communication, and environmental variability. Effective branding, therefore, entails creating an image that is appropriate to the brand, positive in perception, and easily retained in memory (Saxena, Dhar, 2021).

The Role of Associations in Society

Since the mid-twentieth century, organizations have been classified into three major socio-economic sectors (Bogacz-Wojtanowska, 2016; Pilch, 2018). The first is the public sector, responsible for meeting citizens' needs in accordance with existing legal regulations. The second consists of enterprises and is associated with business activity. The third sector, often referred to as the civic sector, comprises initiatives and non-governmental organizations (NGOs) (Pilch, 2018). The dissemination of the term "third sector" is most frequently attributed to Levitt (1973) and Touraine (1985). Formed primarily by foundations and associations, it constitutes an essential component of building civil society (Sarzała, 2012). Indeed, the voluntary association of individuals to pursue common objectives is regarded as one of the fundamental indicators of social trust (Czapiński, Panek, 2015). As scholars emphasize, social trust is not only a key element in the development of civil society (Pilch, 2018; Gulińska, 2023) but also an important vehicle of social capital (Janoś-Kresło, 2011).

As Gulińska (2023) further argues, a defining feature of such a societal model is the participation of free, conscious, and responsible citizens in shaping the principles by which modern society operates. The emergence and development of civic organizations are predicated upon the activity of individuals and social groups, understood as their involvement in defining organizational objectives, principles, methods, and forms of action (Gulińska, 2023). One form of such organizations is the association. Their functioning is governed by the Law on

Associations of 7 April 1989 (Journal of Laws, 2020). An association is defined as (1) voluntary, (2) self-governing, and (3) permanent, with non-profit objectives (Journal of Laws, 2020). The first feature, voluntariness, is primarily expressed through the constitutional right to freedom of association (Gulińska, 2023). The second, self-governance, refers to the autonomy in shaping organizational structures, defining membership criteria, setting tasks, and determining the scope and intensity of activity. Associations are goal-oriented organizations, whose aims may be internal-focused on satisfying members' needs, or external, directed toward serving external stakeholders. The third feature, permanence, pertains to the durability of organizational objectives, independent of the continued participation of individual members (Gulińska, 2023).

According to data from the Central Statistical Office of Poland, in 2022 there were 103.4 thousand non-profit organizations operating in the country, encompassing 8.3 million members (GUS, 2023). Self-governing organizations enjoy strong public support and trust. More than 62% of respondents believe they are necessary, and 56% express trust in them (KJ, 2020). Notably, this trust is independent of citizens' actual contact with NGOs, suggesting that such organizations inherently evoke positive associations. Approximately 53% of respondents consider NGOs to be more effective than state institutions, while 39% report perceiving tangible effects of their activities on a daily basis (KJ, 2020).

A particular type of association is the professional association, which unites individuals practicing a specific profession. The role of such associations includes (CAZ, 2024):

- disseminating knowledge within a given field,
- initiating and supporting scientific and technical creativity,
- conducting research activities,
- safeguarding the collective interests of the profession,
- representing the interests of the profession,
- fostering integration among practitioners,
- supporting professional development,
- providing opinions and expert assessments,
- cooperating with external stakeholders,
- engaging in informational and publishing activities,
- supporting social initiatives.

It is precisely this type of association that forms the subject of the present analysis.

History and Contemporary Role of OSPSBHP

In Poland, within the occupational health and safety (OHS) service community, several organizations with the legal status of associations are active. Their objectives include educational and promotional activities concerning working conditions and labor law, the establishment of professional standards, the safeguarding of ethical principles, and the enhancement of members' knowledge, skills, and competencies (Prawo, 2008). The largest of these is the National Association of Occupational Health and Safety Service Employees (Ogólnopolskie Stowarzyszenie Pracowników Służby BHP, OSPSBHP) (Lotko, 2023). Established on 7 January 1993, it has operated continuously to the present day (OSPSBHP, 2023). The Association comprises 37 regional branches with a total membership of approximately 2,700 individuals (Bożejewicz, 2023). Its statutory objectives are pursued through the voluntary engagement of its members and include (OSPSBHP, 2023):

- creating organizational, legal, and functional conditions for the integration of OHS service employees,
- representing and protecting the professional, social, and legal interests of members,
- promoting awareness of occupational health and safety issues,
- providing opinions on new legal and organizational solutions related to occupational health and safety,
- safeguarding the dignity of OHS service employees and ensuring adherence to professional ethics,
- fostering the development of members' skills and knowledge.

The activities undertaken by the Association's branches primarily consist of training sessions designed to improve knowledge, skills, and competencies; workshops for novice OHS practitioners; seminars; conferences; technical visits to workplaces; experience-sharing events; educational picnics; study visits; OHS knowledge contests; and art competitions for children, adolescents, and workers (OSPSBHP, 2023). In 2022 alone, the Association organized 195 such initiatives, which attracted a total of 12,800 participants (Bożejewicz, 2023).

The Association also actively contributes to the implementation of national social campaigns promoting workplace safety and the protection of workers. These campaigns are coordinated by the Central Institute for Labour Protection – National Research Institute, the National Labour Inspectorate, and the Office of Technical Inspection, with the support of the Social Insurance Institution (OSPSBHP, 2024). Figure 1 presents the Association's logo, in use since 1 January 2022.



Figure 1. OSPSBHP logo.

Source: (OSPSBHP, 2024).

According to the members of the Association, affiliation provides inspiration, support, access to knowledge, professional development, experience exchange, a sense of community, guidance, and mutual assistance (Bożejewicz, 2023). The same author emphasizes that the OSPSBHP brand should be consistent, modern, professional, and active - a brand image actively promoted by the Association's management.

Research Problem in the Light of Literature Review

The conducted literature review revealed a limited number of studies devoted to the topic under investigation. At the outset, it is worth noting a certain concentration of research: many of the identified scientific works were produced at the Faculty of Management and Social Communication at Jagiellonian University in Kraków. These studies address, among other topics, employer brand creation using the example of an association (Gryz, 2016), the use of storytelling in shaping the image of non-governmental organizations (Handzel, 2022), building the brand of a selected association (Heród, 2014), shaping NGO image in social media (Słonka, 2014), and the relationship between organizational identity and the image of self-governing organizations (Ślusarczyk, 2014). The issue of storytelling in NGO branding is also addressed by McCarthy (2021) among foreign authors and by Rodak (2023) among Polish scholars. Brand image as an element of effective NGO communication with the environment is analyzed by Kotas (2014), while Pilch (2018) examines methods for shaping it. Łuczak (2011) further elaborates on issues of brand image creation and management, and Sondej (2016) provides a more comprehensive discussion on NGO communication with stakeholders and the role of brand image in this process.

In addition, there are findings from independent studies on the image of NGOs, particularly those conducted by the Klon/Jawor Association (Przewłocka, Adamiak, Herbst, 2013; KJ, 2020). These studies include analyses of knowledge sources and perceptions of NGOs, public trust and assessments of their credibility, as well as societal expectations regarding their functioning and communication with stakeholders (Adamiak, 2015). Several authors, including Gulińska (2023), Sarzała (2012), and Janoś-Kresło (2011), extensively discuss the role of

associations as significant actors in contemporary civil society. Other scholars examine the role of professional associations (Bożejewicz, 2023; CAZ, 2024).

Challenges related to the brand image of NGOs partly stem from the fact that many organizations do not devote sufficient attention to promotional activities (Adamiak, 2015). Few provide information about their activities on their websites or maintain contact with members and interested parties through modern communication channels (Przewłocka, Adamiak, Herbst, 2013). It is therefore evident that, although the subject of NGO brand image—particularly that of associations—is somewhat represented in the literature, none of the identified studies have specifically addressed professional associations within the occupational health and safety sector. Consequently, this issue has been deemed worthy of scholarly investigation.

Analysis of Empirical Study Results

The collected data allowed for a textual analysis. Since respondents were asked to identify attributes (features, values), answers containing proper names of institutions or geographic locations were excluded. The most frequently reported associations with the examined brand are presented in Table 1.

Table 1.

The ten most frequent associations with the OSPSBHP brand based on the survey

No.	Association	Occurrences
1	Knowledge	19
2	Professionalism	17
3	Safety	14
4	Assistance	11
5	Support	10
6	Cooperation	9
7	Experience	7
8	Contacts	7
9	Friendship	5
10	Trainings	5

Source: authors' own elaboration.

Preliminary statistical analysis of the data in Table 1 indicates that the brand is most frequently associated with three concepts: knowledge, professionalism, and safety (with 19, 17, and 14 mentions, respectively). This suggests that the Association's image conveys the creation and dissemination of occupational safety knowledge, while also connecting professionals and promoting professional service delivery. These three associations therefore reflect the professional character of OSPSBHP.

The next three identified attributes pertain to an organization that unites collaborating individuals (9 mentions), who, through cooperation, can rely on assistance (11 mentions) and support (10 mentions). The following association concerns the acquisition of professional experience (7 mentions), which is also related to the professional dimension of the organization. The remaining attributes reflect social relations: contacts (7 mentions) and friendship (5 mentions). The final frequently mentioned attribute is training (5 mentions).

In summary, the identified associations correspond to two dimensions of the Association's activities: (1) professionalism – attributes 1, 2, 3, 7, 10; and (2) social relations – attributes 4, 5, 6, 8, 9. This analysis is visually represented in a tag cloud shown in Figure 2.

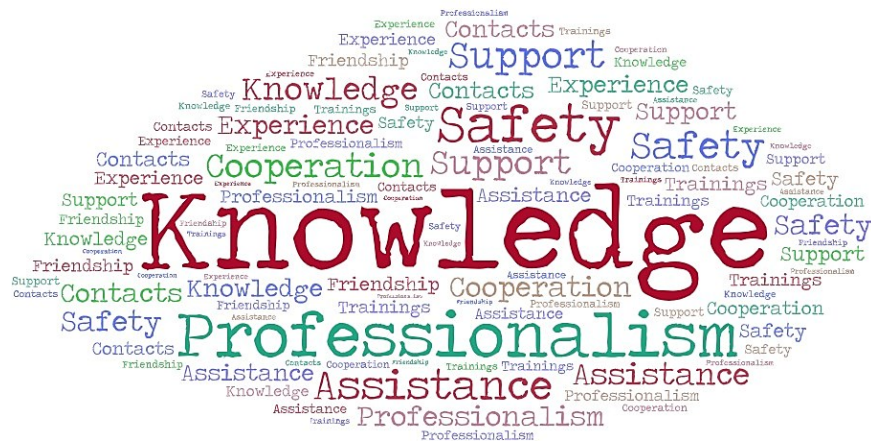


Figure 2. Cloud of tags for the most frequent associations with the brand OSPSBHP.

Source: authors' own elaboration.

Based on the interpretation of the results presented in Figure 2, it can be concluded that the OSPSBHP brand is primarily perceived as a professional organization grounded in occupational safety knowledge, acquired through experience and formal training. The second dimension of the brand image concerns the collaboration among affiliated individuals, who can rely on mutual assistance and support. These interactions are primarily professional in nature but may also develop a more personal dimension, evolving into friendships. Synthesizing these preliminary findings, OSPSBHP can be characterized as a professional association based on knowledge that facilitates the establishment and maintenance of meaningful social relationships.

The results of the association analysis, organized according to the order of mentions, are presented in Table 2.

Table 2.*Associations with the OSPSBHP brand in order of occurrence*

Association					
First	Count	Second	Count	Third	Count
Safety	11	Assistance	6	Knowledge	8
Professionalism	9	Professionalism	6	Cooperation	4
Knowledge	6	Experience	5	Trainings	3
Assistance	4	Knowledge	5	Support	3
Friendship	3	Support	4	Safety	2
Support	3	Contacts	3	OHS	2
OHS	2	Development	3	Experience	2
Information flow	2	Community	3	Sharing knowledge	2
Group	2	Cooperation	3	Contacts	2
Integration	2	Ergonomics	2	People	2
Contacts	2	Competence	2	Content	2
Cooperation	2	Unity	2	Protection	2
Brotherhood	1	Competencies	2	Professionalism	2
Interesting training	1	Loyalty	2	Friendship	2
Consulting	1	Protection	2	Power	2
Sharing knowledge	1	Trainings	2	Common goals	2
Quality	1	Engagement	2	Audits	1
Unity	1	Ambition	1	Determination	1
Competencies	1	Safety	1	Good climate	1
Conferences	1	Discipline	1	Good food	1
Creativity	1	Acting together	1	Ergonomics	1
OHS culture	1	Professional ethics	1	Group	1
Lance	1	Evolution	1	Companionship	1
Numerous	1	Group	1	Competencies	1
Connecting different branches	1	Idealism	1	Creativity	1
Modernity	1	Innovations	1	Supervision	1
Openness	1	Cronyism	1	Non profit	1
Politics	1	Companyship	1	Innovations	1
Job	1	Conferences	1	Objectivity	1
Team work	1	Passion	1	Responsibility	1
Prestige	1	Politics	1	Organisations	1
Development	1	Fire protection	1	Openness	1
Reliability	1	Promotion	1	Beautiful greenery	1
Power	1	Rules	1	Politics	1
Professionals	1	Risk	1	Assistance	1
Tradition	1	Meetings	1	Practical	1
Multigenerationality	1	Regularity	1	Practic	1
Influence	1	Chance	1	Reliability	1
Community	1	Fun	1	Seminars	1
Reach	1	Trust	1	Contributions	1
Collectivity	1			Community	1
				Old	1
				Structures	1
				Chance	1
				News	1
				Trust	1
Number of associations	41		40		46

Source: authors' own elaboration.

The analysis of the data presented in Table 2 indicates that the associations across all groups are highly diverse. The first group contains 41 associations, the second 40, and the third 46. This finding is corroborated by the sequence analysis, which did not reveal any recurring sets of associations with the OSPSBHP brand. This outcome reflects the aforementioned high variability of the variables. Conducting a non-sequential (i.e., “weaker”) association analysis produced the results shown in Table 3.

Table 3.

Results of non-sequential association analysis of associations with the OSPSBHP brand

Association	Number of elements	Count	Support [%]
Professionalism	1	17	21,79
Knowledge	1	19	24,36

Source: authors' own elaboration.

Analysis of the data in Table 3 leads to the conclusion that the most frequently occurring associations with the examined brand, regardless of their order of mention, were professionalism (17 mentions) and knowledge (19 occurrences). Based on these findings, OSPSBHP can be characterized as a knowledge-based organization that brings together professionals.

Managerial Implications and Recommendations

Brand policy does not necessarily have to involve aggressive promotion, nor does it require substantial financial resources (Adamiak, 2015). It is important to distinguish between simply informing stakeholders about organizational activities and engaging in professional promotion. The latter is conducted by very few organizations with appropriate resources. As Adamiak (2015) further notes, there are examples among associations and foundations of conscious brand-building, with the key factor being the effective use of available communication channels to reach the environment.

The Association's management (Bożejewicz, 2023), in shaping the brand image, emphasizes that it should be consistent, modern, professional, and active. The empirical study primarily highlighted the aspect of professionalism (attributes of knowledge, professionalism, and safety), followed by activity (support, cooperation, acquiring experience, and establishing and maintaining contacts).

Several recommendations, drawn from the literature, are particularly relevant for building the Association's brand image (Hernik, 2016; Adamiak, 2015; Pilch, 2018), and are perhaps best summarized in BW (2021):

- Actions build reputation. The brand image of a social organization is most influenced by its actions. Therefore, the foundation of conscious image-building should be the quality of initiatives and projects undertaken.
- Evaluating projects in the context of image-building. Activities should be planned with consideration of how they may impact the organization's image. It is useful to analyze whether a given initiative supports the way the Association aims to be perceived.
- Emphasizing the organization's credo. To build the brand image, the organization's identity must first be defined (Lotko, Lotko, 2020). This identity should then be intensively communicated in promotional messages, confronting potential recipients with the promoted values.
- Clarifying outcomes of completed projects. Communication should not only focus on current or planned activities but also identify and disseminate the results of past initiatives. It is valuable to document and publish evidence of undertaken actions, share positive stories about the experiences of both recipients and members, and employ storytelling (Rodak, 2023; Handzel, 2020; McCarthy, 2021).
- Highlighting experts. It is important to emphasize that professionals are actively engaged in the Association's activities. These voices should be leveraged in promotional messages, ensuring that communications come from experienced, competent individuals aware of real-world challenges.
- Expanding beyond the bubble. New media can be used to reach a broader audience. Opening up to collaboration with various information distributors can yield highly positive effects.
- Understanding the audience. Identifying the target audience of the Association's activities allows for recognition of their expectations and needs. With this knowledge, actions can be more effective, contributing to an improved brand image.

Many other guidelines – both conceptual and practical – regarding the shaping of an organization's image are available in the literature (Łuczak, 2011; Schimanek, 2006; Przewłocka, 2011; Adamiak, 2015; Kotas, 2014; Pilch, 2018; Słonka, 2014; Gryz, 2016; Hernik, 2016).

Summary and Conclusions

As a result of the conducted analysis, the following conclusions were drawn:

1. Based on the empirical assessment of the OSPSBHP brand image, it can be characterized as a professional association grounded in knowledge, enabling the establishment and maintenance of meaningful social relationships. Specifically, two dimensions of the Association's image were identified: (1) professionalism –

a professional organization based on occupational safety knowledge acquired through experience and training; and (2) social relations – an organization that facilitates collaboration among affiliated individuals, offering mutual assistance and support within professional contacts, which may evolve into friendships.

2. The sequence analysis did not reveal any recurring sets of associations defining the examined brand image.
3. The non-sequential association analysis indicated that the most frequently occurring associations, regardless of their order of mention, were professionalism (17 mentions) and knowledge (19 occurrences). Based on these results, OSPSBHP can be described as a professional, knowledge-based organization.

Overall, the obtained brand image appears to align with the objectives set by the Association's management (Bożejewicz, 2023). The indicated recommendations may be applied to further strengthen the brand.

Research Limitations

The primary limitation of this study was the small sample size of 78 respondents. Additionally, the measurement of brand image was highly simplified, being limited to listing three associations. However, due to temporal constraints during the SAWO trade fair, it was not feasible to implement a more complex study.

Directions for Future Research

Future research could consider more complex analyses, for instance, based on in-depth interviews or storytelling (Handzel, 2020; McCarthy, 2021).

It would also be worthwhile to examine the relationship between the Association's image and the engagement of its members in organizational activities. The analysis could employ modeling of the relationships between perceptions of the organizational brand and members' declared attitudes and behaviors, thereby enabling an assessment of the role of reputation in building long-term relationships (Fombrun, van Riel, 2004).

It also appears justified to conduct comparative research involving other professional organizations in the field of occupational safety, which would make it possible to identify the specific characteristics and distinctive features of the OSPSBHP's image. Such an approach would facilitate the identification of factors that contribute to building a strong brand of

an expert organization in the social sector and allow for an assessment of its competitive position (Cornelissen, 2020).

In light of contemporary trends, another promising direction for future research would be to analyze the role of online communication (website, social media, expert publications) in shaping the perceived professionalism and credibility of the Association (Cees, van Riel, Fombrun, 2007).

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FAMILY COMPANIES PRESENCE ON THE WARSAW STOCK EXCHANGE – TEN-YEAR ANALYSIS

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Purpose: The aim of this paper was to thoroughly and long-term verify how family companies behave on the Warsaw Stock Exchange (WSE) and what changes occur in the context of generational change in key functions like management and supervisory boards from 2015 to 2024.

Design/methodology/approach: The presented research results is an overview and attempts to analyze of family companies behavior on the WSE in the period 2015-2024 in accordance with the theoretical basis of systems theory (Three Circle Model).

Findings: The results obtained from the ten-year analysis show a decline in the number of family companies whose shares are listed on the capital market in accordance with the criteria adopted for the study. Their number decreased by 40.7%. Another concerning finding is the CEO age at the end of the study, as well as the low percentage of family companies actively engaged in the generational renewal process.

Research limitations/implications: Pointing out the limitations, it should be noted that the presented results of the conducted study focus on family companies that met the criteria adopted for the study in 2015. During analyzed period, new entities meeting the requirements certainly appeared, which due to the purpose of the study were not taken into account. In future it seems necessary to explore the dominant succession pattern and the variables resulting from the family system influencing the decisions made regarding the future of the family companies.

Practical implications: Referring to the data presented in the article, it can be noted that for many family companies a presence on the WSE is only a temporary solution. The conclusion regarding the involvement of these entities in the process of management and ownership succession is also disturbing. This may require in future a redefinition of this group of business entities.

Originality/value: According to the author's knowledge, this is the first scientific study presenting real changes in the presence of family companies on the WSE over a ten-year period on one paper, taking into account the theoretical foundations of presenting family companies through the prism of systems theory.

Keywords: family companies, Warsaw Stock Exchange, Three Circle Model, family system.

Category of the paper: Research paper.

1. Introduction

Family businesses, despite being a heterogeneous group of business entities, owe their uniqueness to the coexistence of two systems with different roots in one organization - the family system and the business system (Tan, Guo, Zhang, 2024; Olson et al., 2003). The indicated uniqueness is manifested by the need to achieve both economic and non-economic goals. According to the available knowledge, many scientists believe that the family system is the most important one and influences the strategic direction of a given family business (Alves, Gama, 2020). However for the effective functioning of a family business, it seems essential to balance the influence of the family and business systems – this function is performed by the ownership system (Sharma, Nordqvist, 2008). Therefore it would seem, that the presence of family companies on the stock exchange is a very good solution for them, due to the need to open ownership structures, they would be able to maintain a balance between the influences of the two indicated systems. Also, the annual results published by Grant Thornton under the patronage of the WSE indicate a stable and well-established position of the highlighted companies (approx. 40%) on the WSE. However the author of this paper would like to note, that according to the literature the systems that constitute family businesses (FBSs) are not static. They have development cycles, both in terms of their entirety and of the individual systems that comprise them. Furthermore, each configuration may have a different development process, beginning and ending at different times (Dawson, 2012).

Taking into account the presented theoretical outline it seems necessary to conduct an in-depth analysis of what specifically happens to the indicated companies over the long term. The existing stage of knowledge inspired the author of this article to conduct a ten-year analysis of the presence and changes occurring in family companies listed on the WSE. To ensure the analysis provides a comprehensive understanding at first the author of this article presented a literature review describing family businesses through a systems theory. Next part refers to the characterization of the family system as a key influence on the functioning the entire business entity. Within this section, the author also presents the annual reports results of Grant Thornton's analyses. The research section begins with a description of the research methodology and refers to the obtained results. The last parts of this article consists of limitations with directions for further research, and conclusions.

2. Literature review – the essence of family businesses

The first attempt to describe a family business using systems theory emerged from the Three Circle Model presented in 1982 by R. Tagiuri and J. Davis (1992; 1996), which viewed a family business through the prism of three overlapping systems: family, enterprise, and ownership. This model remains widely used and relevant to this day, as evidenced by numerous scientific publications in which researchers base their considerations on the Three Circle Model (Sharma, Nordqvist, 2008). It is also worth noting that the indicated interdependence in family businesses underscores their unique nature (Tan, Guo, Zhang, 2024; Olson et al., 2003). Research conducted in this area has demonstrated the need to understand the functioning of individual systems and the relationships between them in order to understand the model of family entrepreneurship. Therefore, the author attempts to characterize them in the following section of this article.

The family system represents individual family members and the interactions that occur between them in their natural environment—the family (Dawson, 2012; Bubolz, Sontag, 1993). The attitudes and beliefs of family members will have a key impact on the values and goals they want to pursue as a family. However, due to the close relationship between the three systems, their influence will also be reflected in the operation and strategic goals of the enterprise. As J.J. Chrisman, J.H. Chua, and P. Sharma point out, many researchers currently agree that the family system is a key variable determining the functioning of both the other systems and the entire family enterprise (2005). Therefore, understanding the mechanisms of creation and the changes occurring within this system seems crucial for understanding the business decisions made in these economic entities.

The next system is represented by the business perspective, which is created by individuals employed in a given enterprise who share common goals, vision, and values shaped by the business environment. At this stage, the first discrepancies between the intentions and needs, as well as the motives behind the family's and the enterprise's actions can be observed. Family norms revolve around ensuring the safety of family members, organizing family life, procreation, and creating development opportunities that are equal for siblings and tailored to the individual's individual needs. Enterprise norms focus on achieving economic goals, development through employing individuals with appropriate qualifications, approaching employees through the lens of a group, and creating opportunities for further learning tailored to the organization's operational needs (Safin, 2007). The presented mechanism highlights also another characteristic of family businesses, where the priorities established will consist of both family needs (non-economic goals) and business (economic) goals (Alves, Gama, 2020).

According to the literature, for the effective functioning of a family business, it seems essential to balance the influences of the family and business systems – this function is performed by the ownership system (Sharma, Nordqvist, 2008; Olson et al., 2003). Maintaining

this balance through the latter system is possible by clarifying both the family's goals and needs, as well as the economic ones underlying the establishment of the business entity (Tower et al., 2007).

It should be noted that the systems that constitute family businesses (FBSs) are not static. They have development cycles, both in terms of their entirety and of the individual systems that comprise them. Furthermore, each configuration may have a different development process, beginning and ending at different times (Dawson, 2012). This perspective also highlights the characteristics of this group of entities and enhance its heterogeneity compared to non-family businesses. The heterogeneous nature of family businesses also highlights the approach to the previously discussed values and goals. According to research, the vast majority of family businesses operate in a manner that favors the needs arising from either the family system or the business system (Haynes, Onochie, Muske, 2007; Gomez-Mejia, Núñez-Nickel, Gutierrez, 2002). Moreover, as researchers have noted, even in businesses with the same orientation regarding the selection of the key system determining the family business's operation, the goals pursued may differ (Reyna et al., 2025; Castillo, Wakefield, 2007). This observation also confirms the complexity of the aspects that make up the specificity of family businesses and manifests itself in one of the difficulties that is the attempt to create a definition for this group of business entities (Davis, 2018).

It is also worth noting that due to the interpenetration of the discussed systems that constitute family businesses, they possess many types of resources, such as: human resources – also understood in the context of knowledge, experience, skills, innovative approach (Reyna et al., 2025; Miroshnychenko et al., 2021; Litz, Kleysen, 2001), interpersonal resources – commitment, sense of bond, mutual trust and honesty, shared passion and commitment to the business (Andersson, Carlsen, Getz, 2002), resources related to the business environment – support of the local community, access to a network of contacts (Hoffman, Hoelscher, Sorenson, 2006) or tacit knowledge (Cabrera Suárez, De Saá-Pérez, García-Almeida, 2001). It is worth mentioning that the perception of the importance of individual resources will vary across family businesses and depend on the priority set within the family or enterprise system. Regardless of the priority set within a given system, the transfer of necessary resources will still be significantly faster than in non-family businesses, primarily due to the emphasis on strong ties and close family relationships, reflected in the discussed configurations of the three systems (Pearson, Carr, Shaw, 2008). Analyses exploring the issue of resource allocation in family enterprises confirm that only in this group of enterprises, in difficult economic periods all available resources are redirected to the enterprise (Reyna et al., 2025; Olson et al., 2003), while in favorable economic times, resources are divided between the family system and the enterprise (Haynes, Onochie, Muske, 2007). The occurrence of the described phenomenon also seems to confirm the unique nature of this group of enterprises and their distinction from non-family counterparts (Grant Thornton, 2022-2025).

3. Literature review-The influence of the family system on the functioning of family businesses

As it was pointed out in the previous section of this article, the family system seems to be a key variable determining the functioning of both the other systems and the entire economic entity, therefore, taking a closer look at this variable seems to be necessary.

When considering the influence of family on the actions undertaken and implemented by family businesses, it seems necessary to reiterate that these entities pursue not only economic goals but will also be characterized by the need to achieve non-economic objectives (Alves, Gama, 2020; Chrisman, Chua, Zahara, 2003). The set of non-economic goals indicated is the result of this group of businesses possessing family capital, which, as scholars point out, is a specific type of social capital (Miroshnychenko et al., 2021; Distelberg, Sorenson, 2009; Bubolz, 2001).

This feature has been proven to create a unique work atmosphere that fosters increased employee motivation and loyalty to the employer, as well as mutual respect and trust (Danes et al., 2009; Tagiuri Davis, 1996). These companies are characterized by flexible work methods and informal communication, which, due to the intimacy and close contacts contributes to increased efficiency and the discovery of talents and the best qualities of individual employees (Tan, Guo, Zhang, 2024; Distelberg, Sorenson, 2009; Sorenson, Bierman, 2009).

The highlighted factors also positively impact building a strong and credible reputation (Distelberg, Sorenson, 2009; Poza, Alfred, Maheshwari, 1997; Tagiuri, Davis, 1996). As scientist pointed out due to personal involvement in the success of a family business, these entities commit to prosper in accordance with the established mission, which is an authentic reflection of the founder's beliefs. The interpersonal relationships distinguish this group of enterprises from non-family businesses on the one hand, constitute the basis for formulating the company's code of conduct on the other, which support long-term relationships with suppliers, customers, and other external entities cooperating with the business entity (Reyna et al., 2025; Miroshnychenko et al., 202; Distelberg, Sorenson, 2009; Sorenson, Bierman, 2009). As scientist emphasize, the indicated characteristics arising from the family's influence on the enterprise result in the inseparability and interpenetration of family goals with the business assumptions, creating a unified long-term strategy for the entity (Reyna et al., 2025; Tan, Guo, Zhang, 2024; Mzid, Khachlouf, Soparnot, 2019; Leszczewska, 2017).

Confirmation of the theoretical considerations presented above can be found in reports published periodically by Grant Thornton presenting both business and financial analyses for family companies listed on the WSE.

The first report published in 2018 indicates that in recent years the WIG-family index has been more stable than WIG20, which means that the family feature has become an indicator of a stable investment and investments in WIG-family were more effective than in WIG20.

Additionally, according to the results of the analysis, 20% of companies listed on the WSE are family companies in accordance with the definition adopted for the research purposes¹ (Grant Thornton, Fundacja Firm Rodzinnych, 2018). In the report published in 2021, its authors indicate that family businesses, despite the difficult economic situation, still show positive financial results both at the operating level and net profit, and it is precisely this period in the economy that allows them to see their competitive advantage over their non-family counterparts, and thus they can be perceived by potential investors as a safer option for capital allocation. Furthermore, the results achieved were attributed to characteristics stemming from their family nature, as described above. Additionally, according to the results of the analysis, 32% of companies listed on the main market of WSE are family companies in accordance with the definition adopted for the research purposes (Grant Thornton, 2021). A report published in 2022 indicated that non-family companies achieved higher operating profitability than family companies. However, the latter group of entities still generates higher returns on assets and equity for investors. As indicated, family companies provide shareholders with stable added value regardless of economic conditions. What is more in this edition of the report highlights that family companies constitute 41% of all companies listed on the main market of the WSE in accordance with the definition adopted for the research purposes (Grant Thornton, 2022). The results published in 2023 confirmed a similar situation to the data presented the previous year. However, despite demonstrating lower operating profitability, the valuation of family listed companies relative to their non-family counterparts remained unchanged, which may be due to their management and leadership style. The style of performing these functions reflects the characteristics of family businesses. Additionally, it is worth noting that the share of family companies in the total number of companies listed on the main market was 40% in accordance with the definition adopted for the research purposes (Grant Thornton, 2023). A new variable appears for the first time in a report published in 2024. It indicates that as many as 92% of entities considered family businesses emphasize the "family" aspect in their marketing communications. This is attributed primarily to their inherent characteristics of higher trust, stability, and stakeholder loyalty. Based on financial data, family businesses generate lower profits than their non-family counterparts, which still doesn't change their valuations. Additionally, according to published data, the share of family companies on the main market was 42% compared to all companies listed on the WSE in accordance with the definition adopted for the research purposes (Grant Thornton, 2024). A report published in 2025 indicates that family businesses have remained one of the most stable segments of the WSE for years. Although they are, on average, smaller and less profitable than non-family companies, they are characterized by lower earnings volatility, which the market rewards with valuations based on

¹ It should be noted, however, that this edition of the report provides the total result for both the main market and New Connect. The author of this article would also like to point out that the data provided in this part are based on the definitions provided by the authors of the reports, which changed with subsequent editions of the published analyses.

multiples similar to those of larger entities. As the report's authors point out, an analysis of its results shows that "family" is still synonymous with resilience. Over the long term, these stocks offer rates of return comparable to the broader market with significantly lower volatility. Their valuations remain similar to those of non-family companies, demonstrating that investors value the stability and predictability that comes from consistent planning. Additionally, according to published data, the share of family companies on the main market was 41% compared to all companies listed on the WSE in accordance with the definition adopted for the research purposes (Grant Thornton, 2025). Unfortunately, this edition of the report did not verify the information on communicating family values by family companies listed on the WSE.

Referring to the conclusions drawn from the literature section, it can be stated that family nature should have a positive impact on the activities conducted by this group of business entities. Also analyzing the data presented above, it appears that family companies have become a permanent fixture on the WSE main market, maintaining a stable position regardless of market conditions. Considering both the conclusions drawn from the literature and the results of the analyses, it could be concluded that family businesses, by their nature, possess certain competitive advantages unavailable to non-family businesses. Furthermore, considering that the ownership system should balance both indicated systems, their presence on the stock exchange should be a very good solution for them. Suggested presumptions prompted the author of this article to verify the presence of family companies on the main market over a 10-year period, which will be presented in the next section.

4. Methods

The research methodology was based on the documentation analysis method, drawing on the formal documentation of companies listed on the main market of the WSE since 2015, to present a realistic picture of the presence and changes occurring in family businesses over a 10-years period. By using this method obtained data was processed and the analysis was conducted in order to obtain the results presented in the next section.

The list of companies listed on the WSE subject to empirical analysis was taken from the Thomson Reuters database and included entities belonging to the WSE Index (WIG). This choice was intentional, because the indicated index is the oldest and the widest index published by the WSE, which allows for the mapping of the broadest picture of the market.

The first step aimed at separating family companies in accordance with the adopted definition was to understand the composition of the management boards, the supervisory boards and the shareholder structure in the end of the year 2015. It should therefore be noted that the study period begins before the list of family businesses was introduced on the WSE. The aforementioned definition adopted for the research is - a family listed company is

a company in which a family member is the CEO of management board, the management or supervisory structures may include other members of the same family and direct or indirect ownership in the amount of a minimum of 25% of the votes at the general meeting of shareholders belong to a member or members of this family. The mentioned family is the founder of the company and in exceptional cases gained control². The number of family companies that met the definition criteria adopted at that time was 54, which accounted for 32.7% of all companies listed on the main market in that period³. Therefore, the results of the conducted research refers to the situation of the identified 54 family companies from 2015 to 2024, due to availability of data at the time of preparation of this article.

5. Results

The first section of data present their characteristics at the time of beginning of the study. The next section is devoted to presenting real situation of the distinguished family companies over a ten-year period and the last one refers to their characteristics at the time of completion of the analysis.

Table 1.
Family founder

Family founder	Number of companies	Percentage share of companies
Family founder	46	85,2%
Gain control	8	14,8%
Total	54	100%

Source: author's own elaboration.

In reference to the data presented in Table 1 only eight companies were not founded by a family that held the position of CEO in 2015 and had the minimum required ownership. This group includes: Biomed Lublin Wytwórnia Surowiec i Szczepionek S.A. (founder: Polish Government), Energoinstal S.A. (founder: Polish Government), Eurocash S.A. (founder: McLane Polska limited liability company), Fabryka Sprzętu i Narzędzi Górniczych Grupa Kapitałowa Fasing S.A. (founder: Polish Government), Triton Development S.A. (founder: Cezary Augustynowicz- not related to family members managing or owning property as required by the adopted definition), Ursus S.A. (founder in 1893 by Rossman Ludwik, Kazimierz Matecki and Emil Schönfeld), Groclin S.A. (founder: Zbigniew Grzymała - not

² The adopted assumption has its legal justification in the Commercial Companies Code (section II. Joint-stock companies), which states that a shareholder holding at least 25% of votes at the General Meeting of Shareholders has the right to block the decision made by the management board, and also has a real impact on the selection of management board members and may request an independent audit of any transaction.

³ The financial sector was excluded from the research sample. This also had an impact on the results presented above, prepared by Grant Thornton.

related to family members managing or owning property as required by the adopted definition) and INC S.A. (founder: Mostostal- Export S.A.).

Table 2.
Founder sex

Founder sex	Number of companies	Percentage share of companies
Male	44	95,65%
Female	2	4,35%
Total	46	100%

Source: author's own elaboration.

According to the data presented in Table 2 only two of the analyzed family companies were founded by women: Archicom S.A. by Jarodzka-Śródka Dorota and PA Nova S.A. by Bobkowska Ewa.

Table 3.
CEO sex in listed family companies in 2015

CEO sex	Number of companies	Percentage share of companies
Male	51	94,4%
Female	3	5,6%
Total	54	100%

Source: author's own elaboration.

In relation to the data relating to the CEO gender at the time of the study initiation (Table 3) only three women held this position. This applies to the two companies mentioned above, where the founders were also women and Triton Development S.A.

Table 4.
Age of CEOs in listed family companies in 2015

Age of CEOs (in years)	Number of companies	Percentage share of companies
Under 40 years old	7	12,96%
Under 50 years old	19	35,19%
Under 60 years old	20	37,04%
Over 60 years old	8	14,81%
Total	54	100%

Source: author's own elaboration.

Table 5.
Education level of CEOs in listed family companies in 2015

Education level	Number of companies	Percentage share of companies
Vocational/secondary education	7	12,96%
Higher education	43	79,63%
Ph.D. or higher	4	7,41%
Total	54	100%

Source: author's own elaboration.

Referring to the data presented regarding CEO age (Table 4) at the time the research began, it should be noted that the most numerous group consists of CEOs under 60 years of age (37.04%). It therefore seems that these companies should already have a succession process implemented if they are to continue unchanged despite generational change. This is especially

true given that the first succession process is the most difficult, and most of the listed family companies should be in the process of planning or implementing it⁴. This planning phase should apply to the second most numerous group, CEOs under 50 years of age, who constitute 35.19% of all respondents. The least numerous companies are represented by CEOs over 60 years of age at the time the research began (14.81%), and those under 40 years of age (12.96%). In terms of CEO education level (Table 5) at the time the study began, the largest group had higher education (79.63%), followed by secondary education (12.96%), and 7.41% had a doctoral degree or higher. The data presented above will be compiled and compared with the results obtained at the end of the research process, i.e., in 2024. The next section of data focuses on presenting the detailed situation of identified family companies listed on the WSE over the last ten years.

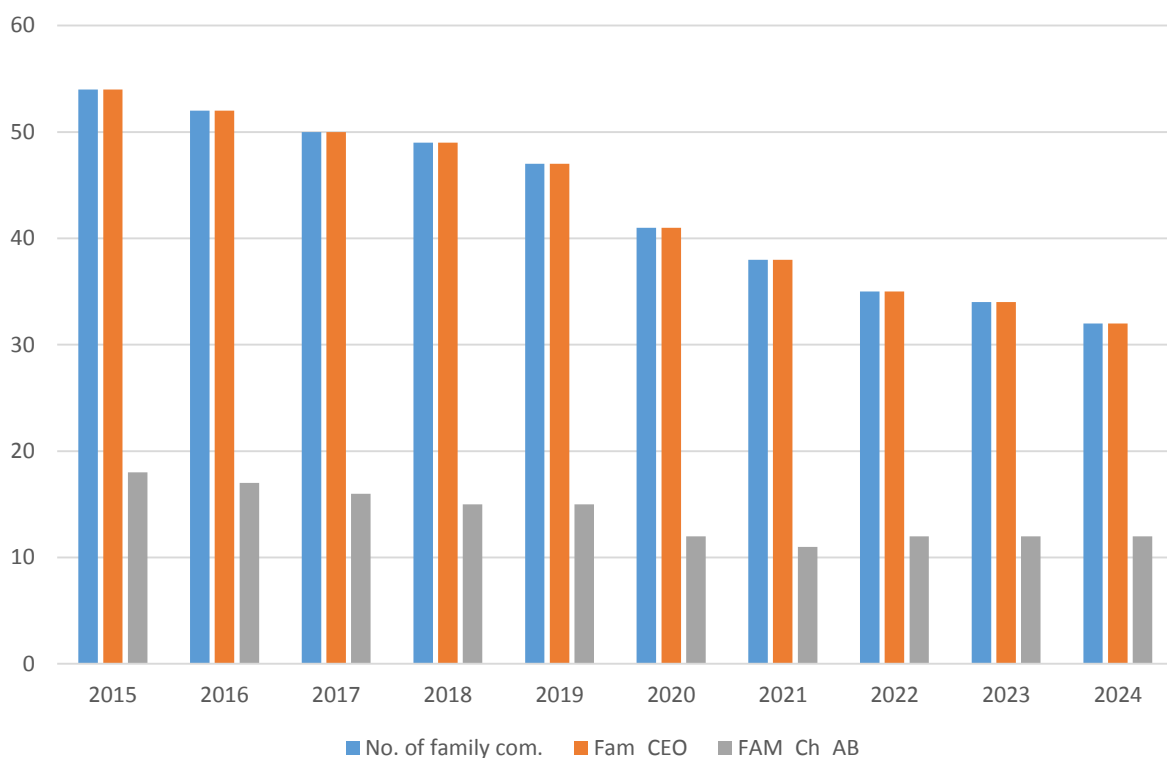


Figure 1. The presence of family companies on the WSE 2015-2024.

Source: author's own elaboration.

⁴ According to the results of international research projects only 30% of family businesses are able to pass on the company to the second generation, while less than 14% of family businesses pass on to the third generation (Bjuggren, Sund, 2001). As indicated by the scientists one of the key reasons, if not the most important one, behind such a high percentage of failures revealed at the stage of passing on the company to the next generations is the lack of skills to manage the complicated process of succession. It is also burdened with a significant emotional charge. The influence of the above-mentioned emotional factors is particularly visible when planning and implementing the succession process from the generation of founders and their successors (Venter, Boshoff, Maas, 2003).

According to the data presented in figure 1, it can be seen that the number of family entities identified in 2015 is significantly decreased. As mentioned, at the beginning of the study the number of companies meeting the definitional criteria of family businesses was 54, and at the end of the study in 2024, this number was 32. Therefore, it seems necessary to look at the situation year by year. In 2016, Biomed Lublin Wytwórnia Surowic i Szczepionek S.A. and Wasko S.A. ceased to meet the criteria defining them as family companies. In the case of Biomed Lublin Wytwórnia Surowic i Szczepionek S.A., this was due to Waldemer Sierocki's withdrawal from the CEO position and his transition to a supervisory board position, the withdrawal of other family members from other supervisory roles, and the Sierocki family's ownership decreasing over time. In Wasko S.A., its founder, Wojciech Wajda, previously acting CEO, ceased to serve this function in 2016 until 2018. In 2017, he served as chairman of the supervisory board for a year and return to the CEO position as mentioned in 2018, the family holds ownership throughout the entire period of research. In 2017, PA Nova S.A. ceased to meet the family requirements adopted for the study, the founder and acting CEO - Ewa Bobkowska resigned from this position, until the end of the period covered by the study she held the position of Vice CEO, other family members remained in the company in supervisory bodies and in ownership (including the second generation of the Bobkowski family) thus it seems that the management function was handed over to an external manager. Also Syntetik S.A. does not meet the requirements to be named a family company any longer. In the next year covered by the study, the company that no longer meets the requirements of a family company was Archicom S.A. The founder and acting CEO, Dorota Jaródzka-Śródka, resigned from this position, serving as Vice CEO for a year, only to return to her previous position for a two-year period. In 2021, the Archicom Group was sold and joined the Echo Investment Capital Group. Since then, the Jaródzka-Śródka family has had no involvement with Echo Investment. As the founder indicated, the decision to sell the company resulted from a lack of interest in the second-generation succession process. The second company to lose its family status that same year was Ursus S.A. Karol Zarajczyk, who no longer served as CEO, and Andrzej Zarajczyk continued to serve as chairman of the supervisory board and own the company. Since 2020, the company has been undergoing restructuring, and a year later, a court declared it bankrupt. In 2019, Atrem S.A. ceased to meet the criteria for defining family company. Its founder, Konrad Śniatała, resigned from CEO position also other family members resigned from their functions. It is worth noting, however, that the aforementioned company was taken over by the Jerzy family, associated with another family capital group- Immobile S.A., which remained unchanged throughout the study period. However, in the case of Atrem S.A., Rafał Jerzy decided to accept the position of supervisory board member. The second company was Capital Partners S.A., which, since 2019 has had no other family members besides the founder and CEO- Paweł Bala. Cyfrowy Polsat S.A. also no longer meets the requirements set for family businesses in this study after the change of CEO from Tobiasz Solorz, who was related to the family of Zygmunt Solorz-Żak (founder and indirectly the main shareholder) to Mirosław

Błaszczak. In 2020 companies that lost their family status according to the criteria adopted for the research were: Indypol S.A. (sold to a French poultry company), Krynica Vitamin S.A. (resignation from the position of chairman of the supervisory board belonging to the family, no other family members except CEO), Pozbud T&R S.A. (sale of the company), Wadex S.A. (delist of shares from the WSE), Arcus S.A. (delist of shares from the WSE) and Inter Cars S.A. (it ceased to meet the family criteria adopted for the study, however, it is an interesting case because it is a company that completed the full management and ownership succession in the indicated year-2020). In 2021 companies that no longer meet the family requirements adopted for the study were an example mentioned and described earlier Archicom S.A., PGS Software S.A. (sold to the Dutch capital group - Xebia Group) and Groclin S.A. (changes in the shareholding structure, management and supervisory boards- no family members). In the following year, changes took place in the following companies: Izo- Blok S.A. (sale of ownership to a foreign entity), Eurocash S.A. (changes in the management and supervisory boards, loss of the CEO position by the family) and Vistal Gdynia S.A. (changes in management board and loss of the CEO position by the family; what is more in 2024 the company declared bankruptcy). In 2023 only one company- Master Pharm S.A. decided to delist of shares from the WSE. In the last year covered by the study, Drozapol Profil S.A. and Comarch S.A. decided to delist shares from WSE, and Comarch was sold by the Filipiak family to CVC Capital Partners. Research conducted over a ten-year period revealed that 22 companies, for various reasons lost their family status according to the definition adopted for the study. At the end of the research period, the number of family companies that still met the requirements was 32. The last research section will address their characteristics in 2024 and conclusions.

Table 6.
CEO sex in listed family companies in 2024

CEO sex	Number of companies	Percentage share of companies
Male	30	93,75%
Female	2	6,25%
Total	32	100%

Source: author's own elaboration.

Table 7.
Age of CEOs in listed family companies in 2024

Age of CEOs (in years)	Number of companies	Percentage share of companies
Under 40 years old	2	6,2%
Under 50 years old	7	21,9%
Under 60 years old	12	37,5%
Over 60 years old	11	34,4%
Total	32	100%

Source: author's own elaboration.

Table 8.*Education level of CEOs in listed family companies in 2024*

Education level	Number of companies	Percentage share of companies
Vocational/secondary education	4	12,5%
Higher education	27	84,4%
Ph.D. or higher	1	3,1%
Total	32	100%

Source: author's own elaboration.

Comparing data from a ten-year analysis of family companies' presence on the WSE, it is particularly noteworthy that their numbers are decreasing (according to the criteria adopted for the study), with a decline of 40.7%. Another concerning finding is the CEO age. At the time of the study's conclusion, 71.9% of all family CEOs were in the under-60 and over-60 age group (Table 7). At the time of the study's inception, this group was 51.85% (Table 4). A particular increase occurred in the over-60 age group (an increase of 19.59%). These results clearly signal a problem with the management and ownership succession in family companies listed on the WSE. In the group of companies that met the family-based criteria adopted for the study, only three companies underwent an intra- family management succession process during the study (Enel-Med Medical Center S.A. – Jacek Rozwadowski took over as CEO in 2018, Fasing S.A. – Mateusz Bik took over as CEO in 2024, and Mercator Medical S.A. – Monika Żyznowska took over as CEO in 2024). However, none of them underwent a full succession process. Energoinstal S.A. is also among the companies that underwent a management succession earlier. It should also be noted that despite the passage of time, the dominant CEO pattern is predominantly male (Table 6). Regarding the level of education at CEO level, higher education still dominates (Table 7).

6. Discussion

The data collected from the ten-year analysis of the presence of family companies in the WSE indicate that a significant number of them treat their presence on the stock exchange as a temporary solution. During the study period, new family companies meeting the criteria adopted for the study emerged, which were not subject to analysis. This could be considered a criticism of this article. However, Grant Thornton employs this approach in its annual reports, and analyzing these results would suggest that family companies have a stable position on the WSE (Grant Thornton, 2022-2025). These conclusions contradict those obtained by the author of this article. The aim of this paper was to thoroughly and long-term examine how family companies behave on the WSE and what changes occur in the context of generational change in key functions like management and supervisory boards.

Reflecting on the results, the author would like to highlight another topic that, in her opinion requires further discussion- the definition of family companies. The definition adopted by the author meant that Inter Cars S.A., the only company to experience full succession during the research period, no longer met the accepted family requirements. After the succession, only one family member held the position of CEO and ownership, and there were no other related family members in other management and supervisory bodies. While the company's website, in the investor relations section, states that Krzysztof Oleksowicz (the father and former CEO) serves as a strategic advisor to the company, but he is not included in any formal documentations. The adopted criteria required more than one family member. Therefore, the question arises whether the criteria for defining family companies should be changed after the transition from the first to the second generation. Or perhaps the heterogeneity of these entities, as indicated in the theoretical section, makes their unambiguous definition difficult. The relevant issue is also raised in the article by W. Popczyk and A. Winnicka-Popczyk, which focuses on considerations regarding contemporary criteria for defining family businesses (2022).

It's also worth exploring the approach to the succession process by the owners/founders of family companies themselves. Perhaps the need for intra-family succession is no longer dominant and perhaps other patterns are currently dominant in which, for example, the family retains only ownership and/or supervision of the company, handing over management functions to external managers, as was the case at PA NOVA S.A. It's also significant that seniors are reporting a lack of interest in the second-generation succession process –for example in Archicom S.A., which due to a lack of interest in taking over management and/or ownership, was sold to an external entity. An equally interesting case involves Comarch S.A., which following the death of CEO and founder Janusz Filpiak, was also sold to an external entity, despite the senior's stated desire for intra-family succession. The author of this article has been trying to research the indicated issue for a long time, however the lack of clarity in the highlighted area may result from the heterogeneity of the analyzed group of enterprises (Majda-Kariozen, 2025).

The analysis conducted only allows for the identification of decisions, but does not allow for the understanding of the determinants influencing a given decision of the listed family businesses. It's worth examining, within the framework of qualitative research, what variables influence decisions regarding the future of the discussed group of entities. As suggested in the theoretical section, this is the family system (Miroshnychenko et al., 2021; Chrisman, Chua, Sharma, 2005). Therefore, examining the determinants of its structure should help answer this question. However, the author of this paper would like to reiterate the heterogeneity of this group of entities, which may translate into difficulties in identifying these variables.

7. Summary

The results of the study indicate that not all family companies have established themselves on the WSE. Comparing data from a ten-year analysis of family companies' presence on the WSE, it is particularly noteworthy that their numbers are decreasing (according to the criteria adopted for the study), with a decline of 40.7%. The most common phenomena that occurred during the ten-year study period include the sale of the company, delisting of shares from the WSE, or changes in management, supervisory and/or ownership structure.

The age of the CEO at the time of the study's conclusion is also a concern when assessing the presence of family companies on the WSE. The data obtained clearly indicate a problem with the process of management and ownership succession. This situation indicates the need to verify the preferences of current CEOs, who are the vast majority founders of these companies. Depending on this decision, it may be necessary to redefine the concept of a family company.

Once again, the author of this article would like to emphasize that during the study period, new family companies meeting the criteria adopted for the study emerged, which were not subject to analysis. This could be considered a criticism of this article. However, the lack of in-depth analyses verifying the behavior of family companies on the stock exchange may result in misleading results. What is more the conducted analysis shows only the state of decision-making regarding the future of the company, but does not show the factors influencing a given decision. These variables may result from the family system. In reference to the literature on the subject, the family system is a key system influencing decision-making in family businesses. Given this significant change in the presence of family businesses included in the study, it seems justified to conduct qualitative research to understand the reasons for decisions made within highlighted system. However, due to the nature of the family system and the significant complexity and heterogeneity of this group of entities, this may prove difficult or impossible to determine.

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MAN AND MACHINE: THE LIMITS OF HUMANITY AND AI. PROLEGOMENA

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Purpose: The aim of the publication is to analyze the limits of artificial intelligence in emulating the human mind and to show that, although AI can imitate cognitive processes, it remains far from fully capturing the specificity of human nature, which encompasses dimensions such as imagination, intuition, emotionality, and creative reflection.

Methodology: The publication is theoretical in nature and is based on an analysis of the relevant literature. The applied method allowed for an examination of the current state of knowledge by combining reflection on the concept of human nature with a critical interpretation of literature in the field of artificial intelligence research. The analysis focuses on comparing the functional capabilities of AI with the essence of the human mind and its elusive dimensions.

Findings: The publication highlights key issues related to the impact of AI on the condition of contemporary humans: the development of AI allows us to examine which aspects of human functioning can be formally captured and which remain elusive. Humans are not limited to information processing; they experience meaning, values, and responsibility, which go beyond the capabilities of AI. Analyzing these relationships leads to a deeper understanding of the differences and similarities between human and artificial intelligence.

Social consequences: The social consequences of the increasing significance and role of AI may include the need to revise the division of roles and responsibilities between humans and machines, the strengthening of the importance of ethical competencies, and the development of debates on regulations and the limits of artificial intelligence applications in social life.

Originality: The study indicates which aspects of human functioning can be replicated in computational systems and which remain elusive, treating artificial intelligence as a tool for exploring human nature.

Keywords: human, artificial intelligence, phenomenology, functionalism, subjective experience, human nature, human-machine relation.

Category of the paper: conceptual paper, viewpoint.

Introduction

The development of artificial intelligence systems in recent decades from classical symbolic algorithms to contemporary deep learning models and large language models (Kaplan, 2025) poses a question that has for centuries stood at the core of philosophical reflection: what, in fact, is a human being, and what distinguishes humans from machines? In an era when machines are capable of generating language, solving problems that require planning, and displaying apparent forms of creativity, the classic question “what makes us human” returns with renewed force and in a new context. It is no longer merely a problem of abstract philosophy; it is becoming a real epistemological, ontological, and ethical challenge (Harari, 2024). The reflections focus on the question of whether intelligence, understood as the capacity to process information, learn, reason, and adapt, constitutes the entirety of humanity, or whether there are aspects of human nature that cannot be reduced to it. In the context of contemporary AI systems, which can imitate human behavior at a functional level, the problem becomes particularly pressing (Chalmers, 2010). Is the simulation of thinking and understanding equivalent to genuine thinking? Does the ability to perform cognitive tasks imply participation in the same experience of consciousness and responsibility that is proper to human beings?

Meanwhile, the literature on artificial intelligence is dominated by analyses focusing on the technical capabilities of computational systems and their functional effectiveness in performing cognitive tasks. Much less frequently undertaken is an in-depth reflection on the ontological consequences of a functional understanding of intelligence, or on whether the ability to simulate intelligent behavior can be regarded as a sufficient criterion of humanity. This creates a research gap concerning the relationship between a functional conception of intelligence and the multidimensional structure of human subjectivity. Based on these gaps in the literature, the article proposes the hypothesis that the ability of artificial intelligence systems to simulate intelligent behavior does not exhaust the full structure of humanity, as it does not encompass the dimensions of phenomenal consciousness, embodied existence, and normative responsibility. The objective of the article is to analyze the limitations of a functionalist understanding of intelligence in the context of contemporary artificial intelligence systems, particularly large language models. The study has a philosophical-analytical character and is based on a conceptual analysis of key concepts such as intelligence, consciousness, intentionality, and subjectivity, as well as a comparison of the functional model of intelligence with the operational principles of contemporary AI systems and a critical reflection on the limitations of functionalism in capturing the full structure of humanity, highlighting dimensions that are irreducible to computational processes. The contribution of the article lies in demonstrating that the ability to simulate intelligent behavior does not exhaust the structure of the human mind. The analysis shows that dimensions such as phenomenal consciousness, embodiment, and normative responsibility remain irreducible to functional models of

information processing. In this way, the article contributes to a deeper philosophical reflection on the relationship between humans and artificial intelligence.

Cogito ergo sum... or not?

In the context of research on thinking machines, the discussion of what makes us human naturally focuses on the concept of intelligence. A fundamental question arises: is the capacity to “think” in a computational sense sufficient to regard a system as intelligent in the full, human sense? This problem has been considered in modern philosophy and cognitive science by both classical thinkers and contemporary researchers of artificial intelligence (Chwedeńczuk, 1995; Prescott, 2025). The beginning of the modern debate on “thinking machines” is associated with Alan Turing’s work *Computing Machinery and Intelligence* (Turing, 1950). Instead of asking the metaphysical question, “can machines think?”, Turing proposed to operationalize the problem in the form of the so-called imitation test. The criterion did not refer to the internal structure of the machine, but to its behavior: if, in the course of linguistic communication, a system proves indistinguishable from a human for a competent observer, then in a functional sense the system may be said to “think”. In the functionalist approach, mental states are defined by their role within a system: by input–output relations, patterns of information processing, and the function they perform in generating behavior (Dennett, 2016). In this sense, it does not matter what “material” the subject is made of whether biological or silicon-based. What matters is its functional organization. The Turing test shifts the centre of gravity from ontology to epistemology: instead of examining what thinking is “in itself”, we ask according to what criteria we can attribute it to someone. Intelligence becomes identified with the ability to produce contextually appropriate responses that are semantically coherent and pragmatically effective, such that an observer cannot distinguish the machine from a human. Contemporary language systems, especially generative models, are approaching the realization of this criterion in certain domains (Kaplan, 2025). In this sense, Turing’s project proved prescient, for intelligence appears as an engineering problem rather than a metaphysical one: functionalism, in Turing’s formulation, makes it possible to separate science from metaphysics. It becomes possible to study machine intelligence empirically: we measure effectiveness in performing cognitive tasks, generating coherent responses, or adapting to new problems: “We cannot rule out the possibility that one day some large generative network will begin to talk with us and we will be able to ask it for explanations” (Sejnowski, 2019, p. 151). However, this shift carries a significant philosophical consequence: if intelligence is taken as a sufficient criterion for humanity, then the human being ceases to be perceived through the lens of subjective perspective and individual experience, and instead begins to be evaluated according to measurable functions. To be human would mean nothing more than effectively processing

information, generating responses, and adapting to a symbolic environment. This perspective, however, leads to a far-reaching reduction, narrowing the concept of humanity to a set of cognitive competences that can be described in functional and operational terms. Functionalism assumes, often only implicitly, that everything essential to the mind can be captured in the structure of functional relations, that is, in the way processes are organized and interconnected. Consequently, consciousness can be interpreted as a particular type of computational organization, meaning as the result of operations performed on symbols, and subjectivity as the effect of integrating informational processes into a coherent whole. As Dennett observes: “Essentially, it does not matter whether a system is made of organic particles or silicon, as long as it performs the same task. Artificial hearts do not need to be made of organic tissue, so artificial brains need not be either - at least in theory. If all the control functions of a human wine taster’s brain can be reproduced using silicon circuits, the pleasure will be *ipso facto* reproduced along with them” (Dennett, 2016, p. 47). Understood in this way, the perspective shifts the focus from the ontological status of the person to their functional structure, leading to the conception of the human primarily as an information-processing system whose properties can be described, modeled, and reconstructed in formal terms. Such an approach may result in cognitive reductionism, in which humanity is reduced to intellectual capacities, while other dimensions, such as embodiment, emotionality, existential aspects, or normativity, are treated as secondary to information processing. From this perspective, the distinction between humans and advanced artificial intelligence would be quantitative, depending on the system’s level of complexity, the amount of data processed, or the speed of computation, rather than on essential qualitative differences. The human-machine boundary would thus become fluid and largely technical, practically reducible to the operational parameters of the system (Dennett, 2016).

Although the functional paradigm defines intelligence as the ability to effectively process information and generate appropriate responses, it reveals a number of critical tensions that highlight its limitations as a criterion for humanity. The first of these relates to the very process of understanding: the question arises whether a system that produces correct answers actually understands their meaning, or merely manipulates symbols according to formal rules. A classic illustration of this problem is Searle’s Chinese Room argument, which shows that even if a machine behaves intelligently from an external perspective, it lacks access to the semantics of the symbols, because there is no internal subject that genuinely understands. This issue will be explored in greater detail later in the publication. The second tension is ontological: the Turing test measures only the external indistinguishability of human and machine behavior, without resolving whether the system possesses any experience, intentionality, or first-person perspective. From Nagel’s point of view, even the most functionally complex systems cannot capture what it is “like” to be a conscious subject, because subjective experience cannot be reduced to behaviors observable from the outside (Nagel, 1997). This criterion is therefore pragmatic and epistemic in nature; it does not encompass or resolve metaphysical problems. The third tension concerns normativity: the functional understanding of intelligence focuses on

adaptive effectiveness, whereas humans are not limited to reacting to stimuli and optimizing actions; they are capable of questioning their own goals, refusing to act, acting against their own interest, or sacrificing themselves for the sake of values (Schaich-Borg, Conitzer, Sinnott-Armstrong, 2024). Reducing humanity to cognitive competences thus overlooks a crucial normative and existential dimension. Therefore, in the context of AI, the boundary between humans and machines is not merely a matter of technical parameters, system complexity, or the amount of data processed. It is philosophically rooted in the structure of subjectivity, in consciousness, intentionality, and normative responsibility, qualities that no machine, however advanced, possesses. As Putnam observes: “Admittedly, a machine may converse beautifully about, say, Polish landscapes. However, it would not be able to recognize a tree, an apple, a mountain, or a cow, a field, or a tower if placed before any of these things. There is no reason to believe that when a machine talks about apples, its words refer to actual apples, just as there is no reason to believe that an ‘outline’ of an ant refers to Winston Churchill” (Putnam, 1998, p. 309). Reducing these aspects to functional operations can create the mistaken impression that computational intelligence exhausts the essence of human being, whereas in reality they remain dimensions that cannot be translated into formulas, models, or algorithms, dimensions that make a human a conscious, moral, and self-aware subject. Consequently, although the functional paradigm has proven methodologically groundbreaking, enabling empirical research on artificial intelligence, its application as a criterion for humanity is insufficient. It does not engage with metaphysical questions that go beyond functional effectiveness and therefore overlooks the deeper dimensions of human existence: phenomenal consciousness, embodied existence, intentionality, and normative and moral subjectivity. Behavioral indistinguishability, then, guarantees neither understanding, consciousness, nor normative subjectivity. Efficient information processing and generation of appropriate responses may constitute a necessary condition, but they are insufficient for full human being. A profound insight in this context is provided by Kołakowski, who notes: “Sciences measure things without knowing what they measure; in performing cognitive acts, they are unable to grasp the acts themselves. They are incapable of spontaneously creating their own meaning and justifying their claims to objectivity” (Kołakowski, 2003, p. 32).

Man and machine

Since the functionalist conception of intelligence redefines the boundary between humans and machines, the fundamental question is whether its assumptions are borne out in actual artificial intelligence systems. Contemporary large-scale language models represent the most advanced realization of this paradigm, and therefore their analysis allows for an empirical examination of the philosophical consequences of functionalism.

The functionalist paradigm in the context of contemporary artificial intelligence systems gains a new perspective in the 21st century through large-scale language models (LLMs) such as GPT, PaLM, and LLaMA. These systems are based on transformer neural architectures, which enable the models to capture complex statistical dependencies present in data sequences. By analyzing vast text corpora, they identify linguistic regularities and extract recurring structural and semantic patterns. On this basis, the models generate predictions of subsequent tokens according to the context of an utterance, which in practice results in coherent, logically connected language sequences often interpreted as a sign of “understanding” (Kacprzak, 2024). At the same time, these systems demonstrate the ability to adapt to new tasks through procedures such as fine-tuning or prompt engineering, without the need to modify the underlying model architecture. This mechanism reflects the functionalist conception of intelligence, in which the essence of intelligence is determined by the cognitive function it performs, rather than the material substrate on which it is implemented. In practice, LLMs are capable of producing grammatically flawless statements, answering questions, and creating coherent narratives, which from the perspective of the Turing test can be interpreted as “intelligent behavior”. As Kaplan notes: “Generative artificial intelligence shakes the foundations of our sense of self and challenges our view of human uniqueness in much the same way the Copernican revolution altered our understanding of the solar system by placing the Sun at its center. Are we merely a stepping stone to a new form of non-biological life? Or are we simply getting better at constructing useful gadgets?” (Kaplan, 2025, p. 16). Technical analysis, however, reveals significant limitations of the functionalist approach to intelligence in the context of large language models. First, these models do not possess internal semantics; they operate solely on token statistics and correlations between them, without forming meaningful representations in a subjective sense. In Searle’s terminology, such a system “processes symbols” but does not understand them (Searle, 1995). Despite the impressive capabilities of contemporary LLMs, a crucial philosophical and technical limitation emerges: the absence of genuine understanding of meaning. Searle articulated this critique of functionalism in the context of functional intelligence through the Chinese Room argument. Imagine a language model that receives text in Chinese and generates correct responses using only statistical procedures and transformational rules. From the outside, the system’s behavior is flawless: it responds sensibly, coherently, and appropriately. Yet, it contains no semantic representation or subjective understanding of the language. The model manipulates symbols based on statistical patterns from training data, but it does not “know” what they mean, just as a person in the Chinese Room manipulating symbols according to instructions does not understand the language, even if their responses appear correct to an observer. Contemporary neural models confirm Searle’s fundamental thesis that simulating understanding is not equivalent to actual understanding, that the absence of intentionality and a first-person perspective limits the system to the syntactic rather than the semantic level, and that external evaluation of behavior cannot fully reveal the internal state of the model. The fact that responses are sensible does not prove

the existence of a subjective perspective. Searle argued that: “Equipping any artifact we build with a computer program is not sufficient for it to have mental states comparable to human ones. Such an artifact should, of course, have causal powers comparable to those of the human brain. Brain activities limited only to executing a computer program are not sufficient for the functioning of the brain to give rise to a mind” (Searle, 1995, p. 36). Consequently, the Chinese Room argument reveals a fundamental ontological gap, as it exposes the difference between simulation and realization. Simulating a cognitive process is not equivalent to its actual occurrence, just as simulating a physical phenomenon is not the phenomenon itself. A language model may reproduce the structures of reasoning, but it does not need to possess the states that, in humans, constitute the experience of understanding; it does not experience meanings, relate them to the world intentionally, or have a first-person perspective. This problem is illustrated by Chalmers, who analyzes a hypothetical system capable of reporting its own perceptual states. Such a system could claim that it “sees” an object and base its beliefs on this claim, even though it would be unclear whether it actually experiences anything. As Chalmers notes, it is more likely that the system would respond: “I know there is a red tricycle there because I see it”, and if asked how it knows that it sees it, it would reply: “I just see it” (Chalmers, 2010, p. 317). This description shows that the functional ability to report cognitive states does not entail the existence of phenomenal experience. A system may behave as if it has access to its own experiences, even though there is no basis for asserting that any experiences actually occur. Thus, the simulation of cognitive processes does not imply the existence of consciousness or a first-person perspective. A similar point is made by Sejnowski: “Although neural networks correctly solve the tasks assigned to them, we currently do not have an appropriate method that could explain how they arrive at the correct answers” (Sejnowski, 2019, p. 150). This gap is structural, not gradual. It does not concern the level of system complexity or the scale of its computational capacities, but the very kind of being we are dealing with. On one side is a functional system whose operations can be described in computational and behavioral terms; on the other is a subject capable of experiencing, understanding, and relating to meanings internally. Even perfect alignment of a model’s behavior with that of a conscious being does not eliminate this difference, because it concerns not what the system does, but what it is and whether it possesses a qualitative dimension of experience.

In this sense, the ontological gap indicates the limits of functionalist explanations of the mind. It shows that describing a system’s operations, even in extremely precise and complete terms, may not suffice to explain the existence of consciousness or subjective understanding. There remains a distinction between operational efficiency and phenomenal experience, a distinction that cannot be reduced to mere function, structure, or behavior. It is precisely this irreducible difference that forms the core of the ontological problem in the analysis of contemporary artificial intelligence systems. Another important limitation is the lack of intentionality and subjectivity. The cognitive capacities of models are largely determined by the scope and quality of the training data, and the systems themselves do not “think” or form

concepts independently of the available information, which restricts their cognitive autonomy. Furthermore, these models lack embodied experience; the absence of sensory input and interaction with the physical world means that their “situational awareness” is purely syntactic and contextual rather than phenomenal, that is, devoid of subjective experience. As Przeglasińska notes: “Humans use body language, facial expressions. This is our interface. It gives us an advantage in discussion; it is in itself more persuasive than a computer block standing in front of you and presenting arguments” (Przegalińska, 2020, p. 109). Consequently, although language models can generate behaviors resembling intelligence, the question remains open as to whether these behaviors are sufficient to capture the fullness of human being or to draw conclusions about the nature of humanity. Analyzing contemporary large-scale language models (LLMs) in light of the functionalist paradigm, several key aspects can be observed. First, intelligence in this framework is perceived as irreducibly behavioral; it is evaluated based on manifested behaviors rather than by analyzing internal states, processes, or the structure of the system. Language models practically illustrate the potential of functionalism, as many behaviors traditionally considered signs of intelligence can be effectively replicated in digital systems. At the same time, a significant ontological gap remains: these models lack consciousness, intentionality, and the capacity for normative responsibility. They can simulate reasoning processes and generate meaningful responses, but they do not possess a first-person perspective or genuine understanding of meaning. As Schneider observes: “Currently, we face the question of consciousness - a kind of ‘hard problem’ of machine consciousness: whether information processing by AI will be associated with any internal experiences” (Schneider, 2021, p. 32). In this sense, LLMs confirm both the strengths and the limitations of the functionalist paradigm: they demonstrate that intelligence can be formalized and implemented in machines, yet at the same time they reveal that functionally intelligent behavior is not equivalent to humanity and is far from capturing the essence of the mind and human being. The way LLMs operate exposes the ontological limits of functionalism: intelligence in the sense of symbol processing does not provide subjective experience, normative subjectivity, or the capacity for creatively assigning meaning and value. In this context, one can refer to the embodied approach, which emphasizes an aspect of cognition unavailable to artificial intelligence: “The embodied approach to studying cognitive processes is based on the thesis that a condition for understanding the nature of cognition is to pay attention to the essential role played by the acting body, situated in a specific environment and interacting with it dynamically, online, and without mediation by representations” (Przegalińska, 2016, p. 178).

The analysis of the functionalist paradigm in relation to contemporary language systems reveals a subtle yet crucial problem: the simulation of behavior is not equivalent to the experiencing of consciousness. Machines can generate utterances suggesting an emotional state, report their own “experiences”, or respond contextually, both in Turing tests and in everyday interactions with LLMs. However, these actions remain entirely syntactic and formal; from the outside, they may appear as intelligent responses, but internally there is no subject that

actually experiences anything. Philosophically, this exposes a significant gap between the functional capacity to behave intelligently and phenomenal consciousness (Chalmers, 2010). The fact that a machine can “describe” emotional states or coherently report its “experiences” does not imply the existence of a subjective point of view. Subjectivity and experience are inextricably linked to a first-person perspective; without it, we observe only an external effect, a semblance of intelligence that is not fully human. In this sense, contemporary LLMs, despite their impressive ability to imitate behaviors and create first-person narratives, remain “black boxes” without a subjective interior. Their functioning may be functionally analogous to human thinking, but there is no guarantee that they actually “experience” anything. This raises the need for deeper reflection on the limits of artificial intelligence in the context of what defines human existence and allows us to speak of it as a unique form of being, especially as Harari notes: “Science concentrates all its claims in a single all-encompassing dogma, which states that organisms are algorithms, and life is data processing. Intelligence separates from consciousness. Devoid of consciousness but extremely intelligent algorithms may soon know us better than we know ourselves” (Harari, 2015, p. 445). Technological development provokes a shift in the boundaries of subjectivity and cognitive capacity. The question of the limits of artificial intelligence thus becomes, in essence, a question about the limits of humanity. The focus shifts from anthropology to modern technology. The question is old, but it arises in a new configuration: who is human, and in what sense do consciousness, subjectivity, and the capacity to assign meaning determine our uniqueness and remain the foundation for understanding our existence in terms irreducible to an algorithm. To speak of what truly makes us human, it is not enough to analyze cognitive abilities or external behaviors. One must consider the subjective dimension of experience, embodied existence, and normative responsibility (Przegalińska, 2016). Machines can simulate intelligence and generate linguistic descriptions of states and relations, but “thinking” in the functional sense does not imply being a subject that experiences. In this light, the Turing test and AI simulations remain extremely valuable research tools, but they do not resolve a question constitutive for the philosophical understanding of humanity: whether we are dealing with a being capable of lived experience, or merely a system reproducing its external forms. They rather reveal the limits of formal intelligence: limits that indicate that phenomenal consciousness and subjectivity remain a qualitatively distinct dimension from functional cognitive competencies (Przegalińska, Triantoro, 2025).

Conclusion

The development of artificial intelligence does not so much pose entirely new questions as it radically intensifies old ones, forcing us to reconsider them in light of new technological possibilities. Already in classical debates in the philosophy of mind, the relationship between function and experience, between behavior and lived experience, and between structure and meaning was already being examined (Searle, 1995). However, it is only with the emergence of systems capable of autonomously generating utterances, learning from data, and simulating decision-making processes that these questions cease to be purely speculative. They become experimentally tangible: machines are no longer merely hypothetical thought constructs, but real cognitive partners with whom humans interact, as Przeglasińska aptly notes: “Chatbots and avatars defy the label of ‘computer program’; they are something much more, something that enters into an interesting, complex relationship with the identity and consciousness of the subject who chooses to engage in virtual reality” (Przeglasińska, 2016, p. 189). In this sense, artificial intelligence functions as a kind of “epistemic mirror.” It allows us to observe which aspects of human functioning can be formally described and reproduced, and which elude modeling. Every success of AI systems in pattern recognition, language generation, or action planning provokes the question of whether a given capability was truly a constitutive feature of humanity or merely a functional manifestation of it. At the same time, every technological boundary, difficulties in capturing subjective experience, normative meaning, or the full existential context, points to potential dimensions of human uniqueness. The development of artificial intelligence thus operates as a tool of philosophical reduction: it systematically tests hypotheses about the nature of humans through attempts at their implementation. From this perspective, the question of humanity is no longer merely about what humans are, but also about what can be reconstructed, simulated, or replaced. The problem thus takes on a comparative form: it is not only about describing human nature, but about determining the ontological difference between biological beings and computational systems. Is this difference merely one of degree, arising from the level of complexity, or is it qualitative, concerning the very mode of existence? In other words, is a human being simply a particularly complex information-processing system, or a being whose structure encompasses dimensions irreducible to computation? This distinction directly leads to the tension between functional description and phenomenological description. Artificial intelligence models operate at the level of formal relations: symbol transformations, statistical structures, or vector representations. Meanwhile, human existence reveals itself not merely as a system of cognitive operations, but as a lived world of meanings, values, and references. Humans do not simply process information; they experience significance, suffer, desire, make decisions within a horizon of responsibility, and live in a world that is always already meaningful to them. Kołakowski observes that human existence has always developed in the context of symbols and myths, which give significance

to experience and shape our understanding of the world. Humans are not merely a collection of cognitive functions or biological mechanisms; their psychic and cultural life creates dimensions of meaning, value, and subjectivity that exceed the scope of simple data analysis (Kołakowski, 2005). If these aspects cannot be fully captured in functional terms, then computational intelligence, no matter how advanced, cannot exhaust the structure of humanity (Przegalińska, 2016). At the same time, the development of artificial intelligence forces a more precise clarification of what we actually mean by consciousness, embodiment, and normativity. These concepts cannot remain merely intuitive references to “what is human”, but require systematic philosophical analysis capable of engaging with cognitive science and artificial systems theory (Prescott, 2025). The stake is not merely defending human uniqueness, but developing an adequate model that allows us to understand the relationship between different forms of biological and artificial intelligence without reductionism, yet also without unjustified anthropocentrism. In this sense, a layered model of humanity is both analytical and methodological. It does not presuppose an insurmountable gulf between humans and machines, but systematically examines the levels at which similarity is possible and those at which qualitative differences emerge. This model allows computational intelligence to be treated as one level of description, a functional level that can be shared by both biological and artificial systems, but one that does not exhaust the full structure of human existence (Bennett, 2025). Ultimately, reflection on artificial intelligence becomes reflection on the limits of reduction. It asks not only what machines can do, but also what cannot be reduced to mere function. At this point, the problem of artificial intelligence becomes, in the deepest sense, an anthropological problem: it forces us to reconsider whether humanity is a functional, phenomenological, existential, or normative category, or perhaps a multilayered structure that no single description can fully capture. As Kołakowski notes: “One could say that in the entire universe, a human cannot find a well so deep that, leaning over it, they would not discover their own face at the bottom” (Kołakowski, 2000, p. 78). This serves as a starting point for further reflection, in which successive dimensions of humanity will be examined not only in isolation but also in their interrelations. Only through their integration can we grasp whether, and in what sense, it is possible to compare humans and artificial intelligence, and where the boundary lies between simulation and being.

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LANGUAGE AND SOCIAL IDENTITY: GENERAL AND PRACTICAL INSIGHTS

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Purpose: This paper explores the relationship between language and social identity by integrating theoretical perspectives with an empirical case study. It examines how linguistic practices and communication styles shape social identities within popular culture through the analysis of a selected mass media text. The study identifies linguistic features that differentiate characters from diverse socioeconomic backgrounds and assesses whether speech patterns remain consistent within social groups, with implications for communication management, communication quality, and the effectiveness of social interaction processes contributing to social capital.

Design/methodology/approach: The research combines quantitative analysis of lexical diversity with qualitative examination of the most frequently used vocabulary by the characters. Additionally, extended text fragments were analysed to explore communicative contexts, interactional patterns, and communication processes relevant to communication management. Particular attention was paid to communication effectiveness, consistency, and performance across both homogeneous and heterogeneous social groups.

Findings: The results indicate that differences in language use and communication styles across social groups significantly shape perceptions of class and status, reinforcing social hierarchies within the play. These differences also influence communication performance, perceived communication quality, and the efficiency of communication management processes, thereby affecting access to social capital.

Research limitations/implications: The study is limited to a single literary work, which may not fully reflect the complexity of communication processes and quality-related outcomes in broader social or organisational contexts. Future research could apply this approach to other literary texts, media narratives, or organisational communication settings to further evaluate communication effectiveness and quality under diverse conditions.

Social implications: By demonstrating how language use and communication styles reinforce social class distinctions and affect communication quality and performance, the study raises awareness of linguistic discrimination and its consequences for inclusive and effective communication in society.

Originality/value: The paper contributes to the literature by linking sociolinguistic theory with a quality-oriented analysis of communication practices in popular media. By emphasising communication management, quality, and performance outcomes, it highlights the relevance of sociolinguistic insights for improving communication processes in cultural and organisational

contexts. The study is particularly valuable for scholars in management, quality studies, sociolinguistics, and the social sciences.

Keywords: social identity; style of communication; communication management; quality of communication; communication effectiveness; social capital.

Category of the paper: case study.

Introduction

Language is more than a means of communication—it is a powerful marker of identity and a tool through which social realities are constructed, negotiated, and maintained. The relationship between language and social identity has been the subject of extensive scholarly interest, particularly within the fields of sociolinguistics, linguistic anthropology, and discourse studies. Through language, individuals signal their belonging to particular social groups, express solidarity or distance, and navigate complex networks of power and cultural affiliation.

This paper explores selected theoretical perspectives on the connection between language and social identity, with a particular focus on how linguistic practices both reflect and shape individual and collective identities. Special attention is given to the role of language in constructing social meanings within the context of popular culture, where identity narratives are often reinforced or contested through media discourse.

The empirical part of the paper presents a case study analysis of a selected text of mass culture, illustrating how language functions as a vehicle for social identity construction in a contemporary media context. This case study approach allows for a close examination of concrete linguistic features and their social implications, offering practical insight into the theoretical issues discussed in the first part of the study. This case study aims to analyse the linguistic features that distinguish characters from different socioeconomic backgrounds within the play, shedding light on how these features contribute to the construction of social identities.

Additionally, the paper seeks to explore how these linguistic differences convey and reinforce societal attitudes toward class and inequality. A qualitative research method was primarily used, complemented with qualitative data. This mixed method allowed for a more thorough analysis of language, while also providing an opportunity for interpretation and contextual understanding. Although the case study focuses on a musical, its themes are deeply rooted in reality. Willy Russell wrote ‘Blood Brothers’ through the lens of someone who grew up in Liverpool during that time, having personally experienced the prejudices and inequalities depicted in the story. The play functions as a powerful social commentary, reflecting the realities of class divisions and societal injustices. Analysing the play is important as it offers insight into how language can both mirror and perpetuate societal inequalities, making it an important work for understanding the intersection of language, class, and identity.

Theoretical background

Social identity – definition

As opposed to personal identity, which refers to the idiosyncratic characteristics that make up a person, such as appearance or interests (Ashforth, Mael, 1989), social identity suggests that individuals possess a collective identity shaped by their affiliation with certain groups, such as a racial or occupational identity (Tajfel, Turner, 1986). Social identity theory, formulated by Henri Tajfel and John C. Turner in the 1970s, suggests that people's sense of self-esteem is derived from the status and achievements of the groups they belong to (Tajfel, Turner, 1986).

Social identity theory is closely linked to self-categorisation theory, which describes how belonging to social groups influences our self-perception and the way we perceive others (Abrams, Hogg, 2010). Humans view groups as sets of characteristics (attitudes, behaviours, customs, and so forth) which outline similarities within groups or set them apart from each other. These attributes are represented in one's mind in the form of a *prototype*. If enough people share the same prototype of a group, the prototype ultimately becomes a stereotype (Hogg, 2016).

Language and its role constructing social identity

Language plays a pivotal role in the construction of social identity. As described in the findings of Rakić et al. (2011) and those of Paladino and Mazzurega (2020), language may have a more significant role in social interactions than other markers of social categorisation, such as ethnicity (Champoux-Larsson et al., 2022).

Individuals actively construct their own social identities through the use of language, whilst also being influenced by others in their linguistic environment (Ochs, 1993). The relation between language and social identity is not direct, but rather mediated, meaning that it is influenced by a shared understanding within a community or culture about how language should be used in specific social situations. Social identity is not explicitly encoded in language but rather inferred based on perceived meanings of linguistic acts and stances. When people communicate, they don't usually state their social identity directly; instead, others infer or deduce their social identity by interpreting the meanings conveyed through the way they speak and the attitudes they express (Ochs, 1993).

Sociolinguistic concepts and their application

According to Ochs (1993), the choice of linguistic structures is not random, but linked to cultural expectations. The way people communicate can reveal a lot about their social identity, like their occupation or their role in a family. The way the interlocutor¹ interprets and assigns a person to a specific social identity depends on the interlocutor's understanding of how certain acts and stances encoded by these linguistic structures are linked to certain identities (Ochs, 1993).

It is important to understand that language in relation to social identity is dynamic and not always universal. The way people talk and express themselves can vary from person to person, and the tie between language and social identity is not always clear. Social identities also change over time during social interactions, influenced by how people behave and respond to each other (Ochs, 1993).

As defined by Spolsky, “sociolinguistics is the field that studies the relation between language and society, between the uses of language and the social structures in which the users of language live” (1998, p. 3).

In linguistics, there are many subsets of language. ‘Dialect’ is a very broad term which involves multiple linguistic domains, such as: lexicon (vocabulary), morphology (word structure), syntax (sentence structure) and phonology/phonetics (pronunciation) (Van Herk, 2012). Examples of different dialects within the English language include estuary English, Sothorn American English, Jamaican Patois and many more. These dialects are all different varieties of the same language, but they have their own unique pronunciation, grammar, vocabulary and so forth. Whereas the term ‘Accent’ refers exclusively to pronunciation, often acting as an indicator of the speaker's geographical background or social associations (Wardhaugh, Fuller, 2015). For example, a person who has acquired standard English as a secondary language may exhibit proficiency in the language, yet their pronunciation may reveal their native language.

Language is not just a tool for communication; it's also a reflection of social dynamics. A sociolect is a subset of language unique to a particular a social group (Van Herk, 2012). Interestingly, the language spoken by those in higher socioeconomic groups and by educated individuals is regarded as standard; it is the variety that is taught in classrooms and used by television and radio presenters, the language of literature and documents. As a result of this established standard for “correctness”, other language varieties can be regarded as inferior, some more than others (Van Herk, 2012). Similarly, to how sociolects are the language of specific social groups, ethnolects represent the linguistic characteristics of ethnic communities, while idiolects reflect the unique language patterns of individuals (Wardhaugh, Fuller, 2015). The language of the youth is often associated with the use of slang. It concerns only vocabulary – new words or words that have evolved into new meanings, and is often short-lived, quickly going out of style (Van Herk, 2012).

¹ *Interlocutor* refers to the person being spoken to in a conversation.

It is important to distinguish between the different varieties of language, but it is also crucial to understand that language users can change the way they speak depending on the context. They can adopt various *styles*, changing the degree of formality in their speech. The style used by an individual at a job interview contrasts significantly with that used in a casual conversation with friends (Wardhaugh, Fuller, 2015). People also adjust their speech to their interlocutor or to fit a specific purpose by adopting different registers of speaking (Wardhaugh, Fuller, 2015). A register linked to a specific profession or activity often has its own unique vocabulary, or “jargon.” For those inside the group, jargon facilitates more efficient communication; however, it can also prevent participation and exclude non-members (Van Herk, 2012). Examples of jargon can be seen everywhere, from the courtroom with terms like “voir dire” or “hearsay”, to the football field with terms like “own goal” or “hat-trick”.

Gumperz (1968) describes a speech community as a group of people who share both social norms and linguistic traits, which set them apart from other groups. These communities might use the same language or mixture of languages, have the same accent, or use similar vocabulary, etc., within a specific geographical or social context (Van Herk, 2012). Social networks describe the structure within a speech community. They show the relationship that exists between members and how these relationships affect language (Van Herk, 2012). If a person knows and frequently interacts with people who also know and frequently interact with each other, then that person is a part of a dense social network (Fig. 2), as opposed to a loose social network, where they do not frequently interact (Fig. 1). A multiplex social network is one where people within a social community are connected to each other in more than one way, for example, family members that are also co-workers or students that participate in the same extracurricular activities (Fig. 3) (Wardhaugh, Fuller, 2015). According to Wardhaugh and Fuller (2015), dense and multiplex social networks help people identify with one another and foster a sense of community. Conversely, middle-class networks tend to be loose, which results in a weakened sense of identity and solidarity.

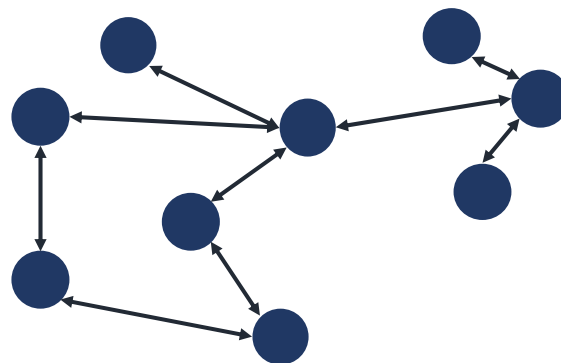


Figure 1. A loose social network.

Source: Adapted from *Infectious Ideas: Modelling the Diffusion of Ideas Across Social Networks* by: Haggith, Prabhu, Colfer, Ritchie, Thomson, Mudavanhu, 2003, p. 232.

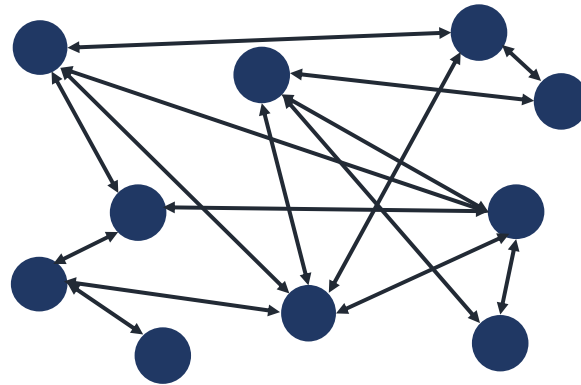


Figure 2. A dense social network.

Source: Adapted from *Infectious Ideas: Modelling the Diffusion of Ideas Across Social Networks* by: Haggith, Prabhu, Colfer, Ritchie, Thomson, Mudavanhu, 2003, p. 232.

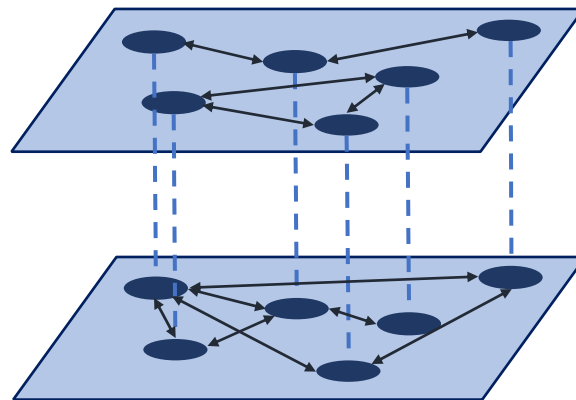


Figure 3. A multiplex social network.

Source: Adapted from: Gomez, Diaz-Guilera, Gómez-Gardeñes, Perez-Vicente, Moreno, Arenas, 2013, p. 1.

Language as a reflection of social hierarchies

In a society, there are noticeable linguistic distinctions across class boundaries (Faizin, 2015). These are further enforced by the fact that certain groups purposefully utilise inferior forms to distance themselves from mainstream society, the same way higher social groups distinguish themselves using language (Faizin, 2015).

As previously mentioned, standard English is universally viewed as “correct” (Van Herk, 2012); but there are other varieties which are also respected and viewed as prestigious, for example, *received pronunciation* (RP). It is important to distinguish between Standard English, a dialect used by educated English speakers around the world, and RP, which is a British accent, associated with a higher educational background or social prestige (Wakelin, 1977).

RP has many distinct characteristics, for example the pronunciation of /ju:/ in words like *news* (/nju:z/) or *Tuesday* (/tju:zdeɪ/) (Mugglestone, 2017). Whereas, certain accents, such as American English, sometimes lose this sound in a process called “yod-dropping” (Wells, 1982). RP pronounces h at the beginning of words, as in *hurt* (/hɜ:t/), and avoids it in words like *arm* (/ɑ:m/), whereas speakers of the Cockney dialect do the opposite (Nordquist, 2020). Furthermore, RP speakers only pronounce the *r* sound in words that are preceded by a vowel sound, for example, *park* (/pɑ:k/) but in words like *proud* (/praʊd/) the *r* sound is vocalised (Payne, 2024).

Pronunciations that may be held in high regard in one location, may be stigmatised in another (Montgomery, 1995). According to Coupland’s research (2007), apart from received pronunciation, British people also value Scottish- and Irish-accented English (Wardhaugh, Fuller, 2015). Coupland’s findings (2007) also showed that people tend to show a preference towards their own language varieties, giving them a more generous score compared to how other groups rated them. Additionally, regular downgrading of certain dialects associated with urban areas or ethnic minorities was evident in the collected data (Coupland, 2007). The Birmingham accent, for example, is associated with industrial conurbation and is often disliked, even by a proportion of its users (Montgomery, 1995). As noted by Ochs (1992), language structures become indirectly associated with certain social categories (Bucholtz, Hall, 2004). This can also be seen with Liverpool English, also known as Scouse. Despite being a hub for pop culture in the 60’s, Liverpool struggled in the following 20 years and gained a reputation for being a city plagued by crime, unemployment, and poverty (Juskan, 2015).

Liverpool is simply Liverpool. Its people – or at least the uneducated among them – have an accent of their own; a thick, adenoidy, cold-in-the-head accent, very unpleasant to hear. (Priestley, 1934, p. 200).

The Liverpool accent [...] is one of Britain’s most recognisable urban accents today, especially the more identifiably working class accent (Grey, Grant, 2007, p. 1, as cited in Boland, 2010, p. 6).

Attitudes towards Scouse are portrayed in the above quotes. Furthermore, Scouse speakers participating in Perini’s study (2017), described often having to modify or slow down their speech, sometimes even refraining from using their accent because “English people tend not to like Scousers”, or because Scouse can be seen as unprofessional. Evidently, Scouse as well as its speakers experience some prejudice, often being associated with negative stereotypes. However, as times are changing, so is the perception of the Liverpool accent. It is apparent that the accent is less stigmatised nowadays than it was in the past, with many Scousers being “proud” of who they are (Perini, 2017) and the accent even being described as “understanding and friendly” (Barbera, Barth, 2007).

Certain language varieties innately sound more pleasing to people, for example RP, but the sound alone does not ensure prestige; it is rather a question of social attitude. For instance, people who do not speak French cannot differentiate between Parisian French and Canadian

French, let alone show a preference to one or the other, but among French speakers, Parisian French holds more prestige (Montgomery, 1995). As explained by Montgomery (1995), the dominant social group's speech patterns get accepted as the norm within a community, even if this normative pressure is sometimes justified in terms of aesthetic appeal or false concepts of linguistic propriety.

Other linguistic characteristics that may convey one's place in the social hierarchy include pronoun use and even politeness. Studies have shown that the use of first-person pronouns attract attention to the self (e.g., Davis, Brock, 1975). As described in the research of Kacewicz et al. (2013), people in positions of higher prestige tend to be more other-focused, whilst those in positions of lower prestige are more self-focused. This is reflected in their use of personal pronouns – lower status individuals use more first-person singular pronouns (I, me, my, mine), whereas individuals of higher status use more first-person plural pronouns (we, us, our, ourselves). The politeness of one's speech can also be linked to power and status. As presented in Morand's research (1996), low status subjects were more polite when addressing people in higher positions of power. Additionally, the results showed that high power individuals used more positive politeness², in comparison to low power individuals. Some politeness strategies include certain types of address forms, indirect speech acts and honorifics³ (Brown, Levinson, 1987).

The intersectionality of language, class, and culture

Language is a huge part of culture. It reflects culture and is actively shaped by it. Individuals from different cultures might use the same word or phrase, but it can carry different meanings or associations with it (Jiang, 2000). For example, in Western cultures the word family is associated only with intermediate family members such as siblings, parents and children, but in Asian cultures family extends beyond the nuclear unit to include extended relatives and ancestors.

According to Straubhaar (2000), people lean towards things that are of cultural proximity to them. On the example of television, Straubhaar explained that most people prefer TV programs and channels which feature their own language, familiar ethnicity, similar fashion and known actors, as well as humour that is contextually relevant to them, concluding that audiences prefer local and national television over globalised productions. However, it is worth noting that younger individuals were found to be more engaged with global media than older people, for example with their music tastes (Straubhaar, 2000).

² Positive politeness, as well as negative politeness, is linked to the concept of positive and negative face. Positive face is the desire for acceptance and appreciation from others, whereas negative face is the need for independence and freedom from imposition. Positive and negative politeness is a matter of attending to people's positive/negative face needs (Brown, Levinson, 1987, pp. 61-62; Eckert, McConnell-Ginet, 2013, p. 122).

³ Honorifics are linguistic forms used to show respect or esteem, typically toward someone of higher social status. Examples include "Sir" or "Ma'am", or the pronoun "Vous" in French (Brown, 2020).

Social class represents more than just people's material situations. Objective resources (such as income) influence cultural practices and behaviours that reflect social class. These signals shape cultural identities in upper and lower classes, which are based on subjective impressions of social class rank in comparison to others (Kraus et al., 2011).

Methods and procedures

Research aims

The aim of this research paper is to investigate how language use in Willy Russell's 'Blood Brothers' reflects and constructs regional identity, educational background, and social class. This study will use content analysis and case-study methodology to explore how linguistic elements shape social identity within the context of musical theatre. Additionally, it will examine the attitudes toward different social groups that are conveyed through the characters' language.

Research questions and hypothesis

The main objective of this case study is to address the following research questions:

- Q1: What linguistic features define the language of characters from different socioeconomic backgrounds?
- Q2: Do different characters within a specific social group exhibit similar speech patterns?
- Q3: Does the play utilise language to illustrate the social and economic inequalities prevalent in their society?

Hypothesis: Characters within the same social group in 'Blood Brothers' will demonstrate similar speech patterns, including the use of colloquial language and regional dialects, which will reinforce their shared social identity and group belonging.

Research subject – plot summary

The musical 'Blood Bothers' by Willy Russell is set in Liverpool in the 1960s and tells the story of two twin brothers, Mickey, and Edward, who are separated at birth. Mickey remains with his biological mother, Mrs. Johnstone, a single woman struggling in poverty, while Edward is given away to her wealthy employer, Mrs. Lyons, who keeps the adoption secret from her husband. Mrs. Johnstone is promised regular visitations with Edward, but she is soon fired and manipulated by Mrs. Lyons into believing a superstition that the twins will die if they ever learn the truth.

At age seven, the boys unknowingly reunite and become best friends, despite their mothers' attempts to keep them apart. They form a close bond with a girl named Linda and begin causing mischief together. Fearing the consequences of their friendship, Mrs. Lyons relocates her family to separate the boys once more.

As teenagers, Mickey and Edward reconnect and both fall in love with Linda. Their lives take divergent paths: Edward goes to university, while Mickey, after getting Linda pregnant, loses his factory job. In a desperate bid for money, Mickey participates in a bank robbery, resulting in a fatality and a seven-year prison sentence.

Mickey becomes addicted to medication in prison and emerges a changed man. Linda, seeking comfort, turns to Edward, who is now a city councillor, and they begin an affair. Discovering the betrayal, Mickey is consumed with rage and confronts Edward with a gun. In the heated encounter, Mrs. Johnstone reveals the boys' true relationship, which only angers Mickey more as he realises that he could have had Edwards privileged life. The confrontation ends tragically: Mickey accidentally shoots Edward, and the police fatally shoot Mickey, fulfilling the ominous superstition.

Procedure

This case study employs both qualitative and quantitative methods of analysis. This mixed-methods approach will maximise the insights gained from the analysed text.

Quantitative research will provide a clearer, more objective picture of how language varies between the characters from different social groups. Whereas qualitative research will enable a thorough and contextually rich analysis of the language, taking into account factors such as personal experiences and relationships, allowing for accurate results.

To ensure a thorough and manageable analysis, the research will primarily focus on the aspect of socioeconomic status. The study will examine the two protagonists, who represent different social classes, along with two additional secondary characters from each social group (upper-middle class and lower/working class). This selection is narrow enough to allow for detailed analysis while remaining broad enough to identify patterns and predominant linguistic features within these social groups.

Corpus description

The corpus used for this study consists of the full textual script, including both spoken dialogue and lyrical content. This theatrical text, situated within a mid-to-late 20th century Liverpoolian context, offers a stratified linguistic dataset ideal for sociolinguistic analysis. The corpus encompasses interactions among characters from divergent socioeconomic backgrounds, enabling comparative analysis of linguistic variation. Quantitative analysis was

conducted via type-token ratio (TTR) calculations to assess lexical diversity across characters, while qualitative analysis focused on morphosyntactic structures, lexical choices, phonological features (e.g., non-standard contractions and g-dropping), and the presence of sociolectal markers. This multi-modal approach facilitated the examination of how linguistic performance aligns with social identity constructs within a fictional yet socially grounded narrative framework.

Data analysis and discussion

The following section integrates quantitative and qualitative findings to examine how linguistic features in ‘Blood Brothers’ reflect and construct social identity. By analysing lexical diversity, phonological patterns, and pragmatic usage across characters from distinct socioeconomic backgrounds, the study demonstrates the role of language as a socially indexical resource within the play’s class-based narrative structure.

Analysis – distinguishing features of the characters’ language

The data presented in Table 1, shows the diversity of vocabulary exhibited by the characters within the play. The table is divided into two sections, separated by a double line – the first, representing working-class characters (Mrs. Johnstone, Mickey, and Sammy) and the second, containing upper-middle-class characters (Mr. and Mrs. Lyons, and Edward). Recognising that language usage evolves with age, the analysed texts have been divided according to the character’s ages as they grow throughout the play.

Table 1.

Linguistic Diversity of Characters in ‘Blood Brothers’ – Type-Token Ratio

Character	Tokens (total number of words)	Types (number of different words)	Type-Token Ratio (TTR)
Mrs. Johnstone	3680	772	0.21
Mickey (child)	1401	385	0.27
Mickey (teenager)	718	262	0.36
Mickey (adult)	870	281	0.32
Mickey	2989	626	0.21
Sammy (child)	215	123	0.57
Sammy (teenager)	46	33	0.72
Sammy (adult)	188	102	0.54
Sammy	449	194	0.43
Mrs. Lyons	1983	475	0.24
Mr. Lyons	595	221	0.37
Edward (child)	629	217	0.34
Edward (teenager)	1070	335	0.31
Edward (adult)	391	163	0.42
Edward	2090	449	0.24

Source: author’s own elaboration.



Figure 8. Word cloud of Sammy's lexicon.

Source: author's own elaboration.

Sammy's word cloud reflects his use of non-standard grammar and informal contractions, such as "gonna" (going to) and "wanna" (want to). His language is further characterised by British slang and dialectal expressions, like "quid" (British pound), "mam" (instead of "mum"), and "soft", which in Scouse means "stupid". The frequent presence of strong language and profanities, such as "fuck", "bloody", and "friggin", suggests a rebellious or confrontational attitude. It might also be indicative of the rough environment Sammy is part of, where such language could be a norm. Additionally, words related to crime and violence, such as "robbin", "shot", and "gun", indicate Sammy's involvement in or familiarity with criminal activities. The inclusion of terms like "dead" and "burial" further underscores the themes of death and mortality that are prevalent in his vocabulary.



Figure 9. Word cloud of Mr. Lyons' lexicon.

Source: author's own elaboration.

Mr. Lyons' word choice avoids informal language and grammar, indicating his use of standard English. The word "Miss" demonstrates his use of honorifics, showing his respect and politeness towards others.

The word cloud also includes "Edward" and "baby", referring to his son, and includes "Jennifer" alongside its diminutive form, "Jen", as well as the affectionate term "darling", suggesting a close, affectionate relationship with his family.

Additionally, words like "work" and "Miss Jones" (his employee) emphasise Mr. Lyons' strong focus on his professional responsibilities.

MRS LYONS: Hello, Mrs Johnstone, how are you? Is the job working out all right for you?

MRS JOHNSTONE: It's, erm, great. Thank you. It's such a lovely house it's a pleasure to clean it.

MRS LYONS: It's a pretty house isn't it? It's a pity it's so big. I'm finding it rather large at present.

MRS JOHNSTONE: Oh. Yeh. With Mr Lyons being away an' that? When does he come back, Mrs Lyons?

MRS LYONS: Oh, it seems such a long time. The Company sent him out there for nine months, so, what's that, he'll be back in about five months' time.

MRS JOHNSTONE: Ah, you'll be glad when he's back won't you? The house won't feel so empty then, will it?

Text fragment 1. Fragment From Act 1 (page 7).

The language used by Mrs. Lyons and Mrs. Johnstone in this extract reveals a clear distinction in their social status. Mrs. Lyons, with her upper-middle-class background, employs a more formal and articulate register. She uses phrases like "It's a pity" and "at present", demonstrating a preference for standard English. Her language reflects her education and upbringing, emphasising her refined and sophisticated demeanour. In contrast, Mrs. Johnstone, a working-class woman, uses a more informal and colloquial style. Her speech is characterised by hesitations ("It's, erm, great") and contractions ("an' that"). Her language reflects her limited education and socioeconomic background, highlighting her working-class identity.

An uneven power dynamic is present not only in terms of socioeconomic status, but also in the employee-employer relationship between the two women. Tag questions⁵, such as "won't you?" and "will it?", are prevalent in Mrs. Johnstone's speech, which may indicate insecurity and a search for validation and connection with her boss. Moreover, in this fragment Mrs. Johnstone is adopting a more professional style, compared to her usual speech, by using vocabulary and phrases that are more polite and formal, such as "such a lovely house" and "it's a pleasure", further indicating that she is outside her usual speech community, and she is trying to fit in more with her upper-class interlocutor and her work setting.

⁵ Tag questions can express uncertainty and request confirmation, clarification, or feedback (Ochs, 1992, p. 335). They can also be used to exhibit control, often asserting more control than other types of questions, like wh-questions or grammatical yes/no questions (Woodbury, 1984, pp. 205-206).

MRS LYONS: How much?

MRS JOHNSTONE: Nothin'! Nothing. (Pause.) You bought me off once before...

MRS LYONS: Thousands... I'm talking about thousands if you want it. And think what you could do with money like that.

MRS JOHNSTONE: I'd spend it. I'd buy more junk and trash; that's all. I don't want your money. I've made a life out here. It's not much of one maybe, but I made it. I'm stayin' here. You move if you want to.

MRS LYONS: I would. But there's no point. You'd just follow me **again** wouldn't you?

MRS JOHNSTONE: Look I'm not followin' anybody.

Text fragment 2. Fragment From Act 2 (page 60) – *Mrs. Lyons is trying to bribe Mrs. Johnstone.*

This fragment reveals a contrast in values and perspectives between Mrs. Lyons and Mrs. Johnstone, further highlighting their social divide. Mrs. Lyons, driven by her upper-class values, attempts to bribe Mrs. Johnstone with "thousands" to leave the neighbourhood. This demonstrates her belief that money can solve any problem, reflecting her privileged upbringing and detachment from the realities of working-class life. The words "you bought me off once before", suggest a history of manipulation and control. However, Mrs. Johnstone's refusal to be manipulated, despite her circumstances, challenges the power dynamics inherent in their social positions. Her language is blunt and defiant, using phrases like "I don't want your money" and "I'm stayin' here". She rejects the idea that money can buy her happiness or security, demonstrating her strong sense of self-worth and independence despite her limited resources. Her use of "junk and trash" to describe her possessions reflects her working-class experience, where material possessions are often seen as less important than personal relationships and community.

FINANCE MAN: Yeh, well y' bloody well shouldn't.

MRS JOHNSTONE (*coming out of her trance; angrily*): I know I shouldn't, you soft get. I've spent all me bleedin' life knowin' I shouldn't. But I do. Now, take y' soddin' wireless and get off.

CATALOGUE MAN: Honest love, I'm sorry.

MRS JOHNSTONE: It's all right lad ... we're used to it. We were in the middle of our tea one night when they arrived for the table. (*She gives a wry laugh.*)

Text fragment 3. Fragment From Act 1 (page 14) – *Mrs. Johnstone is talking with debt collectors.*

Mrs. Johnstone's speech in this fragment showcases a number of linguistic features characteristic of working-class speech. These are much more prominent in this fragment, where she is interacting with someone from a similar background, compared to her interactions with higher status individuals.

Her language is highly informal and colloquial. The use of "y'" instead of "you", and "me" instead of "my" reflects the regional dialect, emphasising her working-class roots and the informal nature of her speech. Additionally, when referring to the men, Mrs. Johnstone does not use honorifics, like she did when talking to Mrs. or Mr. Lyons. Instead, she uses expressions

like “lad” (a friendly term for a young man), and even uses colloquial insults, for example calling the Finance Man a “soft get” (meaning a foolish person). These expressions are specific to a particular geographical area and social group, further emphasising her working-class identity.

In the fragment, Mrs. Johnstone uses expletives, such as “bloody” and “soddin’”, expressing her frustration with the situation. The command, “Now, take y’ soddin’ wireless and get off”, is direct and blunt, highlighting her irritation and weariness, possibly stemming from her difficult socioeconomic circumstances. This shows that she does not feel the need to refrain from using certain language and hold back her frustration, possibly because she is more comfortable speaking openly with people she perceives as being of a similar social status.

Finally, Mrs. Johnstone’s use of humour, particularly her wry laugh during the interaction, reveals her resilience and ability to cope with difficult situations. The statement “I’ve spent all me bleedin’ life knowin’ I shouldn’t”, reflects the long-term struggle with socioeconomic difficulties, and the sentence “It’s all right lad ... we’re used to it”, further emphasises her resilience and acceptance of her circumstances.

MICKY: Hi-ya, Ed. Lind.

LINDA: Where’ve y’ been?

MICKY: I had to do overtime. I hate that soddin’ place.

EDWARD: Mickey. I’m going away tomorrow ... to University.

MICKY: What? Y’ didn’t say.

EDWARD: I know ... but the thing is I won’t be back until Christmas. Three months. Now you wouldn’t want me to continue in suspense for all that time would you?

Text fragment 4. Fragment From Act 2 (page 66).

EDWARD: What about the job you had?

MICKY: It disappeared. (*Pause.*) Y’ know somethin’, I bleedin’ hated that job, standin’ there all day never doin’ nothin’ but put cardboard boxes together. I used to get ... used to get terrified that I’d have to do it for the rest of me life. But, but after three months of nothin’, the same answer everywhere, nothin’, nothin’ down for y’, I’d crawl back to that job for half the pay and double the hours. Just ... just makin’ up boxes it was. But after bein’ fucked off from everywhere, it seems like it was paradise.

Text fragment 5. Fragment From Act 2 (page 70).

Fragments 4 and 5 showcase the contrasting speech patterns of the two main characters – Mickey and Edward. Mickey’s vocabulary is often coarse, informal, and occasionally vulgar, as seen in words like “soddin’” and “bleedin’”. His speech is characterised by informal contractions, such as “y’”, “nothin’”, and “doin’”, and he sometimes uses double negatives, like “never doin’ nothin’”, which can be associated with the working-class Liverpudlian dialect.

Text Fragment 5 shows instances of Mickey repeating himself – “I used to get ... used to get terrified” and “just ... just makin' up boxes it was”. This broken syntax reveals Mickey’s anxiety and uncertainty about his future, which is shaped by the limitations imposed by his working-class background.

In contrast, Edward’s vocabulary and grammar is more refined and polished, reflecting his middle-class upbringing and education.

Analysis – attitudes towards social groups

The POLICEMAN goes to confront MRS JOHNSTONE.

POLICEMAN: And he was about to commit a serious crime, love. Now, do you understand that? You don't **wanna** end up in court **again**, do y'?

MRS JOHNSTONE *shakes her head.*

Well, that's what's gonna happen if I have any more trouble from one of yours. I warned you last time, didn't I, Mrs Johnstone, about your Sammy?

MRS JOHNSTONE *nods.*

Well, there'll be no more bloody warnings from now on. Either you keep them in order, Missis, or it'll be the courts for you, or worse, won't it?

MRS JOHNSTONE *nods.*

Yes, it will.

Text fragment 6. Fragment From Act 1 (page 37) – *Mickey was caught throwing rocks at a window with his friends. The policeman is confronting Mrs. Johnstone about it.*

POLICEMAN: An' er, as I say, it was more of a prank, really,

Mr Lyons. I'd just dock his pocket money if I was you. (*Laughs*). But, one thing I would say, if y' don't mind me sayin', is well, I'm not sure I'd let him mix with the likes of them in the future. Make sure he keeps with his own kind, Mr Lyons. Well, er, thanks for the drink, sir. All the best now. He's a good lad, aren't you Adolph? Goodnight, sir. (*He replaces his helmet*).

The POLICEMAN leaves

Text fragment 7. Fragment From Act 1 (page 38) – *The policeman is talking to Mr Lyons about his son (Edward) throwing rocks at a window*

The contrasting interactions between the Policeman and Mrs. Johnstone (Fragment 6) and Mr. Lyons (Fragment 7) starkly reveal the difference in attitudes towards the working and higher classes.

In Fragment 6, the Policeman's language towards Mrs. Johnstone is harsh and threatening. He uses phrases like "bloody warnings", "keep them in order", and "it'll be the courts for you, or worse", demonstrating a clear power imbalance and a lack of respect. The policeman's repeated warnings and threats, coupled with the use of tag questions like “won’t it?”, “do y’?” and “didn’t I”, serve as deliberate intimidation tactics. Mrs. Johnstone’s nods, rather than verbal responses, imply a submissive and powerless position.

In contrast, the Policeman's language towards Mr. Lyons in Fragment 7 is significantly more polite and respectful. He uses phrases like "if y' don't mind me sayin'" and "goodnight, sir", highlighting a clear shift in his tone and demeanour. The Policeman's advice to Mr. Lyons, "I'm not sure I'd let him mix with the likes of them in the future", shows his use of negative politeness. He indirectly suggests that Mr. Lyons should control his son's associations, which subtly imposes on Mr. Lyons' parenting without being overtly confrontational. This difference in language reflects the societal perception of Mr. Lyons as someone of higher status, deserving of respect and courtesy. In addition, the policeman downplays the seriousness of Edward's actions, calling it a harmless "prank", whereas when talking with Mrs. Johnstone, he used the words "serious crime". He even jokes with Mr. Lyons, suggesting a level of understanding that is absent in his interaction with Mrs. Johnstone. This reveals the policeman's double standard and a clear bias towards the higher class.

The Policeman's contrasting interactions with Mrs. Johnstone and Mr. Lyons highlight the societal bias that often favours the higher classes, demonstrating how language can be used to both empower and disempower individuals based on their social status. The Policeman's advice to Mr. Lyons to "make sure he [Edward] keeps with his own kind" further reinforces this class-based prejudice.

MRS LYONS: You see, you see why I don't want you mixing with boys like that! You learn filth from them and behave like this like a, like a horrible little boy, like them. But you are not like them. You are my son, mine, and you won't, you won't ever ...

Text fragment 8. Fragment From Act 1 (page 29) – *Mrs. Lyons is talking to Edward about his friendship with Mickey.*

MR LYONS: Look, Jen. What is this thing you keep talking about getting away from? Mm?

MRS LYONS: It's just ... it's these people ... these people that Edward has started mixing with. Can't you see how he's drawn to them? They're ... they're drawing him away from me.

Text fragment 9. Fragment From Act 1 (page 35) – *Mrs. Lyons is talking to Mr. Lyons about moving houses.*

Text Fragments 8 and 9 not only show Mrs. Lyons' dislike towards Mickey but also reveal her broader prejudice against the lower social class. She uses terms like "boys like that", suggesting a generalisation of lower-class children as "horrible" and associating them with "filth(y)" language. The idea of being "drawn" to the lower class implies that there is something inherently dangerous or seductive about them, something that could lead to Edward's moral or social decline. The repetition of "you see" and "they're" emphasises Mrs. Lyons' sense of urgency and fear, suggesting a belief that the working class has a corrupting influence that could tear her son away from her and her values.

Furthermore, the use of "my" and "mine" by Mrs. Lyons emphasises possession and control, contrasting with the words "them" and "these people", which create a clear 'us vs. them' narrative. This linguistic separation reflects broader social and class divisions.

Answers to research questions

Q1: What linguistic features define the language of characters from different socioeconomic backgrounds?

In the musical 'Blood Brothers', there is a clear distinction between the language used by upper-middle-class characters and that of the working-class characters.

Upper-middle-class characters predominantly use standard English with formal and polite vocabulary, even in informal settings (such as at home, talking with family). Their speech is marked by the use of honorifics and full names, reflecting their respect for social norms and their concern with maintaining a certain social image. Their speech, though polite, can come across as cold and distant, especially when compared to the language of the working-class characters. For instance, the use of full names, even for close family members, contrasts with the more casual diminutive name forms used by working-class characters (Edward's use of "Mickey" instead of "Michael" is an exception influenced by Mickey's own introduction).

In contrast, working-class characters employ colloquial language characterised by informal contractions, 'g' dropping and diminutives, all heavily influenced by the Scouse dialect – a dialect commonly associated with the working class and crime. Regional vocabulary like "lad", along with the casual use of profanities like "bloody" and "soddin", and terms like "soft get", that are often used in a non-offensive, humorous manner, reflect a sense of camaraderie and openness within the working-class community. The more relaxed and humorous tone of their speech, as seen in Mrs. Johnstone's interaction with the debt collectors, conveys a sense of solidarity and resilience.

It's also worth noting that working-class characters tend to alter their speech when interacting with upper-middle-class individuals, adopting more formal vocabulary, avoiding vulgarities and nicknames, sometimes even showing more hesitations. In contrast, the speech of upper-middle-class characters remains largely unchanged when talking with those of lower status.

Finally, while the size of a character's lexicon does not appear to be determined by class, as suggested by Table 1, the inclusion of song lyrics in the analysis may have influenced these results.

Q2: Do different characters within a specific social group exhibit similar speech patterns?

The characters within specific social groups generally show similar speech patterns. Upper-middle-class speech is more standard, formal, and polite, whereas working-class characters speak with a Liverpool dialect and use more informal vocabulary and phrases. These linguistic characteristics are rather universal throughout the play, as one can easily identify what social group a character belongs to based on their speech.

However, there are small nuances within each group. For example, while both Edward and Mrs. Lyons exhibit formal language, Edward's speech sometimes reflects his close relationship with Mickey through his use of less formal terms like "tits" and "ma" (a regional term for "mum"), indicating that language also reflects individual relationships and experiences.

Q3: Does the play utilise language to illustrate the social and economic inequalities prevalent in their society?

‘Blood Brothers’ effectively uses language to highlight social and economic inequalities.

Firstly, the author deliberately incorporates the Scouse dialect to underscore the characters’ working-class status. This dialect, often associated with poverty and unemployment, carries negative connotations and stigma, which are reflected in how working-class characters are perceived and treated within the play.

Secondly, the language used by the characters also reflects their economic realities. For example, Mrs. Johnstone’s use of words like “price” and “pay” reflects her financial hardships, while Mrs. Lyons’ vocabulary includes terms related to money and material wealth, such as “buy” and “money,” highlighting her access to money and reliance on financial means to solve problems. This contrast in language underscores the economic divide between the characters.

Additionally, the characters’ vocabulary reflects their education and social background. Higher-status individuals tend to use more formal vocabulary, with words like “pardon” and “perhaps,” which contrasts sharply with the more informal and colloquial speech of the working class. Mrs. Lyons’ using the words “these people” and “boys like that” further highlight the social divide, showing her contempt for those of lower status.

Finally, the play critiques societal attitudes toward class through juxtaposition, as seen in the contrasting interactions with the police in Text Fragments 6 and 7. The policeman uses negative politeness when speaking to Mr. Lyons, in contrast to his hostile attitude toward Mrs. Johnstone. His advice to Mr. Lyons, “I’m not sure I’d let him mix with the likes of them in the future. Make sure he keeps with his own kind,” reinforces these prejudices and the rigid social hierarchy.

Conclusions

In conclusion, ‘Blood Brothers’ demonstrates that language functions as a socially embedded and indexical resource through which class identity, power relations, and institutional hierarchies are constructed and interpreted. Consistent with Ochs’s (1993) perspective, social identity in the play is not directly encoded in linguistic forms but emerges through culturally mediated interpretations of speech patterns, stance, and interactional positioning. Similarly, Bucholtz and Hall’s (2004) framework of identity as relational and interactionally achieved is reflected in the way linguistic differences between characters become meaningful only within the broader social and ideological context of class division. The contrast between the standardised, polite, and syntactically controlled speech of upper-middle-class characters and the non-standard, dialectal, and colloquial language of working-

class characters reflects established research on language prestige and linguistic ideology (Montgomery, 1995; Coupland, 2007). The play illustrates how certain varieties are socially legitimised, while others are stigmatised, thereby reinforcing symbolic boundaries between social groups. In this respect, the findings align with the variationist tradition (Labov), which emphasises that non-standard forms are systematic and socially meaningful rather than linguistically deficient.

Institutional interactions within the play, particularly the contrasting treatment of Mrs. Johnstone and Mr. Lyons by the policeman, further exemplify how language indexes power. The differential use of politeness strategies and deference mirrors the theoretical insights of Brown and Levinson (1987) as well as Morand (1996), demonstrating how linguistic behaviour reflects and reproduces structural inequality. Moreover, patterns of stance and pronoun use resonate with findings by Kacewicz et al. (2013), suggesting that linguistic focus can signal social positioning within hierarchies.

The asymmetrical style-shifting observed among working-class characters provides additional support for Gumperz's (1968) concept of accommodation, as well as Kraus et al.'s (2011) view of social class as a culturally shaped system of adaptive behaviour. While lower-status characters adjust their speech in higher-status contexts, upper-middle-class characters remain linguistically stable, highlighting the unequal communicative demands imposed across class lines.

Overall, the study reaffirms central sociolinguistic claims that language is not a neutral medium of communication but a structured social practice deeply intertwined with systems of prestige, stigma, and institutional power. By linking empirical textual analysis with established theoretical frameworks, the research demonstrates that linguistic variation in 'Blood Brothers' does not merely reflect class divisions—it actively participates in sustaining and legitimising them.

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THE APPLICATION OF THE CHAID ALGORITHM IN THE FIELD OF MANAGEMENT

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Purpose: The aim of this paper is to diagnose the main areas of usefulness of the Chi-squared Automatic Interaction Detector (CHAID) algorithm in explaining management problems and to assess its application possibilities in terms of dominant trends shaping functions of contemporary organisations.

Design/methodology/approach: The Systematic Literature Review (SLR) procedure was undertaken using the Web of Science. A set of publications was identified and selected, resulting in the development of a comprehensive database that served as a baseline for further conclusions.

Findings: The study identified key areas of application of the algorithm in management research, as well as the possibilities and limitations of its use in achieving measurable organisational effects. The results confirmed a steadily growing trend in the number of publications. However, predictive models using the algorithm are mainly used in segmentation research related to new customer acquisition, fraud detection and churn analysis. Despite the wide range of research using the CHAID algorithm, there are still areas where its untapped potential can be identified.

Practical implications: Machine learning algorithms (MLA) open up new opportunities for both management practice and theory. The application potential of these tools is particularly evident in relation to the analysis of large data sets and the personalisation of products and services. The detection of useful knowledge patterns using CHAID can contribute to increasing the effectiveness of operational and strategic activities in an organisation. Inspiring examples of classification using CHAID are provided by research in the financial, transport and service sectors.

Originality/value: The paper uncovers the possibilities of applying the algorithm in the field of management. These findings constitute a recommendation for decision-makers looking for tools to improve decision-making in specific areas of business operations. The results of a comprehensive review of the research prove that, thanks to its simplicity, the analysed algorithm can contribute to the discovery of non-obvious but useful patterns from raw data sets, while reducing costs and enabling a faster response to changing market conditions.

Keywords: algorithm CHAID, decision trees, digital transformation.

Category of the paper: literature review.

1. Introduction

Managerial decision-making requires searching for new ideas and tools that systematically improve this process and organise the complex reality of modern organisations. The need to structure business processes is widely emphasised in situations requiring rapid analysis of variable factors (Shamim, 2024), while maintaining objectivity and eliminating intuitive decision-making (Neiroukh et al., 2024). It is pointed out that companies using advanced data mining mechanisms, recognising patterns and useful regularities using machine learning tools, manage risk more effectively (Gubernat et al., 2025) and are able to instantly identify changing operating rules and customer needs and expectations. Furthermore, it is possible to discover new knowledge from available data, so data mining tools, which form the foundation of modern analytics, are booming (Wieczorkowski et al., 2021). Their diversity facilitates the researchers' work in building predictive models (cf. Łapczyński, 2010, p. 13) and enables organisations to model scenarios more effectively and increase the efficiency of management processes (Paramesha et al., 2024).

Scientific studies point to advanced data exploration methods, such as clustering, association rules, regression analysis, classification trees, random forest or neural networks (Wieczorkowski et al., 2021). The authors draw attention to their multidimensional application potential. Most partitioning algorithms are derived from three classic methods: CLS (Concept Learning Systems), AID (Automatic Interaction Detection) and CART (Classification and Regression Trees) (Breiman, 2017). Hou (2018) predicts the directions of development of the decision tree algorithm.

The Chi-squared Automatic Interaction Detector (CHAID) algorithm belongs to the largest family of data mining classification algorithms (Hou, 2018). It is widely emphasised that the method is distribution free (Hache et al., 2017) and fully non-parametric (Durica et al., 2019). In addition, the authors emphasize its simplicity and high level of interpretability, which creates opportunities for transposing research results into practical recommendations and setting further directions for scientific exploration. Interesting conclusions are provided by Smolarek's (2016) empirical research, according to which the most commonly used group of knowledge discovery algorithms are those that allow the construction of a classification model (such as CHAID), with as many as one third of the surveyed companies declaring that they use these classification methods (Smolarek, 2016, p. 100) in HR, among other areas.

Currently, however, it can be assumed that in the face of the increasing dynamics and complexity of phenomena shaping the management of modern organisations, the usefulness of most methods and tools (including the discussed CHAID) is being evaluated for suitability. The need to manage in conditions of information overload (Toffler, 1984) and the greater precision of analytical tools do not always, paradoxically, mean a more accurate diagnosis.

In this context, it is crucial to identify the areas of usefulness of particular methods and tools in explaining contemporary management problems.

Consequently, the aim of this article is to identify the current state of knowledge regarding the use of the selected CHAID algorithm, in particular to recognise its leading applications in management science research. This aim is part of a broad scientific discussion on the phenomenon of algorithmisation in various areas of business operations. The need for even simplified and synthesising research in this area is further supported by its practical value in reducing organisational complexity and accelerating the diffusion of knowledge.

The CHAID (Chi-squared Automatic Interaction Detector) algorithm is used to construct a graphical model (classification tree) that divides a set of observations into maximally homogeneous, disjoint subsets based on a selected categorical dependent variable (Łapczyński, 2010). The most significant independent variable appears in the first node of the classification. The divided set (entire data set) is the so-called parent node (Node_0), while the subsequent subsets are child nodes (Node 1, Node 2).

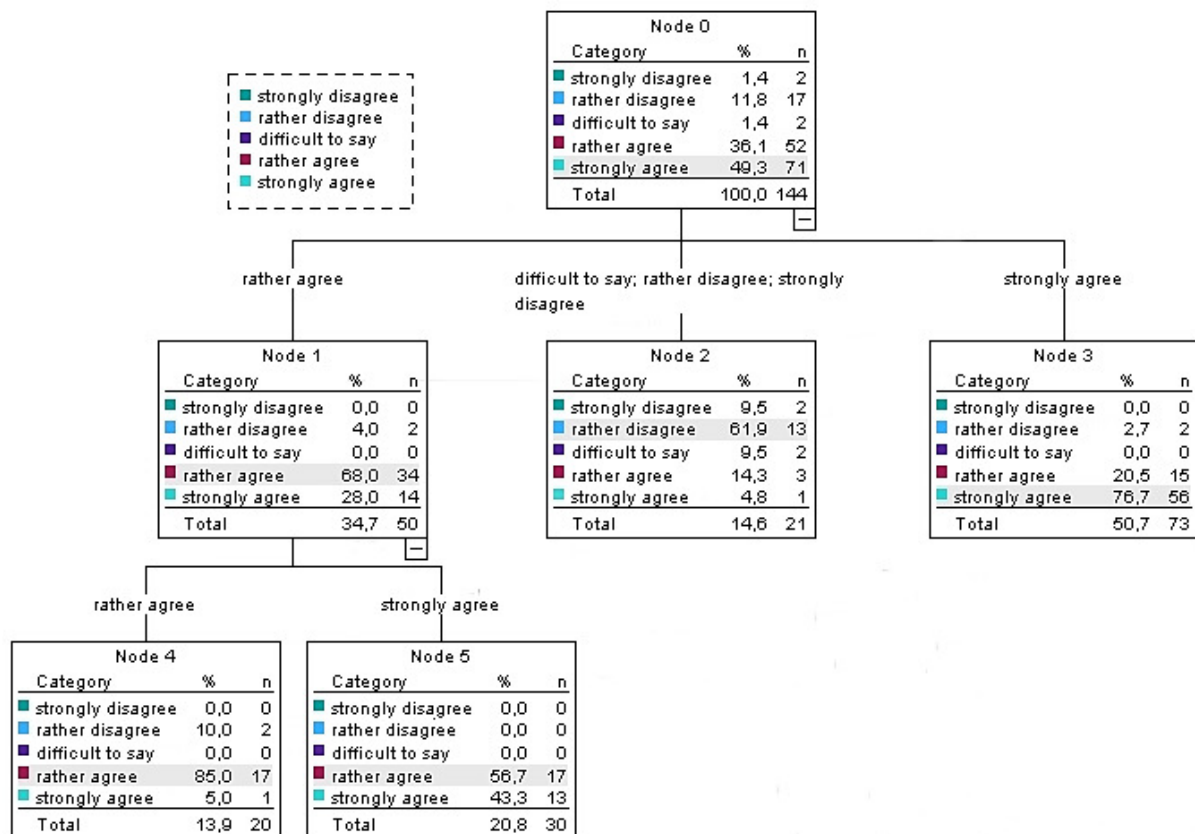


Figure 1. Classification tree CHAID – graphical model.

Source: Author's own study (IBM SPSS Statistics).

Unlike other statistical tools (logistics regression or cluster analysis), CHAID enables optimal splits to be obtained by selecting the predictor that exhibits the most powerful interaction with the endogenous variable (Chang et al., 2023; Higuera-Castillo et al., 2023). The method was popularised by Breiman (2017), Friedman, Olsen and Stone in 1984,

and is described in detail by Gatnar and Walesiak (2004). The use of the algorithm enables decision-makers to provide data, transformed into useful knowledge, in the form of classification or decision rules. Discovering classification rules is one of the most well-known and common tasks in the field of data mining, consisting in finding a way to map data to a set of predefined classes (Smolarek, 2016). This is also where their great usefulness comes from, as managers can directly use these rules to make decisions without the need for complex calculations (Azar et al., 2013).

On the one hand, the ease of interpreting the results obtained is a feature of the algorithm that should prove decisive for its wide application in management sciences. On the other hand, after Choudhury et al., (2020), despite the promise of machine learning in increasing productivity, many firms have encountered significant challenges due to biases in predictions, resulting from either biased training data and/or biased algorithms (Baer, Kamalnath, 2017). Consequently, the above findings further justify the need to assess the tool's application possibilities, especially since contemporary market trends significantly increase the complexity of decision-making processes. The literature points to several key trends that currently create an environment of high uncertainty, including digital transformation, sustainability issues and socio-demographic changes that affect the functioning of modern organisations.

2. Research method

In the context of the formulated objective, the challenge was to identify the most significant and current scientific articles. Using the Systematic Literature Review (SLR) procedure, scientific studies were selected that formed the basis for the development of knowledge about the application potential of the algorithm under study and, indirectly, allowed the opportunities and challenges resulting from the algorithmisation and automation of decision-making processes to be identified.

Bibliometric analysis is a popular and rigorous method for exploring and analysing large volumes of scientific data. It enables the evolutionary nuances of a specific field to be unpacked, while shedding light on the emerging areas in that field (Donthu et al., 2021, p. 285).

A set of publications was extracted from the indexed Web of Science (WoS) database and selected, resulting in the creation of a database that served as a starting point for further inference. The SLR was conducted in stages, in accordance with the approach of Tranfield et al. (2003): (1) planning the review, (2) conducting the review, and (3) reporting.

The starting point was the keywords: "CHAID" and "Chi-squared Automatic Interaction Detector", which were used to identify 1429 records. Then, restrictions were applied based on: document types, Web of Science Categories and English language (Table 1). Finally, the 32 records obtained were subjected to abstract contents and full-text contents analysis.

Table 1.*Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)*

Step in searching	The number of records
	WoS
1. Keywords: “CHAID” or “Chi-square Automatic Interaction Detection” (status: 2024.06.30)	1429
2. Search terms applied:	
a) Document types: journal articles (final and open access)	614
b) Subject area (Web of Science Categories): ‘Business’ (15) + ‘Management’ (14) + ‘Economics’ (14) + ‘Business Finance’ (5)	48
c) Language: English	40
3. Total number of records – the result of abstract contents analysis (Records were removed if they were not connected to CHAID)	36
4. Total number of articles - the result of full-text article contents analysis	32
5. Descriptive analysis: Author, year, journal details, industry, and geographical context	

Source: Author’s own study.

It was decided not to impose any time restrictions on the records examined in order to obtain a cross-sectional picture of the use of CHAID in scientific research over the years. The final, synthetic report took into account, first and foremost, the most-cited papers, and the individual records were supplemented with an indication of the industry context, the size of the sample studied, the definition of the dependent variable and predictive variables.

3. Results

Based on existing theoretical findings and using the SLR, areas of usefulness of the algorithm in explaining management problems were diagnosed. It was confirmed that the use of the CHAID algorithm enables the transformation of large amounts of data into knowledge and the discovery of patterns in various areas of management of organisations of different types and sizes. A summary of the research (Table 2) confirms the possibility of flexible and multidimensional analysis using the machine learning tool in question.

Analysis of the collected empirical material allowed two categories of conclusions to be formulated. The first group consists of empirical conclusions concerning the identified areas of the algorithm’s application to date. The second group consists of methodological conclusions, allowing potential possibilities to be identified for using the algorithm in the future, taking into account its limitations.

Table 2.*Overview of the research designs (dependent variable, predictive variables and samples)*

Author/s, Title	Problem	Sample	Predictive variables
Financial management and banking			
Al-Najjar et al. (2022), Machine Learning to Develop Credit Card Customer Churn Prediction	Predicting credit card customer churn in the banking sector	1627 churned customers	Total transaction count, total revolving balance, and changes in transaction count
Náñez Alonso et al. (2025), Evaluating the acceptance of CBDCs: Experimental research with artificial intelligence (AI) generated synthetic response	Identification of factors of acceptance or rejection of central bank digital currencies	663 synthetic responses	Educational level, financial experience, and income level
Durica et al. (2019), Decision tree based model of business failure prediction for Polish companies	Predicting the financial difficulties of companies	28,908 companies	Twelve financial indicators and company size
Popescu, Dragota (2018), What Do Post-Communist Countries Have in Common When Predicting Financial Distress?	Identification of financial distress predictors for five post-communist countries	20,119 firms	Total Assets and Net Assets Turnover (Croatia), Interest Coverage (Czech Republic), and Profit per Employee (Romania)
Yousaf, Dey (2022), Best proxy to determine firm performance using financial ratios: A CHAID approach	Investigation of the best predictor of firm performance among different proxies	287 Czech firms: automobile, construction, manufacturing sectors	Return on assets (ROA) as a robust proxy to predict financial performance
Maličká (2024), Investigating the Determinants of Local Indebtedness in Slovakia: The Machine Learning Approach	Investigation of local indebtedness determinants in a sample of Slovak municipalities	2926 municipalities	Current expenditure, subsidies, size category, and crises on local indebtedness
Human resources management			
Azar et al., (2013), A model for personnel selection with a data mining approach: A case study in a commercial bank	Developing a model for personnel selection	Case study of a commercial bank	Province of employment; education level; exam score; interview score and work experience
Aşkun et al., (2021), Comparative Analysis of Factors Affecting Employee Performance According to Job Performance Measurement Method: The Case of Performing Artists	Defining and comparing factors affecting employee job performance	305 participants from seven countries	Nationality
Botha (2024), Using entrepreneurial competencies and action to profile entrepreneurs: a CHAID analysis approach	Determining which entrepreneurial competencies predict entrepreneurial action for distinct profiles	1150 South African entrepreneurs	Growth mindset
Silva et al. (2019), Managers' leadership style and the commitment of their team members: associating concepts in search of possible relations	Relationships between the leadership style and the components of the commitment.	587 observations	Time working in the current organization
Bach-Pejic et al., (2020), Data mining approach to internal fraud in a project-based organization	Prevention of fraudulent working-hour claims in project-based organizations	300 employees	Customer, origin and level of expertise of the consultant, and cost of the consulting services

Cont. table 2.

Markowska-Przybyła (2023), External Social Capital of Enterprises in Poland	Identification of level of external social capital	650 companies	Age, firm size and the nature of the market
Guevara-Otero (2025), Factors that determine the level of individual entrepreneurial orientation	Segmentation of emerging entrepreneurs	477 students at a public university	Entrepreneurial orientation among young entrepreneurs
Consumer and social research / marketing segmentation			
Adá-Lameiras (2024), The impact of health crisis on sports consumption – A longitudinal study	Identification of sports spending patterns	20,000 households	Gender, age, and socio-cultural level
Bach-Pejic et al. (2021), Churn Management in Telecommunications: Hybrid Approach Using Cluster Analysis and Decision Trees	Improving customer attrition management to explain customer churn in the telecommunications industry	7043 respondents	Bad initial experience, low satisfaction with services
Borsje et al. (2023), Assessing passenger preferences for Bus Rapid Transit characteristics: A discrete choice experiment among current and potential Dutch passengers	Assessing passenger preferences for Bus Rapid Transit characteristics	1019 Dutch civilians	Frequency, service hours, stop spacing and reliability
Chang et al. (2023), Determinants of Subscription Renewal Behavior in Sport Spectatorship Services: A CHAID Decision Tree Modeling Approach	Season ticket renewal prediction model for regular seats	7982 observations	Recent attendance, discounted tickets, and affordability
Cheng (2023), Predicting abnormal trading behavior from internet rumor propagation: a machine learning approach	Predicting abnormal trading behavior from internet rumor propagation	476 over-the-counter stocks listed on TPEx	The rumor propagation outperforms traditional fundamentals in predicting abnormal trading behavior
Diaz-Perez & Bethencourt-Cejas (2016), CHAID algorithm as an appropriate analytical method for tourism market segmentation	Tourism market segmentation	324 tourists	Tourist nationality
Galiano-Coronil et al. (2023), An approach for analysing and segmenting messages about the SDGs on Twitter from the perspective of social marketing	Analysing and segmenting messages about the SDGs on Twitter from the perspective of social marketing	2433 tweets	Impact, social marketing, and happiness
Galiano-Coronil (2023), Social media impact of tourism managers: a decision tree approach in happiness, social marketing and sustainability	Identifying tourism managers' messages with high impact	9458 observations	Emotions, social marketing and topics
Hache et al. (2017), Beyond average energy consumption in the French residential housing market: A household classification approach	Energy consumption habits	42,963 French households	Heating fuel or equipment type, dwelling type and size, and construction date

Cont. table 2.

Higuera-Castillo et al. (2023), Intention to use e-commerce vs physical shopping. Difference between consumers in the post-COVID era	Segmentation of e-commerce consumers vs. physical shoppers in the post-COVID-19 era	491 Portuguese and 345 Spanish users	Habit, trust, and effort expectancy
Higuera-Castillo et al. (2025), The consumer intention to use e-commerce applications in the post-pandemic era: a predictive approach study using a CHAID tree-based algorithm	Customer segmentation (users e-commerce platforms)	836 observations	Trust, habit, effort expectancy
Walker et al., (2017), Antecedents of Retweeting in a (Political) Marketing Context	Retweeting trends in political marketing	42,444 original tweets	Number of followers
Sustainable development, digital transformation, ESG			
Saáry et al., (2022), Profit or less waste? Digitainability in SMEs - a comparison of Hungarian and Slovakian SMEs	Identification of main driving forces in SMEs	210 SMEs	Digitalisation and sustainability
Juma-Michilena et al., (2023) How to increase students' motivation to engage in university initiatives towards environmental sustainability	Establishing a mechanism to predict behaviour and motivation for sustainability	1446 students from nine Latin American universities	Environmental initiatives proposed by the university, specific courses focusing on climate change
Doğan et al., (2025) Credit rating prediction with ESG data using data mining methods	Integration of environmental, social, and governance pillar scores into traditional financial performance indicators in credit risk prediction	6622 firms	Key financial metrics such as leverage (LEV) and return on assets (ROA)

Source: Author's own study.

The results of the research indicate that in the existing literature on the subject, the CHAID algorithm is used for research focusing on four main aspects.

The first of these is financial management and banking, including the analysis of issues such as business failure, predicting the credit rating of companies, internal fraud and managing bank customer loyalty. The latest research (Doğan et al., 2025) concerns predicting the credit rating of companies.

The second area of issues is personnel and HR management, in particular the identification of key variables affecting employee selection and retention, e.g. in the banking sector. Using CHAID, attempts are made to identify groups of employees at the highest risk of churn in order to design dedicated support programmes for them (Bach-Pejic et al., 2021).

The third area covers consumer and social research, in particular concerning the energy consumption and tourism market segments, and the identification of key dimensions of entrepreneurial orientation and financial literacy. This area also examined respondents' satisfaction with transport services and the detection of regularities in the real estate market and the stock exchange. Authors (Cheng et al., 2023) train decision trees to demonstrate the impact of rumour propagation on stock trading behaviour. Sources indicate that CHAID algorithms are

particularly valued in these areas (Díaz-Pérez, 2016) because they allow decision-makers to identify the hierarchy of importance of factors and take precise action.

However, the last identified area of application of the CHAID algorithm deserves special attention, in which researchers address the issues of sustainability, digitalisation (Saáry et al., 2022) or incorporating ESG data into traditional accounting and financial measures (Doğan et al., 2025). It can be assumed that the complexity of issues in these research areas means that detecting useful knowledge patterns using a specific CHAID algorithm is not a common research approach to, for example, the problem of digital transformation. Furthermore, interpreting the classification results obtained can be challenging if it requires taking into account new, complex or previously unrecognised contextual conditions.

The publications listed (Table 2) are largely theoretical and empirical studies. In the introduction, the authors emphasise the usefulness of the tool for the area of problems described. Researchers commonly point to the multidimensional benefits of implementing data mining, including simplicity, computational speed, and ease of application of algorithms, i.e., CHAID. They also suggest the possibility of identifying so-called outliers in the learning process, which are sent to a separate child node without affecting further division. Among others, Díaz-Pérez et al., (2016) suggest that the analysis based on CHAID matches the nature of the tourism market segmentation problem better than those provided by discriminant analysis. Other studies emphasise the possibility of automating processes using the results of CHAID analysis, constructing a unique, customer-tailored product offer, operating in line with the consumer-centric idea, identifying new revenue streams or creating new business solutions in companies from various industries (cf. Hou, 2018).

The tool discussed has great application potential because CHAID is a non-parametric statistical technique (Higueras-Castillo et al., 2023). As emphasised in scientific studies, the ability to visualise the results obtained and map decision paths is also important, as it further improves their clarity and ease of interpretation by potential decision-makers (Yousaf, Dey, 2022). This is a starting point for practitioners and managers to make wider use of the CHAID algorithm as a tool that is appropriate for the individualised needs of their organisations. As shown in Table 2, grouping and classification using the algorithm can be extremely helpful in understanding the changes taking place in various sectors. Knowledge discovery algorithms can be used in almost every area of organisational management. They contribute to the interpretation of economic practice and, as a result, have become part of the scientific debate. Despite the very wide range of research using the CHAID algorithm, there are still areas where its untapped potential can be identified.

4. Discussion

The literature review confirmed the belief in the extensive explanatory and classification capabilities offered by CHAID. The algorithms are gaining recognition among researchers, but the lack of adequate data may be a significant obstacle to the implementation of such solutions. Before data can be transformed into useful knowledge, it must be combined, integrated, cleaned and visualised using tools that enable it to be manipulated (Slinger, Morrison, 2014). Preparing data for grouping and classification eliminates possible inconsistencies in the results. The correctness of the classification rules formulated depends on the quality of the input data used in the tree construction process. Decision trees can be sensitive to changes in the structure of the training set, so a small change in the input data can mean a significant change in the structure of the tree. However, decision trees require less data preparation than many other techniques, e.g. categorical variables are a problem for neural networks and statistical techniques (Hancock, Khoshgoftaar, 2020).

From the perspective of the limitations of CHAID, the fundamental issue is the decision-maker's responsibility for the ultimate consequences of the decisions made. It is impossible to disagree with Sienkiewicz (2018) that, in each case, limiting human involvement and supervision of the work process can lead to serious ethical and managerial challenges. Therefore, the prerequisites for the smooth implementation of new solutions (including those using LM algorithms) are commitment, good practices and adequate human capital resources. Furthermore, it should also be borne in mind that the algorithm is based on retrospective data, which may limit its usefulness in conditions of rapid market changes. At this point, a legitimate doubt may be raised as to the validity of its application to complex, emerging issues or trends. The literature emphasises that research hypotheses determine the choice of research approach, method and tools (Kumar, 2019).

On the one hand, the systematic literature review results may suggest that the increasing complexity of management and economic phenomena requires the use of more sophisticated models and tools as Random Forest, Gradient Boosting Machine (Luo et al., 2025). On the other hand, however, researchers point out that single decision trees are prone to overfitting and may exhibit limited predictive performance on complex datasets (Yin, Pierce, 2024).

5. Conclusion

In conclusion, it can be noted that the issue of the application of algorithms and classification trees is very broad, and this article and the conclusions formulated therein represent only a small part of this issue. As a result of reconstructing the main areas of

application of the algorithm, it can be concluded that, in particular, the ability of the CHAID algorithm to integrate unstructured data (qualitative and quantitative) determines its potential as a modern analytics tool. The algorithm fits perfectly into the digitainability trend (Saáry et al., 2022). Works such as Saáry et al. (2022), prove that this algorithm can be, for example, an effective tool for exploring attitudes towards digitalisation in the context of sustainable development. Moreover, the research results obtained may provide grounds for reorganising business activities. The adequacy and validity of using the CHAID algorithm to study current market changes and detect patterns in this area remains a complex issue. Its high interpretability must always be weighed against the limitations of processing highly volatile data. The recommendation from previous research concerning the need to develop a hybrid framework combining CHAID with advanced ensemble methods still seems relevant. Considering contemporary management trends, the development of appropriate tools adapted to the needs of a dynamic environment remains a serious challenge for business and the scientific community.

The future direction of research is to further verify the effectiveness of the tool in question and the scale of its use in business practices. It can be assumed that the need for real-time knowledge acquisition reported by decision-makers and the opportunities offered by the use of ML tools will stimulate further scientific exploration.

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URBAN LIVING LABS IN THE PUBLIC SECTOR: ORGANISATIONAL CONDITIONS AND DEVELOPMENTAL BARRIERS

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Purpose: This paper aims to examine the development barriers affecting Urban Living Labs (ULLs) initiated by the public sector in Poland. It focuses in particular on how institutional, financial, procedural and social constraints interact and influence the long-term sustainability and scalability of these initiatives within public administration structures.

Design/methodology/approach: The study adopts a qualitative approach combining a review of relevant literature with empirical research conducted in three Polish cities. Eight semi-structured in-depth interviews were carried out with representatives of public administration, academia, business and civil society, reflecting the quadruple helix framework. The interview material was analysed using qualitative content analysis in order to identify key categories of barriers and the relationships between them.

Findings: The findings suggest that barriers to the development of public-sector ULLs are interconnected and mutually reinforcing. The most significant constraints include project-based funding structures, limited managerial autonomy within municipal hierarchies, complex administrative procedures and difficulties in maintaining sustained citizen engagement. Together, these factors weaken institutional embedding and reduce the capacity to scale pilot initiatives beyond the experimental phase.

Research limitations/implications: The research is exploratory and based on a relatively small qualitative sample, which limits the generalisability of the results. Further studies, including comparative and quantitative research, would help validate and refine the identified barrier categories across different institutional contexts.

Practical implications: The results point to the need for simplifying administrative and procurement procedures, strengthening managerial autonomy and developing more stable funding arrangements. Improving cross-sector cooperation frameworks may enhance the effectiveness and long-term impact of Urban Living Labs operating within public structures.

Social implications: Better institutional conditions for ULLs may contribute to stronger citizen participation, increased trust in public institutions and more inclusive forms of urban innovation and governance.

Originality/value: The paper contributes to the ongoing debate on Living Labs by focusing specifically on initiatives embedded in public administration in a Central and Eastern European context. It highlights the systemic nature of development barriers and provides insights relevant to researchers and practitioners working in the fields of urban governance and public-sector innovation.

Keywords: Urban Living Labs; quadruple helix; semi-structured interviews; institutional barriers.

Category of the paper: Research paper.

1. Introduction

Contemporary urban areas are at a turning point where their role as centres of economic and technological development increasingly intersects with growing structural challenges. The accumulation of demographic, environmental and infrastructural processes within limited spatial boundaries generates tensions that call for a reassessment of established governance approaches (Nguyen, Marques, Benneworth, 2022). Traditional hierarchical planning is gradually giving way to more inclusive and democratic models based on the testing of innovations in real social contexts. A key instrument of this shift is the concept of Urban Living Labs (ULLs), defined as platforms for the active co-creation of urban solutions (Bresciani, 2025; Kosoe, Ogwu, 2025). Urban Living Labs function as environments for both co-creation and the validation of innovative solutions in real-life settings. In the literature, ULLs are described as open, user-centred innovation ecosystems whose core principle is the iterative testing of technologies and services under everyday conditions (Schuurman, Tönurist, 2017).

Urban Living Labs constitute specific physical or virtual spaces in which public authorities, private enterprises, research institutions and end users interact in a collaborative framework. The objective of this cooperation is not only the prototyping and validation of new solutions, but above all their embedding in real social and economic contexts (Sroka, Król, Kulesza, Stanuch, Lisek, 2025). This approach represents a practical operationalisation of the quadruple helix model, which integrates the perspectives of four stakeholder groups in order to generate innovations with high social relevance and utility.

The growing interest in Urban Living Labs observed in recent years is reflected in numerous initiatives supported by European Union framework programmes and national policies promoting open innovation models (Mahmoud, Morello, Ludlow, Salvia, 2021). ULLs are increasingly perceived as important instruments fostering the transition towards more inclusive communities and smart growth trajectories. Unlike early technocratic visions of smart cities, which focused primarily on information and communication technologies, the Living Lab concept places stronger emphasis on human and democratic dimensions of urban development (Esposito, Bertello, Mora, Tucek, 2025). It assumes an active role for citizens in the design of urban services, thereby contributing to the development of social capital and trust in public institutions (Esashika, Masiero, Mauger, 2023).

Despite their recognised advantages, the implementation of Urban Living Labs faces a range of organisational and social constraints. One of the most significant barriers to their effectiveness is the lack of institutional durability and the temporary nature of many initiatives, which often operate only within the timeframe of grant-based funding (Leminen, Westerlund, Nyström, 2012). In practice, maintaining genuine user participation also proves challenging, as involvement is frequently limited to testing activities rather than meaningful co-design processes (Schuurman, Leminen, 2021). The literature also points to power asymmetries among

partners and difficulties in integrating Living Lab outcomes into formal urban policies (Willems, Kuitert, Van Buuren, 2023). As a result, embedding the Living Lab approach within smart city strategies has proven more complex than suggested by simplified interpretations of the quadruple helix model (Nguyen, Marques, Benneworth, 2022).

The aim of this article is to identify and analyse development barriers affecting the functioning of Urban Living Labs (ULLs) initiated by the public sector in Poland. The study seeks to map the relationships between individual barriers in order to demonstrate how their interaction influences the functioning of the analysed initiatives. The analysis is based on in-depth qualitative interviews conducted with representatives of academia, business, public administration and civil society, reflecting the key stakeholder groups involved in public-sector innovation initiatives.

2. Theoretical Foundations of Urban Living Labs: Models, Stakeholder Roles and Development Barriers

Urban Living Labs represent a specific form of cross-sectoral collaboration that enables the creation, testing and implementation of innovations in real-life conditions. Their operation is grounded in the assumptions of the quadruple helix model, which integrates four key sectors: academia, business, public administration and civil society. Cooperation among these actors aims not only at the development of new technologies and services, but also at their social validation and adaptation to user needs (Almeida, Deutsch, 2025). Living Labs reshape traditional perceptions of the relationship between science and its practical application by relocating research processes directly into users' everyday environments. Their core principle is co-creation, which reduces the conventional distance between solution developers and end users. In this framework, users assume the role of active co-authors of innovation, allowing new technologies to be better aligned with actual social conditions and the genuine needs of future beneficiaries.

The literature identifies four main governance models of Living Labs, which differ according to the initiating actor and the dominant operational logic (Leminen, Westerlund, Nyström, 2012):

- User-driven, initiated by citizens and local communities and focused on user needs.
- Provider-driven, dominated by technology providers who use Living Labs to test proprietary solutions.
- Utilizer-driven, organised by firms seeking to commercialise innovations and strengthen market competitiveness.
- Enabler-driven, coordinated by public institutions or development agencies that create the conditions and infrastructure for cooperation across sectors.

These models differ in terms of collaboration patterns and the primary objectives pursued within projects. Bottom-up, user-oriented approaches prioritise relationship-building and the strengthening of local communities. Business-oriented models, such as provider-driven and utilizer-driven Living Labs, focus on market efficiency and the rapid commercialisation of innovations. In contrast, laboratories managed by public authorities within the enabler-driven model provide projects with regulatory support and access to municipal structures. In practice, the leading actor largely determines decision-making processes, the actual influence of residents and the availability of financial resources.

Most academic contributions on Living Labs emphasise their well-documented advantages, including inclusiveness, grassroots participation and the capacity to develop solutions tailored to local contexts (Voytenko, McCormick, Evans, Schliwa, 2016; Schuurman, Leminen, 2021). However, implementation challenges receive considerably less attention. Empirical studies nonetheless demonstrate that translating the Living Lab concept into practice generates numerous difficulties (Leminen, Westerlund, Nyström, 2012; Nguyen, Marques, Benneworth, 2022). The literature distinguishes five main categories of barriers, ranging from structural to social.

First, organisational and institutional barriers relate to unclear role allocation, the absence of long-term strategies and the project-based nature of many initiatives. Numerous Living Labs operate as temporary projects dependent on grant funding, which often leads to their discontinuation once funding ends (Leminen, Westerlund, Nyström, 2012). Second, financial barriers stem from the lack of stable funding sources and limited private-sector interest in projects characterised by uncertain returns. High coordination costs and the time-intensive nature of co-creation processes further hinder financial sustainability (Nyström, Leminen, Westerlund, Kortelainen, 2014). Third, technological barriers include the immaturity of tested solutions, difficulties in integrating them with existing urban infrastructure and challenges related to data ownership and intellectual property rights. Insufficient technological support reduces user motivation and constrains the effectiveness of experimental processes (Bulkeley et al., 2016). Fourth, legal and procedural barriers arise from regulatory frameworks poorly adapted to the logic of open innovation. Rigid public procurement procedures, data protection requirements and ambiguities surrounding the co-ownership of results limit the flexibility of Living Labs. A risk-averse administrative culture further complicates the formal implementation of experimental solutions within public institutions (Lupp, Zingraff-Hamed, Huang, Oen, Pauleit, 2020). Finally, social and cultural barriers concern levels of participant engagement and relationships among partners. Users are often treated primarily as testers rather than genuine co-designers of solutions (Voytenko, McCormick, Evans, Schliwa, 2016).

An analysis of these barriers suggests that their significance and intensity vary depending on the organisational context and the dominant actor. In the case of Living Labs embedded within public administration structures, operating predominantly under the enabler-driven model, these barriers assume a particularly pronounced institutional character. This results from

the procedural and hierarchical nature of the administrative environment. Research indicates that such contexts often constrain flexibility and experimentation, generating tensions between formal requirements and the co-creation-based innovation paradigm (Cuomo, 2022; Lupp et al., 2020; Piziak, Bień, Jarczewski, Ner, 2023). As noted by Sofronievska et al. (2025), the enabler-driven model, closely associated with public initiatives, carries the risk of marginalising social partners' voices. Innovation processes are frequently absorbed by bureaucratic procedures, with declared openness yielding to control imperatives. In some cases, residents' roles are reduced to passive testing of predefined solutions or participation driven solely by grant requirements.

Consequently, Living Labs managed by public administrations face not only bureaucratic constraints but also limited capacities for dialogue and interest mediation among diverse stakeholders (Gago, Rubalcaba, 2020). Moreover, the project-based nature of enabler-driven Living Labs, combined with unstable funding, hampers the development of organisational durability and the scaling of outcomes (Leminen, Westerlund, Nyström, 2012). Additional challenges include the integration of results into urban strategies and limited intersectoral mediation capacity, which exacerbate social and communication barriers (Gago, Rubalcaba, 2020; Nesti, 2018). Public Urban Living Labs thus operate at the intersection of two competing logics: rigid bureaucracy and flexible innovation. Their day-to-day functioning involves an ongoing attempt to balance administrative formalism with the openness required for creative processes (Voytenko, McCormick, Evans, Schliwa, 2016).

3. Research Design and Methods

The study is based on a review of the relevant literature and original qualitative research. The literature review covered publications addressing the Living Lab concept, the quadruple helix model and barriers to the development of urban and social innovation. The findings of this review informed the development of the study's theoretical framework and the design of the interview guide.

The empirical research was conducted in March and April 2025 in Kraków, Toruń and Rzeszów. These cities were selected due to the presence of actively operating Urban Living Labs and their close cooperation with local academic communities. This research setting enabled direct access to practitioners and researchers engaged in innovation processes at the local level. The study employed in-depth individual interviews (IDIs) using a semi-structured format. This approach ensured methodological flexibility and allowed for the exploration of emerging themes that arose dynamically during interactions with respondents (Kvale, 2007). Each interview lasted between 60 and 90 minutes. A problem-oriented perspective was adopted,

focusing on the identification of systemic barriers affecting the functioning of Urban Living Labs.

Respondent selection was purposive and grounded in the quadruple helix framework (Almeida and Deutsch, 2025). A total of eight respondents were interviewed, with two representatives from each sector: public administration (managers of Living Labs operating within municipal structures), business, academia and non-governmental organisations. The recruitment process followed a two-stage procedure. Initially, contact was established with Living Lab managers and an academic community. These participants subsequently identified further respondents representing the remaining helix actors, namely the private sector and civil society, in line with the snowball sampling approach. Participation in the study was voluntary and anonymous.

All interviews were conducted face to face, and the empirical material was documented through detailed field notes prepared by the researcher. The empirical material was analysed using qualitative content analysis. Based on the identified causal relationships, an Ishikawa diagram was developed to illustrate the interconnections among barriers to Living Lab development (Pudło, 2012). The construction of the diagram followed a three-stage procedure: identification of the main problem categories (organisation, regulation, processes, finance, technology and social acceptance), allocation of respondent-identified barriers to these categories, and logical verification of their relationships with the core problem, defined as limited organisational sustainability and difficulties in scaling innovation outcomes. The validity of the interpretation was confirmed through follow-up contact with selected respondents using a member-checking approach.

4. Research Results and Discussion

Interviews conducted with managers of Urban Living Lab units, as well as representatives of the private sector, academia, non-governmental organisations and local residents, made it possible to identify the key barriers constraining the development of these initiatives. The collected empirical material points to the systemic nature of the identified obstacles and to the presence of clear cause-and-effect relationships between them. The analysis indicates that financial deficits and structural constraints within public administration constitute primary barriers that directly contribute to the emergence of further challenges in the technological, regulatory and social domains. As a consequence, the limited flexibility of urban administrative structures emerges as a central factor hindering the operationalisation of the Living Lab concept at the local level. These interdependencies are illustrated through an Ishikawa diagram (Figure 1).

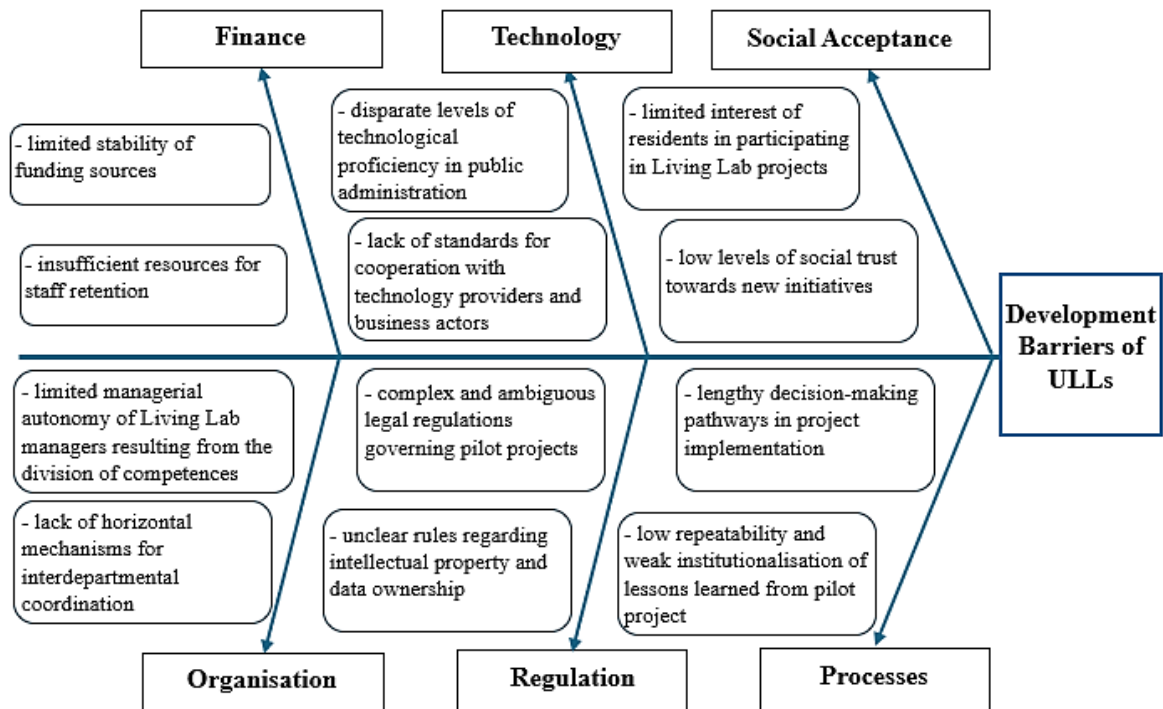


Figure 1. Ishikawa diagram illustrating cause-and-effect relationships among barriers to the development of Living Labs.

Source: own elaboration.

The issue most frequently raised during the interviews concerned the stability of funding for Living Labs. Respondents, particularly Living Lab managers, emphasised that funding is primarily provided through ministerial programmes and secured over a multi-year period, which enables the ongoing operation of laboratories and planning activities within a medium-term horizon (R1; R2). At the same time, it was noted that these resources largely cover basic operational costs and do not provide sufficient conditions for implementing infrastructure-related or investment-oriented initiatives. From the perspective of Living Lab managers, available funding allows for the financing of staff remuneration and the maintenance of existing infrastructure; however, moderate salary levels combined with high organisational and competency requirements significantly limit the ability to build stable and specialised teams (R1).

As a consequence, this funding structure encourages ULL to focus on so-called soft activities, such as educational, participatory or communication-oriented projects (R1, R2). Respondents indicated that initiatives of this type are relatively easier to implement within existing organisational frameworks, as they do not require interference with the competences of other administrative units and allow for the continuity of activities as well as the maintenance of institutional legitimacy within the urban environment (R1). At the same time, this orientation limits the willingness to undertake more complex infrastructural or technological experiments, which would require stronger interdepartmental coordination, additional financial resources and a higher degree of decision-making autonomy.

In effect, the funding structure combined with the institutional embedding of Living Labs within municipal administrations (in the cases of Rzeszów and Toruń, ULLs operate directly within city hall structures) jointly creates a mechanism that constrains managerial autonomy. The necessity to respect formal divisions of competences translates into frequent interdepartmental negotiations and reinforces a focus on activities that are feasible under existing organisational conditions, namely soft projects. The literature emphasises that the dominance of project-based funding in the public sector, combined with the absence of dedicated development-oriented resources, may limit the capacity of Living Labs to gradually build sustainable innovation ecosystems, even where baseline funding remains relatively stable (Leminen, Westerlund, Nyström, 2012).

Organisational barriers were particularly frequently highlighted by representatives of the business sector (R3, R4) and non-governmental organisations (R5, R6). These respondents stressed that although Living Labs have formally designated leaders, their actual capacity to act is constrained by the rigid organisational frameworks of public administration (R3, R5). In their view, ULL managers operate within narrowly defined competences, which restricts flexibility, hampers rapid responses and limits the initiation of more complex undertakings. From the perspective of external partners, the requirement to repeatedly coordinate activities with other administrative units significantly complicates the implementation of projects with an implementation-oriented character, such as pilot urban infrastructure or demonstrator installations (R3, R4). Respondents noted that under such conditions, initiatives extending beyond educational or participatory activities involve lengthy procedures and high coordination costs (R3, R4). At the same time, one ULL manager (R1) pointed out that small-scale solutions had been tested in the analysed laboratory within public space, including covered ecological bicycle shelters. According to this respondent, such initiatives may gradually broaden the scope of interdepartmental cooperation, although they do not eliminate the structural constraints associated with the position of Living Labs within municipal administration.

It should therefore be noted that the limited, and largely non-volitional, organisational agency of Living Lab coordinators, as clearly perceived by external partners, acts as a factor reinforcing other barriers to their functioning. This results in prolonged decision-making processes, hinders cooperation with the business sector and reduces the attractiveness of participation in Living Lab projects. Similar observations are made by Schuurman and Tönurist (2017), who argue that the lack of genuine autonomy and managerial agency weakens interdepartmental collaboration and complicates the transition from experimentation to durable implementation.

Another problematic area concerns technological and procedural conditions. Respondents emphasised that the key barrier is not access to infrastructure as such, but rather unclear and time-consuming procedures for obtaining approval to test solutions in public space. From the perspective of a business representative (R4), procedural unpredictability and long waiting times for decisions reduce firms' willingness to engage in Living Lab pilot projects.

Additionally, respondents pointed to imprecise rules governing intellectual property and the allocation of rights to jointly developed outcomes. According to a private sector respondent (R6), the absence of clear regulations in this area increases perceived risk and diminishes the willingness to invest resources in cooperation with Living Labs. As a result, procedural and legal ambiguity leads to delays in pilot implementation, reduced private-sector engagement and a low level of innovation commercialisation, a pattern also observed in the literature (Van Geenhuizen, 2018).

Regulation and bureaucracy were also identified by respondents as significant barriers. A business sector representative (R5) highlighted complex administrative procedures and lengthy public procurement processes, which prolong project implementation and undermine the momentum of collaboration. From an entrepreneurial perspective, such procedural barriers are difficult to reconcile with the operational logic of firms. These observations were echoed by respondents from the academic sector (R7, R8), who additionally noted that Living Labs could benefit from stronger and more systematic engagement by universities. At the same time, they pointed out that institutional support from academic organisations remains limited and that involvement in Living Lab projects is not adequately recognised within systems of academic evaluation, promotion or workload allocation (R7). Consequently, researchers' participation in Living Lab initiatives is typically additional in nature and largely driven by individual motivation and personal commitment. One academic respondent (R8) observed that, from a regulatory standpoint, Living Labs often closely resemble academic institutions. Rather than introducing genuinely novel rules of operation, they are frequently required to apply procedural frameworks typical of bureaucratised public organisations. As a result, despite declared openness to experimentation, these initiatives tend to reproduce constraints familiar from university-based projects, which in practice hampers the translation of pilots into lasting solutions. The literature highlights that the absence of flexible legal frameworks, including regulatory sandbox-type arrangements, constitutes a significant barrier to the development of urban innovation. At the same time, extensive administrative procedures and high levels of formalisation prolong implementation processes and discourage potential partners from long-term engagement in Living Lab projects (Puerari et al., 2018).

In the area of social barriers, respondents consistently pointed to difficulties in engaging residents in Living Lab activities. It was emphasised that the Living Lab concept remains insufficiently clear to local communities, which complicates the development of sustained engagement. This issue was raised by academic respondents (R7, R8), business representatives (R5, R6) and representatives of civil society themselves (R4), who noted that residents rarely perceive themselves as meaningful partners in innovation processes and more often view themselves as recipients of initiatives launched by public institutions. From the residents' perspective, the lack of a genuine sense of agency and the absence of quickly visible outcomes significantly weaken motivation to participate in ULL initiatives (R5). Respondents also indicated that project objectives and expected outcomes are not communicated clearly enough

and that non-governmental organisations are not always fully included in decision-making processes (R4). As a result, limited perceived influence, low visibility of outcomes and weak communication contribute to low levels of citizen participation and reduced social support for ULL activities, thereby undermining their legitimacy and limiting access to further funding. This mechanism is consistent with previous research on participation in Urban Living Labs (Voytenko, McCormick, Evans, Schliwa, 2016).

The final category of barriers identified relates to processes, particularly slow decision-making and the absence of systemic mechanisms for scaling developed solutions. Both academic respondents (R7) and business representatives (R3, R4) pointed to difficulties arising from the mismatch between the pace of actual implementation work and the procedures and timelines prevailing within public sector organisations. From a business perspective, prolonged procedures and delayed decisions restrict the ability to obtain timely results, thereby reducing the economic attractiveness of engagement in ULL projects (R3). As a consequence, many initiatives remain at the pilot stage, and accumulated experience is not consistently translated into lasting organisational change. The absence of formalised mechanisms for implementation and institutional learning contributes to the fragmentation of knowledge and reinforces the operation of ULLs within grant-based cycles, a pattern also identified in the literature (Bulkeley, Castán Broto, 2013). At the same time, one ULL manager (R1) noted that, in practice, experiences are gradually being transferred and solutions incrementally scaled, both through national and international cooperation among Living Labs. In this respondent's view, such processes are already underway, although their effects are not yet fully visible at the institutional level and require time to translate into durable outcomes.

The analysis demonstrates that barriers to the development of Living Labs are interconnected and systemic in nature, and that their impact extends beyond individual areas of operation. The findings are consistent with earlier studies highlighting the particular sensitivity of Urban Living Labs to resource constraints, process formalisation and organisational conditions characteristic of the public sector (Leminen, Westerlund, Nyström, 2012; Schuurman, Tönurist, 2017). Against this background, a critical question emerges as to whether the challenges faced by public-sector Living Labs stem solely from imperfect implementation, or whether they reflect a deeper structural incompatibility between the ULL model and the operational logic of public institutions. The flexible and experimental nature of Urban Living Labs may come into conflict with the hierarchical and procedural character of public administration, particularly in projects implemented under the enabler-driven model. This raises broader questions regarding the actual capacity of the public sector to act as an effective facilitator of social and technological innovation. Addressing these issues, however, requires further in-depth comparative research.

5. Conclusions

The conducted research demonstrates that the functioning of public-sector Urban Living Labs (ULLs) is shaped by a complex configuration of institutional, financial and social interdependencies. Although the Living Lab concept is widely recognised in the literature as a cornerstone of contemporary innovation processes, its practical implementation within public administration encounters multiple barriers that constrain both the scale and the durability of such initiatives. A key conclusion of the study is that the effectiveness of Living Labs is not determined by isolated obstacles, but rather by the cumulative and mutually reinforcing nature of these barriers.

The central challenge lies in the project-based logic of financing, which imposes a medium-term planning perspective and significantly limits managerial autonomy. Dependence on grant funding hampers the retention of stable and specialised teams and subjects Living Labs to rigid administrative hierarchies. As a result, decision-making processes are slowed, and more ambitious initiatives often remain confined to the pilot stage, failing to achieve lasting integration within municipal structures.

Organisational fragility directly affects relations with the business sector. Complex legal procedures and insufficient coordination mechanisms render the testing of solutions in urban space unpredictable from a corporate perspective. Elevated temporal and procedural risk discourages private-sector engagement in the Living Lab framework, thereby substantially reducing the potential for commercialisation of developed technologies.

An equally significant set of interrelated barriers concerns the social dimension. Limited understanding of the nature and objectives of Urban Living Labs, combined with a weak sense of agency among residents, results in low levels of participation. This situation is further exacerbated by the marginalisation of non-governmental organisations in decision-making processes. The absence of broad social legitimacy reduces political support, creating a self-reinforcing cycle that hampers access to additional funding and constrains long-term development.

The low visibility of outcomes, stemming from the dominance of so-called soft projects and the lack of guarantees for their scaling, discourages further stakeholder involvement. Although respondents pointed to a gradual exchange of experiences among Living Labs, this process remains too slow to generate durable systemic value. Enhancing the effectiveness of public Living Labs therefore requires simultaneous action in several areas, including strengthening managerial decision-making capacity, simplifying experimental and testing procedures, and establishing stable frameworks for cooperation with both the business sector and civil society.

While the conducted interviews enabled an in-depth analysis of practices in selected cities, the limited size of the sample precludes the formulation of generalised conclusions. The study is exploratory in nature, and the identified mechanisms require further validation through quantitative and comparative research.

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CONDITIONS OF INFORMATION FLOW IN SUPPLY CHAINS OF MANUFACTURING ENTERPRISES

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Purpose: The aim of the work is to identify and assess the basic conditions and the role of information flow in the aspect of creating relationships between manufacturing enterprises within supply chains.

Design/Methodology/Approach: The paper presents the results of a pilot study examining key aspects of information flow and exchange within the framework of collaboration between manufacturing companies in supply chains. The study was conducted using a proprietary survey questionnaire and included companies operating in Poland. The research covered topics such as identifying the role and scope of information exchange in supply chains, actions taken to improve information flow, issues of trust, risk, ensuring confidentiality, and barriers in relationships between business partners in the supply chain.

Findings: The obtained results allowed us to identify the role of information exchange among the surveyed enterprises and the activities undertaken in the field of information exchange as a fundamental element of integration and cooperation within the supply chain.

Research Limitations/Implications: The article is of an exploratory nature and provides a basis for further research in the field of building effective information exchange between enterprises in supply chains.

Practical Implications: Understanding the role of information exchange within inter-organizational relationships is a fundamental element of supply chain management and, at the same time, a significant challenge for many enterprises.

Social Implications: Building relationships based on information exchange within the supply chain is an important aspect of business operations and creating value for customers.

Originality/Value: The research niche presented in the article concerns the application of opinion and judgment research, based on the author's survey questionnaire, in the environment of manufacturing enterprises.

Keywords: information flow, supply chain, manufacturing companies, information security.

Category of the Paper: Research paper.

1. Introduction

In the current operating environment of businesses, identifying resources that ensure competitiveness plays a crucial role. Among these key resources is building relationships between business partners within the supply chain. The foundation for creating relational resources is collaboration in information exchange, which allows for the integration of the customer value stream and also provides opportunities for development and increased competitiveness.

Creating value currently requires focusing on activities such as speed of product or service introduction, shortened order lead times, and flexibility. This, in turn, requires the integration of resources, both physical and information, across all supply chain participants. Achieving benefits requires not only process optimization but, above all, close collaboration based on information exchange and trust between partners (Daneshvar Kakhki, Gargeya, 2019).

Collaboration, information exchange, and the use of information technology that ensures access to relevant and up-to-date information form the foundation of relationships in supply chains. It is worth emphasizing, however, that the basis for these activities is internal integration in the area of information flow, which is then extended to all supply chain participants. Collaboration within such an "extended enterprise" requires overcoming numerous barriers to information flow between supply chain links.

The aim of this study is to identify the determinants and role of information flow in establishing relationships between manufacturing companies and to assess the fundamental barriers and constraints in creating information resources in supply chains.

The research method used was a proprietary survey addressed to manufacturing companies operating in Poland.

The research objective was related to the following research questions:

- What competencies in the areas of internal integration and information flow in supply chains do the studied manufacturing companies demonstrate?
- What level of cooperation in the area of information exchange with contractors in the supply chain does the studied companies operate at?
- What actions are being taken and what information exchange tools are being used for integration in supply chains?
- How were the risk elements assessed and what security measures related to information exchange in supply chains were implemented?
- What actions are being taken to improve information flow and build trust within supply chain integration?

Obtaining answers to these questions allowed to assess the role of information flow in manufacturing companies and identify areas that influence effective cooperation in information exchange within supply chains.

2. Information flow in supply chains

Enterprises are a system of interacting material variables and information, and the efficient flow of information streams is a fundamental requirement for the effective functioning of their information system. Its efficient operation requires the involvement of IT services, the use of IT tools, and their adaptation to individual needs to collect, store, process, and use information in decision-making.

Currently, information technologies supporting Industry 4.0 play a special role within the information system (Fatorachian, Kazemi, 2021; Ghadge, Er Kara, Moradlou Goswami, 2020). New technologies can facilitate information exchange and reduce disinformation (Zissis, 2023), influence the decision-making process, streamline information flow in supply chains, and increase their resilience to disruptions (Huang, Wang, 2023). Information sharing in supply chain processes also has a significant impact on costs, financial results, and overall business performance (Şahin, Topal, 2019).

The concept of supply chain management is based on integration activities within individual organizations, which are then extended to other links. The essence of modern supply chain management (SCM) is the decision-making process related to the synchronization of physical, informational, and financial flows of demand and supply between its participants (Witkowski, 2016). In turn, functioning within a supply chain requires the development of new information channels that encompass all supply chain partners and address both internal and external information sources. This requires collaboration and commitment to integrate and coordinate material and information flows (Raweewan, Ferrell, 2018), particularly in areas such as inventory management (Dominguez et al., 2018).

Information exchange is a fundamental prerequisite for integration and coordination in modern supply chains (Huang, Phan, Do, 2023) between supply chain partners, which affects the level of cooperation and operational efficiency, reduces uncertainty and costs, and enables the fulfillment of demand-related (Wang, Zhuo, 2020) and pro-environmental (Zhang, Wang 2022) functions. Effective information flow combined with the use of modern technologies provides an opportunity to improve SCM efficiency (Gouiferda, Mounir, 2020), both in terms of integration, information exchange, and transparency (Dominguez et al., 2018), reducing forecasting errors, and improving the resilience of supply chain systems (Tang, Yang, Tu, Ma, 2021). However, it requires taking into account many factors that determine the effective flow of information (c.f. Kalaiarasan et al., 2022).

Supply chain efficiency is therefore the result of many factors: from personal relationships (Van der Walt, Niemann, Meyer, 2021), trust (Kim, 2025), digitization and access to information (Tiwari et al., 2024), to real-time visibility (Swink et al., 2023, Agrawal et al., 2024), which is currently a key issue. 2024), to real-time visibility (Swink et al., 2023, Agrawal et al., 2024), which is currently a key issue for organizations (AlMahri, Xu, Brintrup, 2025).

It is worth emphasizing that, apart from the use of modern technologies that support the flow of information and reduce uncertainty (Khamaiseh et al., 2024), reducing the bullwhip effect, increasing resilience and balancing the supply chain, organizational and relational conditions for information sharing are also important (Kembro, Näslund, Olhager, 2025). These include trust, culture, information asymmetry, risk, and organizational and relational factors that may limit the flow of information about threats in supply chains (Can Saglam, Sezen, Çankaya, 2020).

Reluctance to share information, incompatibility of IT systems, and lack of commitment to cooperation are just some of the factors hindering cooperation within the supply chain. Other important issues include information exchange (Wang, Zhuo, 2020), contractual arrangements between business partners regarding the use of information (Parry et al., 2016), and information sharing (Lotfi et al., 2013). The basic barriers (Hannibal et al., 2022) and limitations found in information systems in supply chains also include organizational standards, concerns related to trust (Collier, Sarkis, 2021), privacy and data security management in supply chains (Daneshvar Kakhki, Gargeya, 2019), and cybercrime (Herburger, Wieland, Hochstrasser, 2024).

However, it is worth pointing out a number of solutions (cf. Yin et al., 2025) currently recognized as tools supporting information sharing (Xue, Dou, Shang, 2021) or the dissemination of risk information in supply chains (Zhou et al., 2025; Fernando et al., 2022). One of them may be blockchain technology, which allows for reducing opportunism and lack of transparency through better information flow in chains and building trust (Dubey et al., 2020), increasing transparency, better planning, and supporting cyber resilience (Hajian et al., 2025).

3. Research Methodology

The research forming the basis of the study was pilot in nature. It was conducted using a proprietary survey questionnaire consisting of questions concerning the characteristics of the surveyed companies and the research issues addressed. The survey contained closed questions with the option to expand or supplement some of the answers. The questionnaires were completed by the target respondents, i.e., people in managerial positions, mainly in the area of supply chain management or other related areas (e.g., procurement, production). The results obtained in this way were subjected to quantitative and qualitative analysis and formed the basis for the conclusions.

The research sample was selected deliberately and focused on manufacturing companies. The research was conducted in 79 companies located in southern and central Poland (micro-enterprises were not included in the research). The characteristics of the companies surveyed are presented in Table 1.

Table 1.
Characteristics of the surveyed businesses

Classification criteria	Characteristics	Share, %
Size of operations	small	14
	medium	37
	large	49
Ownership	Polish capital	52
	with a share of foreign capital	34
	foreign capital	14
Range of operations	international	77
	domestic	18
	regional	5
Period of operation in the market	1-5 years	10
	6-20 years	47
	over 20 years	43

Source: Own study.

4. Research Results

The first issue examined was the assessment of the role of such elements as: internal integration of activities and functions, improvement of information flow, implementation of modern IT systems, and value creation in supply chains. The assessment was carried out using a 5-point Likert scale. The detailed results of the respondents' assessments are presented in Figure 1.

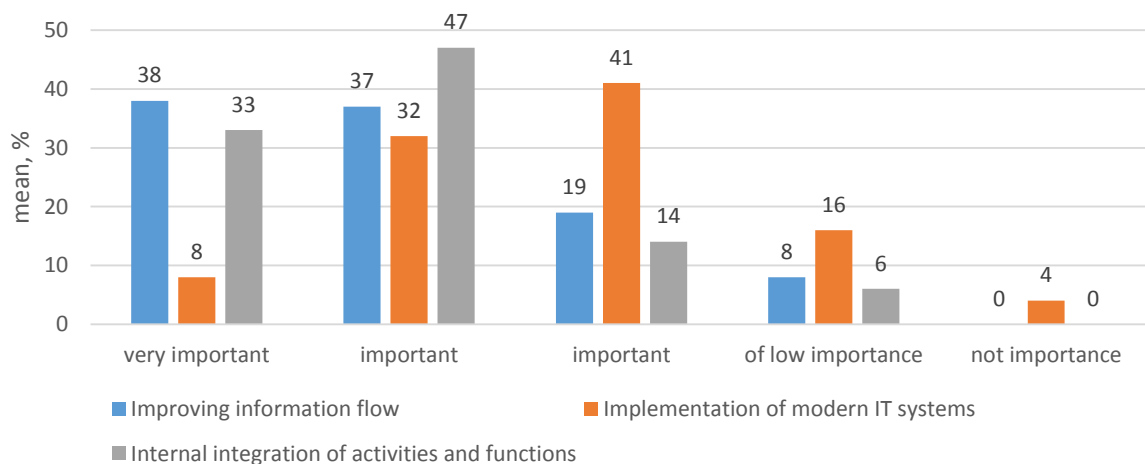


Figure 1. Assessment of the role of internal integration, improving information flow and implementing modern IT systems.

Source: Own study.

The results of the assessment in companies indicate the particular importance of integrating activities (as many as 80% of respondents rated this factor as important or very important). The role of improving the flow of information was also rated as important or very important by 74% of respondents. Surprising in the era of Industry 4.0 is the assessment of the factor concerning the implementation of modern IT systems (rated as important or very important by only 40% of respondents).

Another issue addressed in the survey concerned the assessment of the effects (achieved or expected) that may be associated with cooperation within an integrated supply chain in the area of information flow. Areas such as improving the flow of information, increasing the possibilities for fuller use of information and knowledge, increasing the accuracy of customer needs identification, and improving accuracy in planning and forecasting were taken into account. The results of the respondents' assessment are presented in Figure 2.

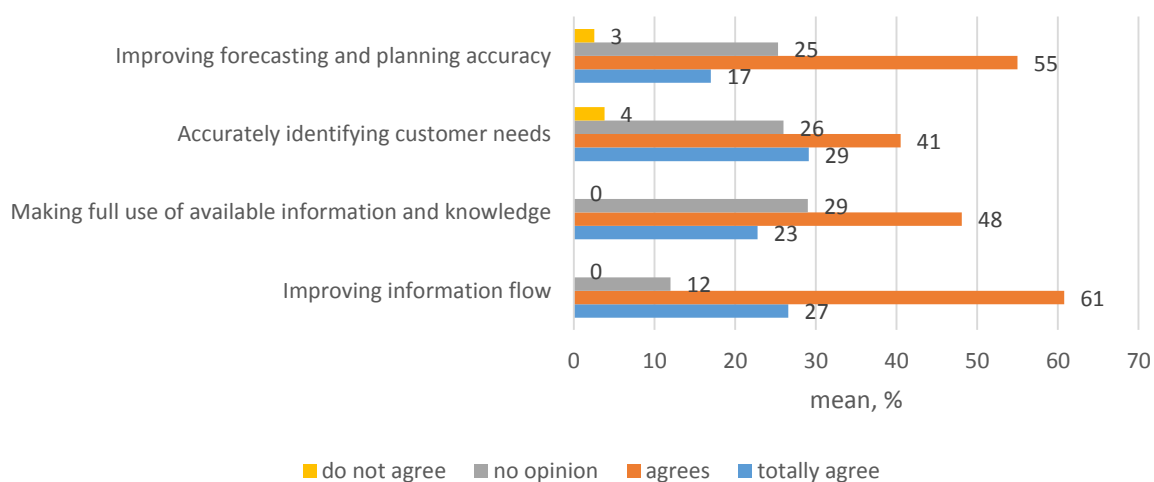


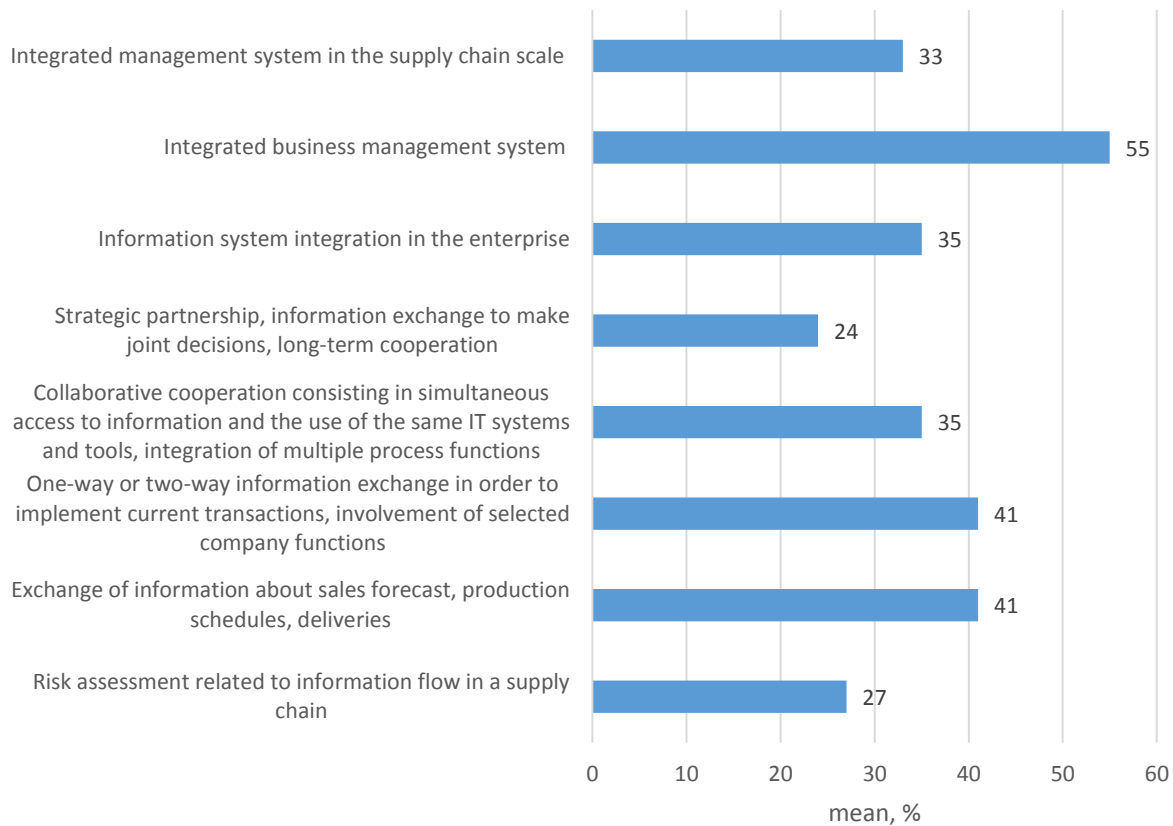
Figure 2. Effects (achieved or expected) in the area of information flow in integrated supply chain management.

Source: Own study.

The results obtained from the respondents' opinions indicate a significant correlation between supply chain integration and the positive effects achieved in the areas surveyed. For the vast majority of the surveyed companies, the positive effects of integrated supply chain management include improved information flow (88%), more complete use of information and knowledge (71%), improved forecasting accuracy (72%), and increased ability to identify customer needs (70%). The level of respondents' responses indicates a significant impact of the integration of companies within the supply chain on the improvement of the flow of information and knowledge, increased accuracy in forecasting, and identification of customer needs.

However, reaping the benefits of cooperation within integrated supply chain management requires a number of actions, from establishing rules for cooperation with partners, through the use of available tools, to building a common value system. Therefore, the next aspect examined concerned the identification of the competencies of the surveyed companies in the area of

integration, the nature of cooperation related to the exchange of information within companies and in supply chains. The results are presented in Figure 3.



* it was possible to choose more than one answer.

Figure 3. Competences of the enterprise in the area of information flow and integrated supply chain management.

Source: Own study.

Identifying the nature of cooperation between the surveyed companies in the supply chain allows for an assessment of the intensity and related scope of information exchange. Only 24% of respondents describe cooperation as a strategic partnership, characterized by long-term relationships and information exchange for the purpose of joint decision-making. As many as 40% of respondents describe their relationships with partners as cooperative collaboration involving simultaneous access to information and the use of the same IT systems and tools, as well as the integration of multiple process functions. Relationships involving the exchange of information on sales forecasts, production schedules, and deliveries, as well as those characterized by one- or two-way exchange of information for the purpose of carrying out current transactions, received 41% of responses each.

IT tools play a significant role in the integration process, both in terms of information flow and across the entire supply chain. Modern technologies enable not only the flow of information and communication, but also full time coordination and teamwork in a distributed environment, corresponding to modern supply chains. The basis for effective information exchange is the

integration of information systems, supported by modern tools in the form of integrated systems. In the first phase, information system integration most often takes place at the organizational level (35% of responses) and/or the implementation of an integrated management system (55% of responses), and can then be extended to the entire supply chain (33% of responses).

The results of the responses regarding the assessment of risks related to the flow of information in the supply chain (27%) can be described as low. At the same time, it should be emphasized that effective information exchange and trust are fundamental conditions for partnership in the supply chain. At the same time, lack of trust is most often indicated as a significant and very significant barrier to integrated supply chain management (74% of responses).

It was therefore reasonable to obtain information on which elements of information flow management influence trust building in the supply chain. The results are presented in Figure 4.

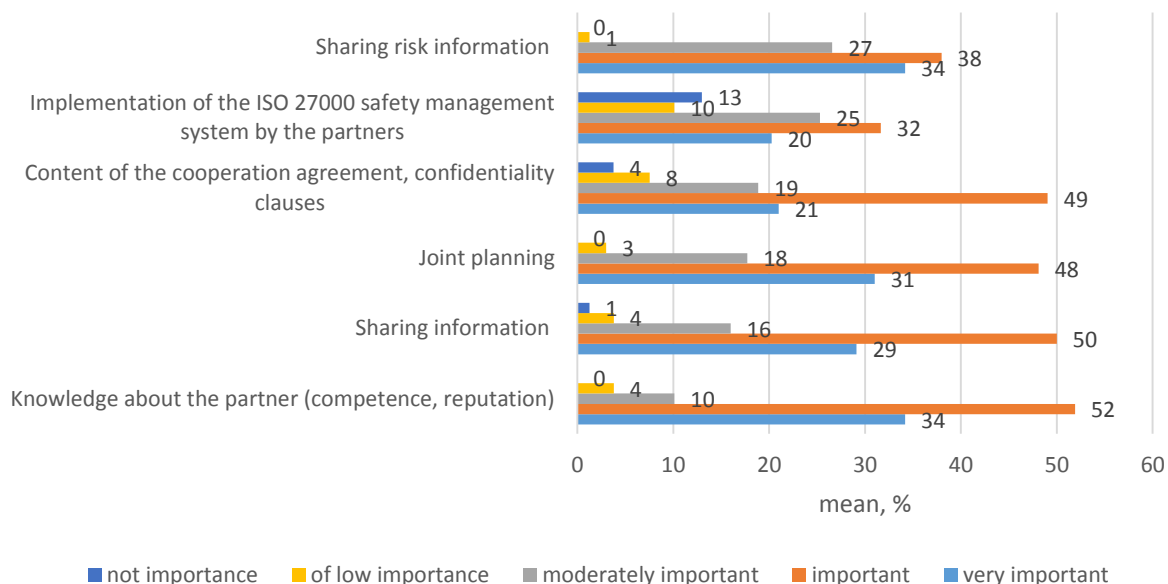
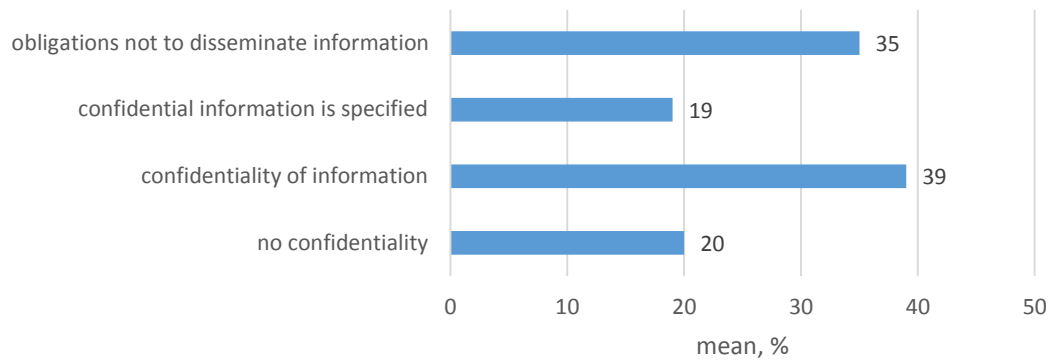


Figure 4. Information flow management elements influencing trust building in the supply chain.

Source: Own study.

According to respondents, the most frequently cited element of building trust in the supply chain is knowledge about the partner (86% indicated it as very important or important), followed by information sharing and joint planning (79% each), then 72% of respondents indicated that sharing information about risk and the content of the cooperation agreement and confidentiality clauses (70%) were important. Respondents considered the implementation of an ISO-based information security management system to be less important.

Another issue concerned measures taken to ensure the confidentiality of information in cooperation with partners in the supply chain, and the results are presented in Figure 5.



* it was possible to choose more than one answer.

Figure 5. Obligations towards partners in terms of confidentiality.

Source: Own study.

The regulations and activities concerning mutual obligations most frequently indicated by respondents concerned obligations regarding confidentiality of information (39%) and non-disclosure of information (35%), while 19% of respondents indicated obligations of confidentiality only in the case of classified information. At the same time, a significant proportion (20% of respondents) indicated a lack of regulations and obligations regarding confidentiality of information in cooperation with partners.

An important element of the functioning of the supply chain is the issue of risk and disruptions in the flow of information. The results of the assessment of the significance of individual disruptions and restrictions related to the flow of information on the functioning of the supply chain are presented in Figure 6.

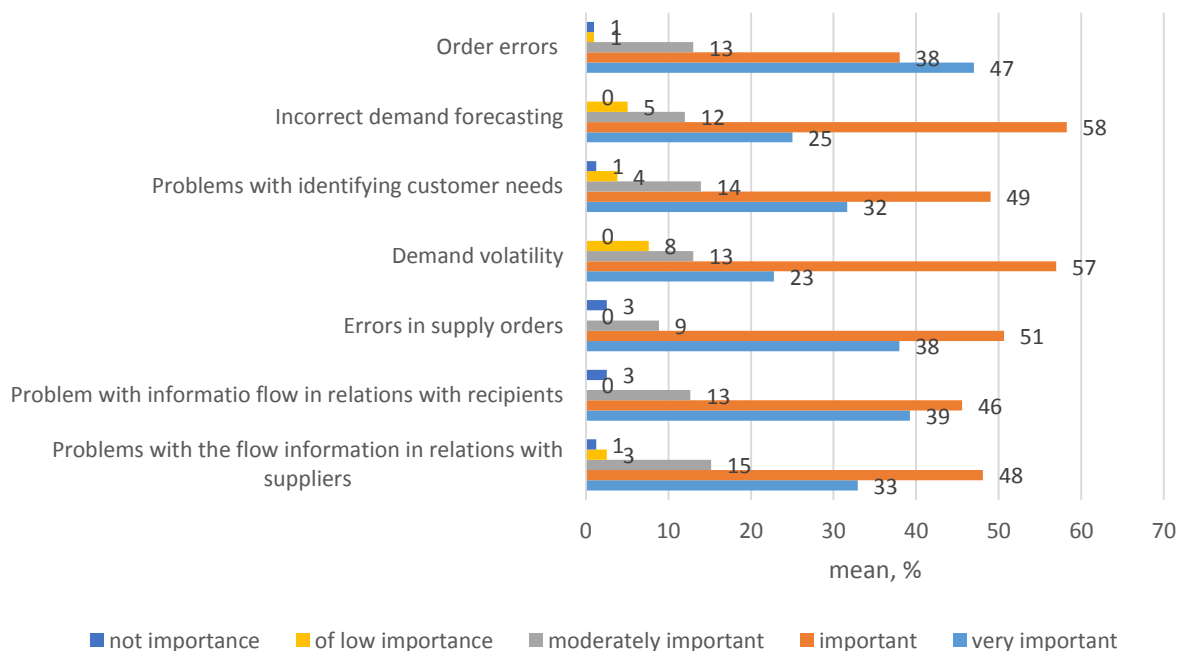


Figure 6. Information disruptions and their significance in connection with partners in the supply chain.

Source: Own study.

The results of the study indicate a significant impact of irregularities in the flow of information on the functioning of the supply chain. According to the respondents, the highest impact on supply chain disruptions is caused by errors in orders, both on the part of customers and in procurement orders. Respondents ranked problems in the flow of information in relations with customers and suppliers second. Problems related to identifying customer needs, forecasting demand, and its volatility received lower scores.

5. Summary

Gaining a market advantage requires close cooperation with business partners, which can be one of the greatest opportunities for stimulating business development. At the same time, effective information flow in supply chains remains a major challenge in business practice and an untapped area with significant potential for creating competitive supply chains.

Based on surveys conducted on the conditions for information flow in supply chain management in manufacturing companies, it can be concluded that they recognize the important role of information exchange between partners in the supply chain and elements such as integration of activities and improvement of information flow. The most frequently mentioned positive effects of integration in the supply chain are the streamlining of information flow, fuller use of available information and knowledge, and improved forecasting and planning accuracy. In terms of the scope of cooperation and information exchange in the surveyed companies, links can be identified mainly in the exchange of information on sales forecasts, production schedules, and deliveries. Cooperation defined as a strategic partnership is not very common, nor is the assessment of risks related to the flow of information across the entire supply chain.

The results indicate that the basis for building trust in relations with business partners is gaining knowledge about the partner, joint planning, and sharing information. At the same time, ensuring security in the flow of information through regulations such as confidentiality or non-disclosure agreements is an important aspect of information flow in business practice. However, it is worth noting that in the case of a significant proportion of the companies surveyed, there is a lack of regulations in this area.

The research results presented in this paper are limited to manufacturing companies, but a comprehensive analysis of cooperation involving partners throughout the supply chain seems justified. Similarly, in the case of risk analysis, in the area of such important resources as information and knowledge, it seems reasonable to extend the research to include issues related to the effective and efficient flow of information and its security. It should be emphasized that the flow of information is the basis for the formation of knowledge, which plays a special role in gaining a competitive advantage.

The article did not conduct a statistical test of correlation between the level of supply chain integration and the obtained results and the impact of limited strategic collaboration (24%) on supply chain resilience was also not examined. Moreover, the research results presented in the article are of a pilot nature, therefore further research requires the definition of a methodological framework.

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EVALUATING SELECTED AI TOOLS FOR LITERATURE REVIEWS: A CASE STUDY IN LOCAL ADMINISTRATION CYBERSECURITY

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Purpose: The objectives of this article are to identify scientific articles on the cybersecurity of local administration and to assess how useful the aid of two Artificial Intelligence tools: SciSpace.com (Advanced Plan) and Consensus.app (Pro tier) can be in this type of research.

Design/methodology/approach: The method of conducting the screening and verifying its results based on manual screening partially assisted by LLMs is described in detail in the article. The PRISMA 2020 protocol was used for a part of the preliminary screening.

Findings: The study indicates that both tools have limited usefulness for screening based on abstract content and better for full text document screening. When using the Scopus database, the study showed minimal utility of the PRISMA protocol implementation within the SciSpace tool, particularly when weighed against its usage cost.

Research limitations/implications: Due to both: the nature of LLM tools, whose immanent feature is indeterminism, often leading to the lack of reproducibility of obtained results, and the business model, where the tools are continually developed and their behavior changes over time, the obtained results are not general or universal.

Practical implications: Local administration cybersecurity is a very specific field of knowledge and practice. This type of literature review can be helpful to those working in said field in different countries. and the identification of the tested AI tools' limitations – particularly the relatively low quality of screening based solely on article abstracts – may allow for more effective use of similar tools.

Originality/value: The results provide knowledge about publications in the field of cybersecurity in local government administration and include calculations of the basic statistics (accuracy, sensitivity, and specificity) of the discussed tools in the examined case. To our knowledge, this is the most current and comprehensive literature review on this topic to date, while the calculations constitute a contributory study.

Keywords: information security management systems, local administration cybersecurity.

Category of the paper: research paper.

1. Introduction

The rapid expansion of scientific literature has made traditional systematic literature reviews (SLRs) increasingly time-consuming. In response, artificial intelligence (AI) has emerged as a modern tool, offering automation across multiple stages of the SLR process. As in a number of other applications, AI can be a promising tool for this process but - also similarly to other AI applications - serious doubts arise regarding the admissibility of its use, from the threat of losing creative originality of the researcher's work (see e.g. Lund et al., 2023; Hosseini et al., 2023; Ateriya et al., 2025; Cheng et al., 2025), to the issue of the quality of the obtained results, including their reliability, especially in the context of the tendency of some AI tools - mainly Large Language Models (LLM) - to "hallucinate", which can manifest itself e.g. in the production of non-existent bibliographic entries (see e.g. Walters et al., 2023; Chelli et al., 2024; Tosi, 2025).

Most existing studies examine AI-assisted screening in broad or well-established research areas, often in medical or interdisciplinary contexts. Less attention has been given to narrowly defined and semantically heterogeneous domains, where relevance cannot be determined solely by keyword matching but contextual and institutional interpretation is also required.

Cybersecurity in local administration is one such field. Both "local administration" and "cybersecurity" are conceptually broad and interpreted differently across countries and disciplines. This diversity complicates query construction and screening criteria and raises questions about how reliably AI tools can identify relevant publications.

Against this background, the study addresses the research problem: to what extent can selected AI tools help with literature screening in such a field? The research question is: how accurate and useful are SciSpace (Advanced Plan) and Consensus (Pro tier) in identifying publications devoted to cybersecurity in local administration?

This article has two objectives: first, to identify all relevant publications across major academic databases; and second, to evaluate the classification performance and utility of the AI tools in question in abstract-based and full-text screening procedures.

2. Literature review

AI can help with SLRs in several ways: early use covered automating repetitive tasks such as literature search and screening using artificial neural networks (ANN) and text mining (de la Torre-López et al., 2023). More recent developments leverage advanced machine learning (ML), natural language processing (NLP), and LLMs to support not only screening but also data extraction, synthesis, reporting and even automated literature reviews, enhancing

scalability and uncovering interdisciplinary connections (Malik, Terzidis, 2025; Bolanos et al., 2024; Li et al., 2025; Susnjak et al., 2025; Ofori-Boateng et al., 2024). Given the known weaknesses of AI, several frameworks have been proposed that use human supervision over artificial intelligence, emphasizing transparency and reliability (Lee et al., 2025; Le Dinh et al., 2025). These frameworks typically use a cyclical approach, including human testing and validation of AI tools to reduce bias and ensure methodological soundness (called “human-in-the-loop”). A human-assisted approach remains crucial, enabling real-time adjustments to inclusion criteria and continuous quality assurance (van Dijk et al., 2023).

There are a lot of articles devoted to issues related to evaluating the usefulness of this type of tools (Bernard et al., 2025; Pinzolit, 2023; Fuller-Tyszkiewicz et al., 2025; Vallamchela et al., 2025; Abogunrin et al., 2025; Tosi, 2025; Mogoale et al., 2025), especially reduction of workload, precision, accuracy, as well as developing methodologies and tools intended to assist researchers in conducting SLRs (van de Schoot et al., 2021). Arhin in the article (Arhin et al., 2025) declares that a thorough search performed across databases including Web of Science, Scopus, IEEE Xplore, ACM Digital Library, and Google Scholar using keywords such as “AI and academic writing”, “AI in literature reviews”, and “machine-assisted literature review” gave 1153 peer-reviewed studies produced from 2020 to 2024 (after eliminating non-empirical publications and those irrelevant to AI in academic literature review procedures). At the time of writing this (December 2025) there are 2340 findings published in 2025 indexed in Web of Science alone, one could therefore venture that the use of AI tools in this context is currently at a stage named Peak of Inflated Expectations in Gartner’s Hype Cycle model (see e.g. Czerwinka, Podgórski, 2025) perhaps one should even call it overhyped. However taking into account that there are many AI solutions on the market and new ones and new versions and new extensions of previously available ones appearing and moreover, different sciences have different methodological conditions, and the terminology used within them may be amenable to analysis in different degrees (taking into account the methods used by particular tools) it seems useful to conduct similar research for different issues.

In existing literature, evaluations of AI-assisted screening have typically been conducted in broad or well-established research areas, often in medical or interdisciplinary contexts (van de Schoot et al., 2021; Ofori-Boateng et al., 2024). In such domains, inclusion criteria are usually well structured and terminology is relatively standardized, which may facilitate automated classification. However, several authors underline that the effective use of AI in systematic reviews requires careful validation, human supervision, and methodological transparency (van Dijk et al., 2023; Lee et al., 2025).

Less attention has been devoted to narrowly defined and semantically heterogeneous research areas, where relevance is not based on keyword matching. In such areas, classification may depend on institutional or contextual interpretation or regulatory recommendations concerning particular terms, increasing the risk of classification errors. Moreover, generative AI systems may exhibit a tendency to interpret prompts too literally and sensitivity to contextual

framing, which further endangers the stability and reproducibility of screening outcomes (Tosi, 2025).

Cybersecurity in local administration constitutes such a domain. It combines elements of public administration and GRC (Governance, Risk Management and Compliance), especially concerning information security management. Overlapping term ranges – for example between “local government”, “municipality”, and “regional authority”, and between “cybersecurity”, “information security”, and “data protection” – increases the methodological complexity of query construction and screening procedures. This condition makes for a suitable test case for examining how AI tools perform when semantic nuance plays a significant role.

Despite the growing number of publications on AI-supported systematic reviews, there isn’t much empirical research assessing tool performance in narrowly defined domains and comparing abstract-based and full-text screening within such contexts. This study aims to contribute to this discussion by providing a domain-specific evaluation of selected AI tools and by quantifying their classification characteristics.

3. Research methods

3.1. Databases selection and query construction

One of the most important issues concerning local administration cybersecurity is that neither “local administration” nor “cybersecurity” have an unambiguous meaning nor syntax. Instead of “cybersecurity”, it is possible to use such semi-equivalent terms such as “information security”, “data security”, “cybersafety” etc. Additionally different (conjunctive and separated) spelling the “cyber-” prefix are used in the literature. One can find a few synonymous terms for “local administration” (e.g. “local government”, “municipal administration”, “local authority” etc.) also.

Taking the above into account, the queries we constructed for each database were quite complex, as they involved searching for conjunctions of two long phrases (in at least one of the most important fields i.e. title, abstract, keywords): one related to local administration and one related to cybersecurity. Formally, we were looking for conjunctions of complex alternatives. A sample query directed at the IEEEExplore database is shown in the figure below.

```

((((("Document Title":"local government") OR ("Document
Title":municipality)OR ("Document Title":"local administration")OR
("Document Title":"municipal administration")OR ("Document Title":"city
government")OR ("Document Title":"regional government")OR ("Document
Title":"local authority"))AND (("Document Title":"cybersecurity")OR
("Document Title":"cyber security")OR ("Document Title":"cybersafety")OR
("Document Title":"cyber safety")OR ("Document Title":"cyberthreat")OR
("Document Title":"cyber threat")OR ("Document Title":"cyber risk")OR
("Document Title":"information security")OR ("Document Title":"data
security")OR ("Document Title":"security of data")OR ("Document Title":"IT
security")OR ("Document Title":"cyber protection")OR ("Document
Title":"security awareness")OR ("Document Title":"network security")OR
("Document Title":"computer security")OR ("Document Title":"cyber
resilience")OR ("Document Title":"ICT security")OR ("Document Title":"cyber
defence")OR ("Document Title":"cyberdefence")OR ("Document Title":"GDPR")OR
("Document Title":"data protection")))) OR (((„Abstract“:"local government")
OR („Abstract“:municipality)OR („Abstract“:"local administration")OR
(„Abstract“:"municipal administration")OR („Abstract“:"city government")OR
(„Abstract“:"regional government")OR („Abstract“:"local
authority"))AND(„Abstract“:"cybersecurity")OR („Abstract“:"cyber
security")OR („Abstract“:"cybersafety")OR („Abstract“:"cyber safety")OR
(„Abstract“:"cyberthreat")OR („Abstract“:"cyber threat")OR
(„Abstract“:"cyber risk")OR („Abstract“:"information security")OR
(„Abstract“:"data security")OR („Abstract“:"security of data")OR
(„Abstract“:"IT security")OR („Abstract“:"cyber protection")OR
(„Abstract“:"security awareness")OR („Abstract“:"network security")OR
(„Abstract“:"computer security")OR („Abstract“:"cyber resilience")OR
(„Abstract“:"ICT security")OR („Abstract“:"cyber defence")OR
(„Abstract“:"cyberdefence")OR („Abstract“:"GDPR")OR („Abstract“:"data
protection"))))OR(((„Author Keywords“:"local government") OR („Author
Keywords":municipality)OR („Author Keywords":"local administration")OR
(„Author Keywords":"municipal administration")OR („Author Keywords":"city
government")OR („Author Keywords":"regional government")OR („Author
Keywords":"local authority"))AND ((„Author Keywords":"cybersecurity")OR
(„Author Keywords":"cyber security")OR („Author Keywords":"cybersafety")OR
(„Author Keywords":"cyber safety")OR („Author Keywords":"cyberthreat")OR
(„Author Keywords":"cyber threat")OR („Author Keywords":"cyber risk")OR
(„Author Keywords":"information security")OR („Author Keywords":"data
security")OR („Author Keywords":"security of data")OR („Author
Keywords":"IT security")OR („Author Keywords":"cyber protection")OR
(„Author Keywords":"security awareness")OR („Author Keywords":"network
security")OR („Author Keywords":"computer security")OR („Author
Keywords":"cyber resilience")OR („Author Keywords":"ICT security")OR
(„Author Keywords":"cyber defence")OR („Author Keywords":"cyberdefence")OR
(„Author Keywords":"GDPR")OR („Author Keywords":"data protection"))))

```

Figure 1. IEEEExplore query.

Source: Own survey.

3.2. Screening methodology

The SciSpace agent called “Systematic Literature Review” offers systematic literature review using PRISMA 2020 Methodology (Page et al., 2021). We used it to perform screening of Scopus database search results. Taking into account that the cost of the “advanced” subscription (and additional credits because starting number of SciSpace credits is not sufficient to conduct more than one study using advanced agents) is relatively high and automating such screening in the case of high-quality literature databases would only slightly reduce the workload of the process compared to manual review (only 1 record excluded and 8 flagged for manual review, which constitutes just over one percent of the initial number of records), we decided not to use the PRISMA protocol for the rest of the examined databases and instead construct AI prompts in a way that allows eliminate abstracts not related to the relevant subject.

For the screening procedure, we decided to use the algorithm shown in Figure 2.

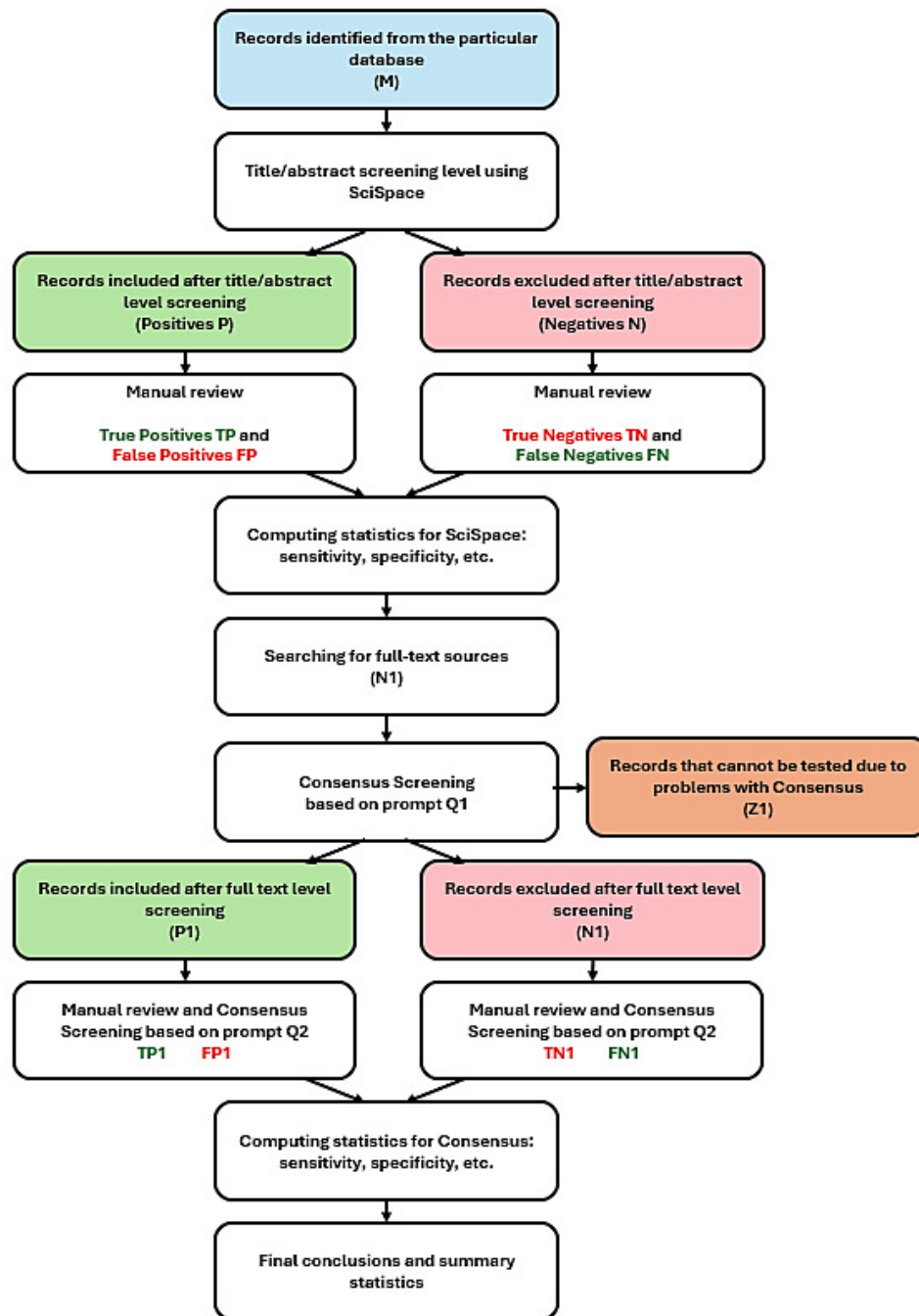


Figure 2. Procedure algorithm.

Source: Own survey using SciSpace.com and Consensus.

The initial screening (using the SciSpace tool) only accounted for abstracts, titles, and keywords, whereas the screenings utilizing the Consensus tool accounted for the full texts of articles (and therefore only for those articles that are available in full-text form). “Records cannot be tested due to problems with Consensus (Z1)” indicates a situation where the process of importing files containing the publication into the tool has failed. We asked the tool’s authors why certain texts could not be imported into Consensus. In response, they explained that Consensus relied on standard journal metadata – such as journal name, publication year, DOI, and volume/issue – and that book chapters, despite being valid scholarly

works, were more difficult to index and upload automatically. Consequently, the system was unable to process such texts.

For all three screenings, we constructed prompts according to the schemas shown in the figures below.

You got file "xxx.CSV" with bibliographic data. I need two CVS: 1. with list of all of text are not devoted to local government (including municipal, city etc.) cybersecurity or information security 2. with list of all other texts

Figure 3. SciSpace prompt schema.

Source: Own survey.

Is this paper devoted to cybersecurity in local administration (Yes/No)?

Figure 4. Consensus prompt Q1 schema.

Source: Own survey.

Summarize the article in Polish. What are the main conclusions? Does the article concern information security in local or municipal government administration? Does it contain any guidelines regarding the organization or management of information security?

Figure 5. Consensus prompt Q2 schema translation.

Source: Own survey.

We decided to pose two questions to the Consensus tool: one aimed at generating a binary (yes/no) answer, and the other at providing a more in-depth discussion and explanation of the decision made. We anticipated that the requirement to give a concise answer could lead to situations where the tool's made decision might be considered incorrect from a human perspective. Therefore, the second question (along with human control) served to verify its accuracy.

4. Results

4.1. Initial queries results

The number of records identified in each database, as well as the number of records remaining after manual and consensus screening (Q2), are shown in table 1.

Table 1.
Initial queries results

Database	Number of records	Number of full text sources	Final records after Q2 screening
Scopus	692	310	137
Web of Science	215	144	61
IEEEExplore	56	18	13
ACM Digital Library	14	14	7

Source: Own survey.

Some publications are indexed simultaneously in several databases. Figure 6 and table 2 illustrate this situation by showing the number of items in each set and their intersections. The number of unique findings after Q2 screening is 169, while the number of full text sources available is 218.

Table 2.
Cardinality of the intersection of full-text sets

Database	Number of records
Scopus AND Web of Science	36
Scopus AND WoS AND IEEEExplore	1
Scopus AND WoS AND ACM Digital Library	4
Web of Science AND ACM Digital Library	1

Source: Own survey.

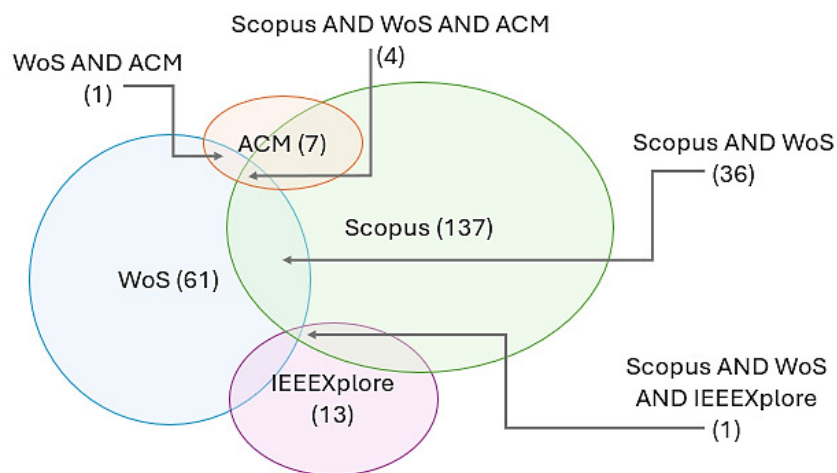


Figure 6. Cardinalities of full-text sets and their intersections.

Source: Own survey.

4.2. SciSpace aided use of PRISMA 2020 on Scopus' search results

Results of having the SciSpace agent “Systematic Literature Review” use the PRISMA 2020 protocol on Scopus Database search results are shown in Figure 7.

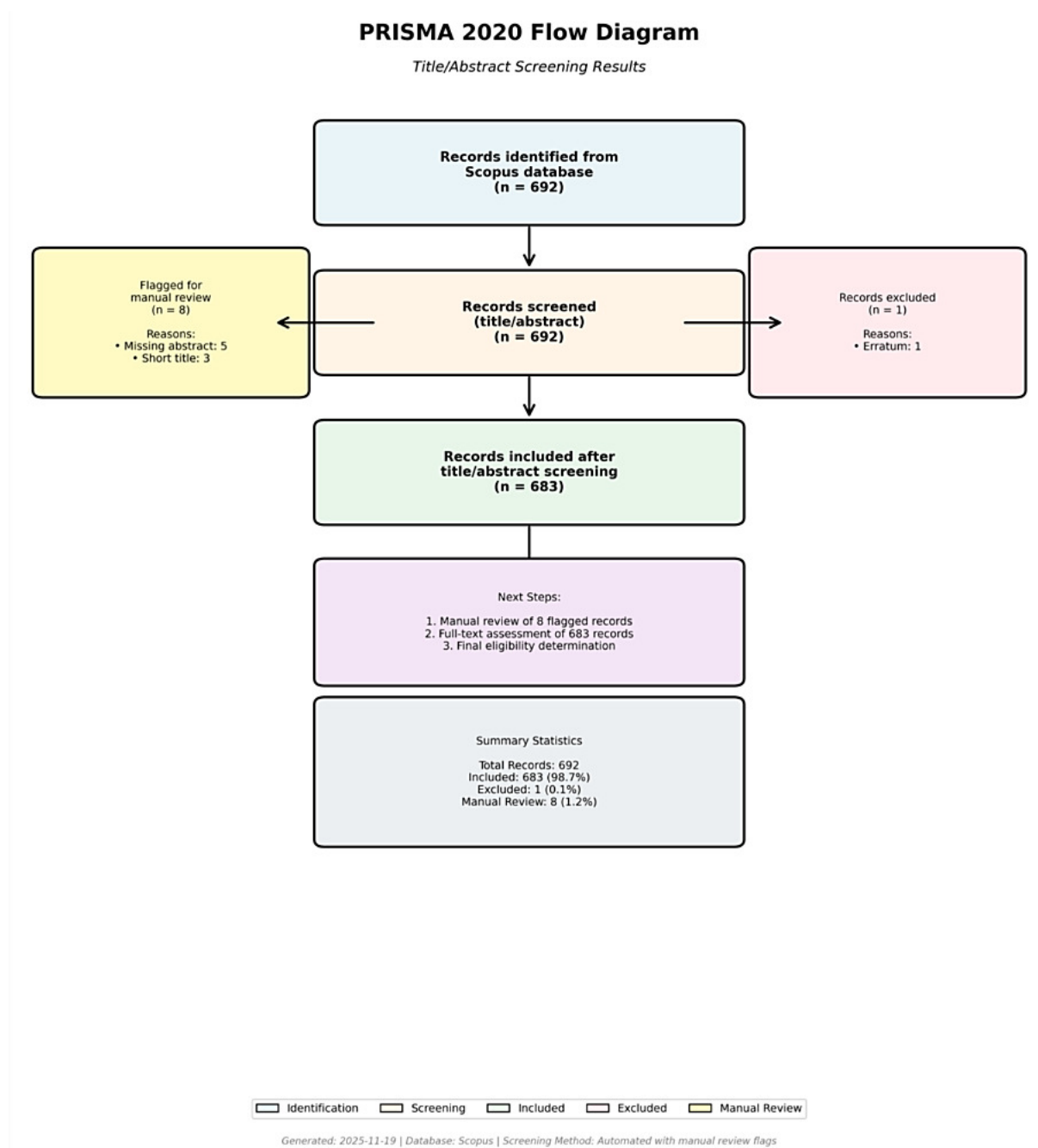


Figure 7. PRISMA report created by SciSpace “Systematic Literature Review” agent on Scopus search results.

Source: Own survey using SciSpace.com.

As mentioned above, due to an insufficient cost-benefit ratio, the use of this protocol for subsequent databases was abandoned in further research.

The study doesn’t include a formal time or cost-per-record analysis for the PRISMA screening conducted using SciSpace. Based on practical experience, manual screening of several hundred records (e.g., 692 in Scopus) typically requires several working days, whereas the automated PRISMA procedure was completed minutes after data upload but the cost is tens of dollars.

However, only a very low number of records were automatically excluded or flagged, and most still required manual verification. Considering the subscription and additional credit costs, the cost–benefit ratio the decision to discontinue PRISMA screening for the remaining databases was made.

4.3. Screening statistics

For this article’s purpose, among all possible classifier characteristics, the most significant are Accuracy, Sensitivity (True Positive Rate), Specificity (True Negative Rate) and Precision – formulas (1), (2), (3) and (4).

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \quad (1)$$

$$Sensitivity = \frac{TP}{TP + FN} \quad (2)$$

$$Specificity = \frac{TN}{TN + FP} \quad (3)$$

$$Precision = \frac{TP}{TP + FP} \quad (4)$$

where:

TP is the number of True Positives,

TN is the number of True Negatives,

FP is the number of False Positives,

FN is the number of False Negatives.

Statistics calculated for each individual database and both tools are shown in Table 4. All classification metrics presented in Table 4 were calculated directly from the TP, FP, TN and FN values reported in Table 3.

Table 3.
Confusion matrix values for each database and tool

Database	SciSpace		Consensus	
Scopus	TP	388	TP1	137
	FP	199	FP1	8
	TN	99	TN1	145
	FN	6	FN1	5
WoS	TP	128	TP1	61
	FP	81	FP1	5
	TN	5	TN1	66
	FN	1	FN1	5
IEEE	TP	12	TP1	13
	FP	5	FP1	0
	TN	38	TN1	5
	FN	1	FN1	0

Cont. table 3.

ACM	TP	7	TP1	7
	FP	7	FP1	0
	TN	0	TN1	7
	FN	0	FN1	0

Source: Own survey.

Table 4.

AI tools statistics

	Accuracy	Sensitivity	Specificity	Precision
SciSpace abstracts screening	Scopus			
	0.704	0.985	0.332	0.661
	Web of Science			
	0.619	0.992	0.058	0.612
	IEEE			
	0.893	0.923	0.887	0.706
	ACM Digital Library			
Consensus full-text screening (Q2)	0.500	1.000	0.000	0.500
	Accuracy	Sensitivity	Specificity	Precision
	Scopus			
	0.956	0.965	0.948	0.945
	Web of Science			
	0.927	0.924	0.930	0.924
	IEEE			
	1.000	1.000	1.000	1.000
	ACM Digital Library			
	1.000	1.000	1.000	1.000

Source: Own survey.

The study doesn't include a controlled experimental comparison of the time required for manual full-text screening versus AI-assisted screening using Consensus.

Based on practical experience, careful manual evaluation of a single full-text scientific article may require from several minutes to almost an hour, depending on length and complexity. Screening over 200 full-text documents would therefore realistically require several days of focused work.

In contrast, once the documents were successfully imported into the Consensus system, initial classification and summarization were generated within minutes. The human researcher's role was limited primarily to verification of the AI-generated classification. While this observation strongly suggests a substantial productivity gain, it should be emphasized that this conclusion is qualitative and experience-based rather than derived from a formally measured time-efficiency experiment. Future research should include controlled timing and costing to quantify the productivity improvement.

5. Discussions

As with other AI tools, it seems crucial to formulate precise prompts. In several cases, asking whether an article is “devoted” to a given topic yielded different results than asking whether it is “concerning” that topic. Additionally, the examined tools appeared to display a tendency toward literal interpretation of prompts, which resulted in arbitrary classification that rejected texts not devoted entirely and exclusively to the given subject (local administration cybersecurity), even when that subject appeared within them as one of the topics (including cases where it was of relatively substantial importance and scope). However, even when trying to force a clear answer, the question (with “Yes/No” clause) sometimes Consensus gave an ambiguous answer (such as “Yes, the paper is devoted to cybersecurity, but not specifically to local public administration”, which is not particularly helpful for someone trying to use an AI tool to extremely simplify text screening). It should be remembered that LLMs such as generative pre-trained transformers (GPT) do not understand the processed text but rely on the knowledge acquired during the training process, so in the case of uncommon and complex language structures (both: the analysed texts as well as the questions asked) they may provide inaccurate or vague answers.

Likewise, when it comes to the analysis of complex and multi-faceted texts (as scientific articles sometimes are), it would be worth considering abandoning the enforcement of unequivocal (“Yes/No”) responses and allowing, perhaps, intermediate answers (“partially”). Admittedly, as is always the case with classifiers, a reduction in type I errors will cause an increase in type II errors (and vice versa); nevertheless, in the context of screening scientific articles, the risk of rejecting relevant texts is a greater concern than a slightly increased workload at the final stage of reviewing articles that have successfully passed the screening process (at least when one is not dealing with a large number of texts).

It’s also important to remember that even the very concepts of cybersecurity, local government data security etc. can be understood differently. The scope of local government activities and the technologies they employ may differ in different countries, so issues that don’t strictly fall under the umbrella of local government cybersecurity in one country (such as medical data privacy, information security in cyber-physical systems etc.) may, in some cases, be a very important aspect of such administration’s operations in another country.

These observations are consistent with existing research indicating that AI-assisted screening may achieve high sensitivity during abstract-only screening, while still requiring substantial human validation (van de Schoot et al., 2021; van Dijk et al., 2023). AI-based tools can accelerate the screening of large volumes of scientific literature; however, they should be supervised by a human to ensure methodological reliability (de la Torre-López et al., 2023; Arhin et al., 2025; Ofori-Boateng et al., 2024).

In the present study, abstract-based screening demonstrated high sensitivity but relatively low specificity in several databases, which reduced the risk of excluding relevant publications but did not significantly decrease the workload associated with false positives. Similar observations have been reported in studies analysing the use of AI research assistants in systematic review frameworks, where AI tools helped identify relevant publications but still required careful human verification (Bernard et al., 2025).

In contrast, the very high values of both: sensitivity and specificity observed in full-text screening using Consensus suggest that access to richer contextual information may partially explain the better classification performance.

These findings support the view that AI tools should be treated as methodological support instruments rather than replacements for expert judgement, and that their effectiveness depends on the type of screening and the characteristics of the research domain.

6. Limitations and Future Research

First, the research did not include a controlled experimental measurement of time efficiency or a formal cost-per-record analysis. Although practical experience suggests substantial differences between manual and AI-assisted screening, the conclusions regarding productivity gains remain qualitative rather than based on systematic timing.

The evaluation was also limited to two specific AI tools: SciSpace (Advanced Plan) and Consensus (Pro tier) and to their functionality at the time of the study. Given the frequent updates and rapid development of AI models, tool performance may change over time. Therefore, the results should not be interpreted as universal or permanent signifiers of these tools' quality.

In addition, the analysis was conducted within a single, narrowly defined research domain which limits generality of results. Tool performance in other domains – particularly those with more standardized terminology – may differ significantly.

Furthermore, the screening procedure relied on specific prompt formulations, alternative formulations might have produced different classification outcomes.

Future research should therefore include formal timing and costing comparisons of manual and AI-assisted screening. It would also be valuable to replicate the study across different research domains and to compare a broader range of AI tools. It also may be interesting use multi-class classification approaches (e.g., allowing “partially relevant” categories).

7. Conclusions

The statistics for abstract screening clearly indicate that the adopted procedure is characterized by high sensitivity but relatively low specificity, and thus leaves significant workload in verifying texts classified as relevant. For unknown reasons, the results are better in the case of IEEEXplore. It may be due to the different characteristics of the database itself or changes that might have occurred in the tools between uses. In comparison, the AI-assisted screening of full texts yields very good results in terms of both sensitivity and specificity. In practice, this means that for large text databases, AI can be a useful assistant in the screening process, provided it works on the full texts of articles, not just their abstracts, titles, and keywords.

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INTELLECTUAL CAPITAL AND ARTIFICIAL INTELLIGENCE AS DRIVERS OF COMPANY PERFORMANCE AND INNOVATION: A BIBLIOMETRIC ANALYSIS

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Purpose: This paper focuses on the intersection of intellectual capital (IC), artificial intelligence (AI), and company performance and innovation, which together constitute the dual dimensions of value creation (VC). It aims to map and interpret the scientific literature on these relationships and to identify dominant and emerging research directions.

Design/methodology/approach: The study applies quantitative bibliometric methods combined with qualitative literature synthesis. A systematic search of the Scopus database yielded 448 records, which were screened and refined to 129 peer-reviewed articles. Qualitative synthesis was then applied to identify key mechanisms linking IC, AI, and VC.

Findings: The results reveal a strong and rapidly growing scientific interest in the IC-AI-VC nexus. The literature most frequently co-evolves with research themes related to innovation and sustainability, digital transformation, knowledge management, organizational performance, environmental and green development, and managerial decision-making. The qualitative synthesis suggests that the interaction between IC and AI supports VC, primarily through learning processes, capability development and adaptive processes.

Research limitations/implications: Future research should develop empirical models testing causal mechanisms between IC, AI, and VC. Context-specific analyses examining firm-specific and institutional effects would enhance understanding of these relationships.

Practical implications: The findings highlight the importance for organizations to integrate investments in human capital, knowledge management systems, and artificial intelligence as mutually reinforcing elements of competitive strategy.

Social implications: Human capital is critical for successful AI adoption, highlighting workforce needs. As AI reshapes firms, policies for continuous learning, skills upgrading, and sustainable innovation are essential for societal adaptation.

Originality/value: This paper offers one of the first comprehensive bibliometric mappings combined with qualitative synthesis of the IC-AI-VC research domain, providing an integrated perspective for researchers, practitioners, and policymakers.

Keywords: corporate finance; value creation; intellectual capital; artificial intelligence; company performance and innovation.

Category of the paper: Research paper; Literature review.

1. Introduction

In the contemporary knowledge-based economy, the sources of sustainable competitive advantage are undergoing a profound transformation (Barney, 2010). Traditional tangible resources are no longer sufficient to explain differences in firm performance, market valuation, and innovation capacity. Instead, intangible resources, particularly intellectual capital, and advanced digital technologies have become central drivers of enterprise value creation (Inkinen, 2015; Madhani, 2012). At the same time, the rapid diffusion of artificial intelligence is fundamentally reshaping how knowledge is generated, processed, and converted into economic outcomes (Cockburn et al., 2019; Dwivedi et al., 2021). Recent empirical studies further indicate that artificial intelligence and digitally oriented organizational capabilities increasingly shape managerial decision-making and firms' innovation-related outcomes (Hofman, Wawak, 2025; Żukowska et al., 2025).

Although both intellectual capital and artificial intelligence have been extensively studied as separate research domains, their joint impact on firm performance and innovation remains conceptually fragmented and empirically under-systematized (Mention, 2012). Existing studies are dispersed across disciplines, employ heterogeneous methodologies, and frequently focus on isolated components of intellectual capital or specific technological applications, making it difficult to derive an integrated understanding of how intellectual capital and artificial intelligence jointly influence measurable firm outcomes (Inkinen, 2015; Van de Vrande et al., 2010).

This article addresses this gap by providing a comprehensive bibliometric mapping and qualitative synthesis of the scientific literature at the intersection of intellectual capital (IC), artificial intelligence (AI), and firm performance and innovation, which together constitute the dual dimensions of value creation (VC). To guide the analysis, the following research questions were formulated:

- RQ1. What are the quantitative publication trends, citation patterns, and geographical characteristics that define the temporal and spatial evolution of scientific research on the Intellectual Capital, Artificial Intelligence, and Value Creation triad?
- RQ2. Which journals constitute the most influential publication outlets within this research field, and what is the structure of the core scientific knowledge base supporting this domain?
- RQ3. What dominant and emerging thematic clusters structure the current research landscape, and how do they differentiate the intellectual capital and artificial intelligence configuration from traditional intellectual capital theory?
- RQ4. What are the key conceptual relationships, mediating mechanisms, and research gaps regarding how intellectual capital and artificial intelligence jointly shape value creation (encompassing performance and innovation)?

The study contributes to the literature in three principal ways. First, it reconstructs the conceptual structure and evolution of research on the intellectual capital, artificial intelligence, and value creation triad using advanced bibliometric techniques. Second, it identifies the dominant thematic clusters and emerging research fronts shaping this field. Third, it develops a qualitative synthesis that reveals key conceptual linkages, limitations of existing approaches, and under-explored research directions.

The article is structured as follows. Section 2 describes the data sources and bibliometric methodology. Sections 3 and 4 present the quantitative bibliometric results. Section 5 provides a qualitative synthesis of the literature focused on conceptual development, and identification of critical research gaps. The article concludes with a summary of key findings, limitations, and directions for further research.

2. Data and methodology

Bibliometric analysis was employed as a quantitative approach to examine a body of scholarly literature, map the intellectual structure of the field, identify influential works, and trace the evolution of themes over time (Broadus, 1987; Pritchard, 1969). In social sciences, bibliometrics helps reveal patterns such as keyword co-occurrence, detect research fronts and knowledge bases, and diagnose gaps that require further investigation (Donthu et al., 2021; Zupic, Čater, 2015). This study focused on a thematic synthesis of intellectual capital, artificial intelligence, and firm performance and innovation in order to highlight dominant and emerging topics and to identify underexplored links within the analyzed triad.

Table 1.
Literature selection and filtering process

Database	Scopus
Search	("intellectual capital" OR "human capital" OR "structural capital" OR "relational capital") AND ("AI" or "artificial intelligence" OR "machine learning") AND ("profitability" OR "market value" OR "value creation" OR "performance" or "innovation")
Records generated after the search	448 records
Selection	Limit to: articles, final, English
Records generated after applying filters	224 articles
Title, abstract and keywords analysis	Articles excluded: AI/ML used as an analytical method, macro-level or educational perspective with no link to company perspective, no connection between the analyzed factors
Final record of articles for quantity and quality analysis	129 articles

Source: own study.

Table 1. summarizes the literature selection and filtering procedure, providing an overview of the search strategy, applied criteria, and the construction of the final dataset used in the bibliometric analysis. To conduct the study and identify relevant literature on the analyzed topics, the Scopus database was selected. It is considered the largest abstract and citation database of research literature in the world (Schotten et al., 2017). Scopus is also a valuable resource in the social sciences especially in the areas of business and management. Content is published according to rigorous selection rules overseen by an independent board of scientists, ensuring that only the highest quality sources are indexed. Scopus also offers advanced functionalities, and analysis tools with built-in bibliometric indicators, making it a high-quality source of bibliometric data for academic research, significantly facilitating literature reviews in particular (Baas et al., 2020).

The search query was performed on 16th September 2025. As the three analyzed concepts represent relatively recent and evolving research domains, the search query was intentionally formulated in a broader manner to capture diverse terminological variations and conceptual perspectives present in the literature. The search phrase was formed as follows: ("intellectual capital" OR "human capital" OR "structural capital" OR "relational capital") AND ("AI" or "artificial intelligence" OR "machine learning") AND ("performance" OR "innovation" OR "profitability" OR "market value" OR "value creation").

The term "intellectual capital" has been expanded in the search to include its main components: human, structural and relational capital. The reason for this expansion was that these three aspects are closely related to the topic of analysis and should be considered complementary. In many articles, the phrase "intellectual capital" itself did not appear in the keywords, titles, and abstracts, but its components were mentioned. Therefore, it was decided to expand this phrase, as all these IC elements should be included in this analysis as important. The concept of artificial intelligence was also expanded to include "machine learning", which can be treated as a practical synonym in the technological sense in the processes used by companies. The third aspect of the analysis was formulated as broadly understood performance and innovation and supplemented with phrases related to the profitability and market value of the company as a financial aspect.

The search string was applied to article titles, abstracts, and keywords and 448 records were identified. The dataset was then restricted to document type "article", resulting in 257 records. Subsequently, non-final publications were excluded, resulting in the removal of 20 records. Finally the language filter was applied, selecting only English-language articles to enable content comparison and analysis. This resulted in a total of 224 articles, which were then exported for further processing.

Microsoft Excel was used for content analysis of titles, abstracts, and keywords to initially clean the data and refine the sample of analyzed articles. To select only topic-relevant articles, these elements were reviewed to verify thematic appropriateness. This thorough screening led to the exclusion of 95 irrelevant articles due to poor thematic fit. Such a substantial number of

articles eliminated from the research sample was determined by the following main factors: (1) use of AI or ML as a method of analysis and not the subject of the research itself; (2) a macroeconomic or educational perspective on the analyzed factors without any connection with firm operations; and (3) a lack of connection between the analyzed factors, specifically simple occurrence of keywords without a visible analysis of influences and dependencies. The exclusion decisions were made by applying these criteria independently to each article's title, abstract, and keywords. To ensure consistency of application, a random sample of 20 articles (approximately 9% of the screened dataset) was cross-checked, confirming full agreement with the applied protocol. The screening was conducted by a single researcher, which constitutes a methodological limitation acknowledged in this study. After applying these exclusion criteria, the final dataset comprised 129 thematically relevant articles.

The bibliometric study was conducted in RStudio with the Bibliometrix package and its web interface Biblioshiny. The analysis generated a comprehensive set of performance indicators and science mapping visualizations. Specifically, the study produced descriptive statistics on annual scientific production, citation structures, and source impact, including the identification of core journals based on Bradford's Law and leading publication outlets. Science mapping techniques were applied to construct keyword frequency distributions, keyword co-occurrence networks, thematic maps, and thematic evolution diagrams in order to identify dominant, emerging, and declining research themes. Additional analyses included trending topics visualization and the quantitative characterization of thematic clusters with respect to their centrality, density, and frequency. These outputs provided the empirical basis for both the quantitative mapping of the field and the subsequent qualitative literature synthesis.

3. Preliminary quantitative bibliometric analysis

This section presents the bibliometric results for the Scopus corpus on intellectual capital in the era of technology and artificial intelligence with a focus on links to firm performance and innovation. The analysis proceeds from global production dynamics to structural features of the knowledge base. First, publication trends over time are examined to situate the temporal evolution of the field. Next, the geographical distribution of research output is analyzed to highlight leading regions contributing to this research stream. The section then explores the structure of publication outlets through the identification of core journals and source concentration based on Bradford's Law.

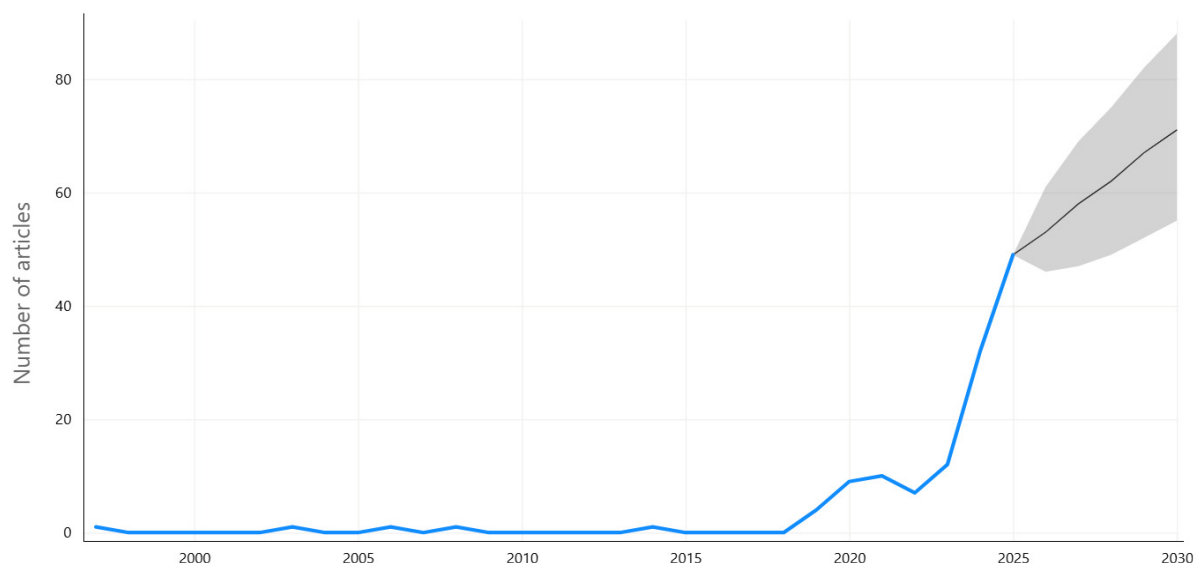


Figure 1. Annual publication output with 5 year forecast.

Source: own study based on Scopus data.

Research on the IC-AI-VC nexus was minimal before 2018, with many years in the 1990s and 2000s recording zero or one article (Figure 1). The first consistent growth begins in 2019 (4 articles), showing dedicated academic interest. This volume sharply increased from 2020 onward, rising from 9 articles in 2020 to 12 in 2023, and then dramatically peaking at 32 in 2024 and 49 in 2025. This surge corresponds with the massive adoption of AI technologies in business, confirming the relevance of this topic. Overall, the production figures emphasize the rapidly growing significance of the field. Projections for 2026–2030 indicate continued growth in annual publication volume, reflecting sustained and expanding scientific interest in the IC-AI-VC nexus. However, such forecasts should be interpreted cautiously, as they assume the persistence of recent trends and do not account for potential disruptions or shifts in research priorities.

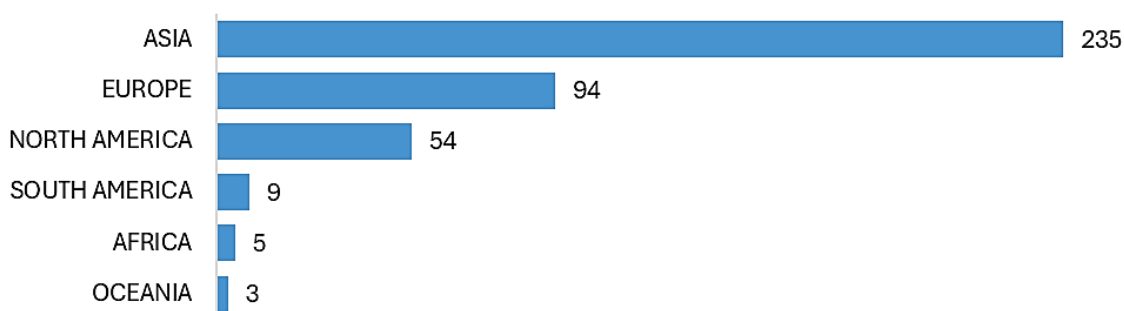


Figure 2. Continents' scientific production.

Source: own study (based on Scopus data, Bibliometrix package).

The geographical distribution of research (Figure 2) reveals a clear dominance of Asia in terms of scientific production within the analyzed field. This region substantially exceeds the contributions of Europe and North America, which occupy the second and third positions, respectively.

A closer examination of country-level contributions helps to explain this continental pattern. China emerges as the most productive contributor with a scientific output of 147, followed by the United States (39), India (26), and Romania (20). The concentration in China and India largely explains Asia's continental dominance. Within Asia, Malaysia (15), Indonesia (9), and Saudi Arabia (8) provide additional contributions, while outside the region, Canada (10) and Italy (8) represent the most active contributors in their respective continents.

Despite ranking second at the continental level, Europe's scientific production remains approximately 2.5 times lower Asia's. Moreover, the European research landscape appears more dispersed, with output distributed across a relatively large number of countries rather than concentrated in a small group of dominant research hubs. Notably, Poland does not appear in the Scopus dataset, which points to a clear gap in the existing literature and limits empirical and conceptual insights into the situation of Polish companies within the IC-AI-VC framework. The remaining continents exhibit only niche levels of participation in scientific production.

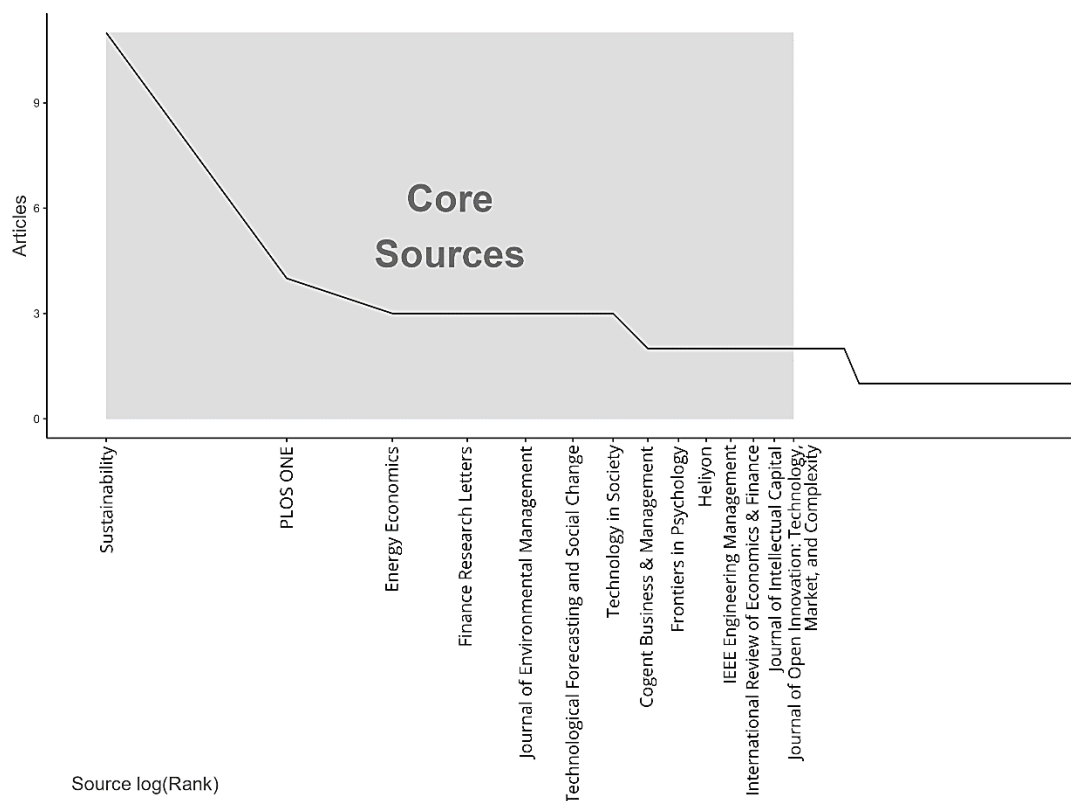


Figure 3. Bradford's Law - core sources.

Source: own study (based on Scopus data, Bibliometrix package).

Figure 3 presents the distribution of research output across journals according to Bradford's Law. The core sources zone (marked grey) identifies journals that contribute the most to the analyzed topic. Results show that there is a high concentration of scientific output within a limited number of journals. This pattern is consistent with the classical interpretation of Bradford's Law. A small group of leading sources accounts for a disproportionately high share of published articles and shapes both the research and communication in this field. These core

sources constitute the primary knowledge base for scholars and practitioners. Beyond the core zone, the number of published articles decreases while the number of contributing journals increases, creating a long tail of occasional publications.

4. Advanced quantitative bibliometric analysis

This section extends the preliminary results by providing a deeper quantitative examination of the intellectual structure of the research field. Specifically, the in-depth analysis explores key concepts, themes, and research streams to reveal the underlying organization and evolution of the literature.

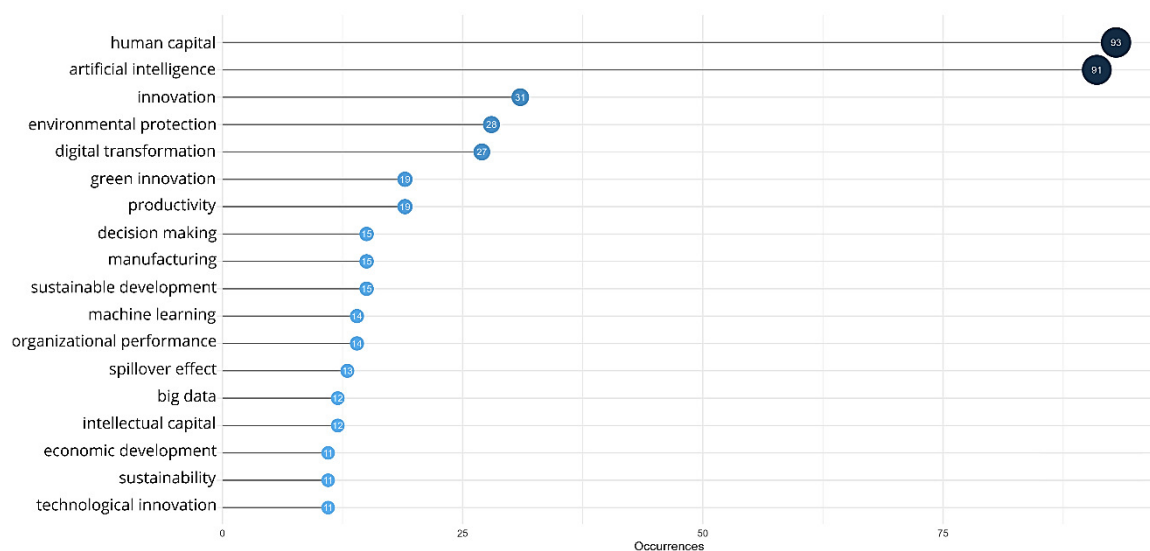


Figure 4. Most relevant words.

Source: own study (based on Scopus data, Bibliometrix package).

Keyword frequency analysis allows us to unveil the most significant conceptual elements which shape the intellectual focus of a research field. By showing the terms that are used most frequently across publications, it reveals the dominant research orientations and provides a preliminary basis for investigating the evolution and clustering of prevailing and emerging research themes. To enhance the interpretability and consistency of the results, a synonym list was used in the analysis to avoid fragmentation of key concepts due to closely related terms or different grammatical forms. Additionally, a standard keyword list was used to eliminate terms that were not substantively relevant to the thematic focus of this study.

Figure 4 shows the keywords that were the most significant in the analyzed corpus and are ranked according to their frequency of occurrence. The overwhelming dominance of human capital (93 occurrences) and artificial intelligence (91 occurrences) - substantially exceeding all other terms - reveals a clear human-centric orientation in the literature. This pattern suggests

that AI is most often conceptualized not as an autonomous technological factor, but as a mechanism that interacts closely with employee skills, knowledge, and competencies.

Beyond the dominant dyad of human capital and AI, the keyword distribution reveals three distinct thematic clusters. First, innovation-related terms (innovation: 31, green innovation: 19, technological innovation: 9) and sustainability concepts (environmental protection: 28, sustainable development: 15, sustainability: 9) form a coherent stream linking AI adoption to broader societal and environmental outcomes. Second, operational and performance-oriented keywords (productivity: 19, decision making: 16, manufacturing: 16, organizational performance: 13) emphasize efficiency gains and strategic decision-making processes. Third, the emergence of digital transformation (27), machine learning (13), and big data (12) signals growing attention to the broader technological ecosystem surrounding AI implementation. In general, the keyword distribution reveals the existing research on the IC-AI-VC triad is conceptually rooted in human capital and innovation outcomes, while more integrative or financially explicit perspectives remain underexplored.

Identifying the frequency of keywords is a way of showing the importance of one concept over the others. Yet, it does not bring out the connections between these concepts within the field's intellectual structure. Accordingly, the next analysis looks for patterns of co-occurrence and thematic structures of keywords to identify dominant research clusters. This co-occurrence approach also allows us to reveal the interdependencies between these clusters, providing deeper insight into the conceptual structure of the research field.

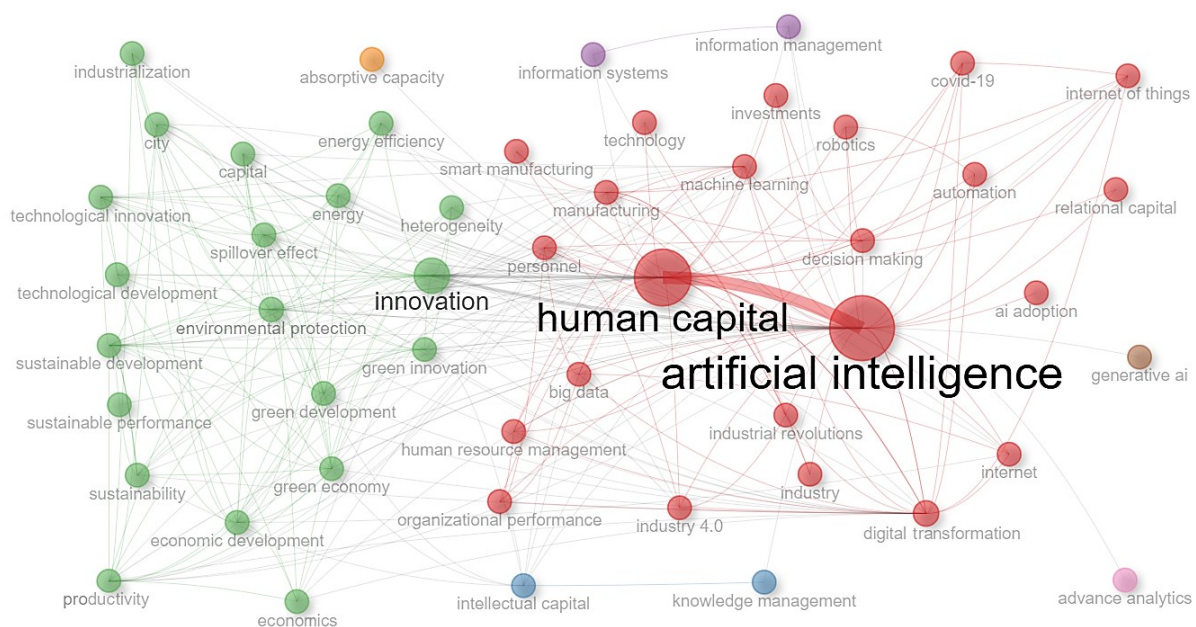


Figure 5. Keyword co-occurrence network.

Source: own study (based on Scopus data, Bibliometrix package).

Figure 5 reveals two main thematic clusters concentrating the majority of co-occurring keywords, alongside five smaller peripheral groups. The largest cluster (red) centers on the human capital-artificial intelligence nexus. Their central position confirms that research predominantly frames AI-driven transformation through the lens of human-related intangible resources. Notably, this cluster incorporates a broader technological ecosystem - including big data, Internet of Things, machine learning, smart manufacturing, robotics, and Industry 4.0, suggesting that AI is conceptualized not in isolation but as part of an interconnected digital infrastructure. Human resource management terms (personnel, decision making) further reinforce the cluster's human-centric orientation. The appearance of relational capital (one of the three main components of intellectual capital) within this cluster is noteworthy, as it co-occurs with both human capital and artificial intelligence. The co-occurrence with organizational performance suggests that authors attempt to link these factors with firm outcomes.

The second main cluster (green) is anchored by innovation and exhibits strong alignment with the sustainability discourse. Keywords such as green innovation, green economy, green development, and environmental protection, as well as sustainable development and sustainable performance, form a coherent thematic stream. In the context of measuring progress, terms such as productivity, economic development, and technological development emphasize the focus on measurable progress and firm-level outcomes.

Among the smaller clusters, the blue cluster containing intellectual capital appears relatively peripheral compared to the dominant human capital cluster. The co-occurrence of intellectual capital with knowledge management suggests that holistic IC constructs are present but play a less central role in current research. The remaining minor clusters exhibit limited connectivity, pointing to niche or emerging research directions that are not yet fully integrated into the core thematic structure.

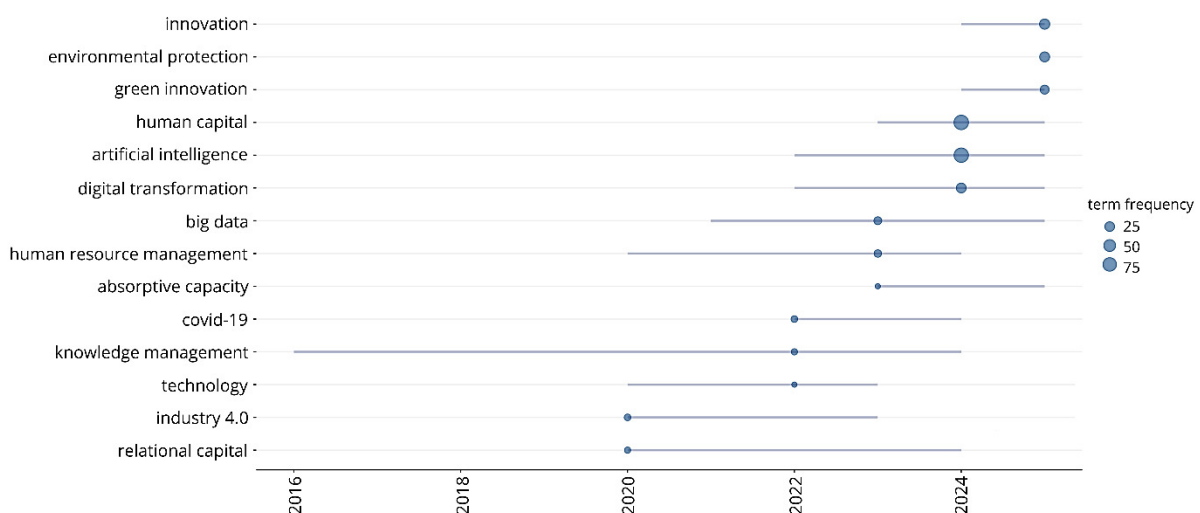


Figure 6. Thematic trends.

Source: own study (based on Scopus data, Bibliometrix package).

The analysis of trending topics reveals the research focus over time, allowing to identify what concepts have emerged in recent years. Figure 6 illustrates current importance of selected keywords highlighting research directions withing the analyzed literature.

The two core concepts, human capital and artificial intelligence, display sustained and increasing relevance over recent years, confirming their role as central and enduring elements of the evolving research landscape. A prominent position is also occupied by innovation, which represents a relatively recent focus within the analyzed literature and emerges primarily in the most recent years of the studied period. Among the reviewed articles, environmental protection and green innovation appear as new yet significant concepts, indicating the growing strength of ecological and sustainability-related trends.

A strong and consistently maintained trend is observed for knowledge management, which suggests that attention is directed not only toward the adoption of advanced technologies and the availability of employees with relevant skills, but also toward processes related to organizing, accumulating, and effectively using organizational knowledge. This reflects a rational approach that supports innovation and organizational efficiency through knowledge management within firms. In this context, the presence of human resource management further emphasizes that, beyond possessing human capital, increasing attention is paid to its management.

Among the remaining trend topics, concepts related to technological progress emerge. The most important are digital transformation and big data, alongside more general terms such as technology and Industry 4.0. Given the rapid pace of technological development, these specific topics may evolve quickly, reflecting ongoing innovations in the field.

An interesting trend is absorptive capacity, which underlines that companies must remain agile in a fast-changing environment and be able to recognize new external information and apply it in practice. It also points to a rising interest in organizational mechanisms that support the effective integration of AI technologies. This may serve as an important indication for those managing organizations that it is not only currently available resources that matter, but also the ability to monitor the environment in order to gain a competitive advantage.

The COVID-19 trend, although present for only a few years, is unlikely to remain a broadly discussed topic in the academic literature. However, it demonstrates that scholarly research responds to short-term external shocks. The final trending concept identified is relational capital, which, although less prominent, signals recent interest in the relational dimension of intellectual capital.

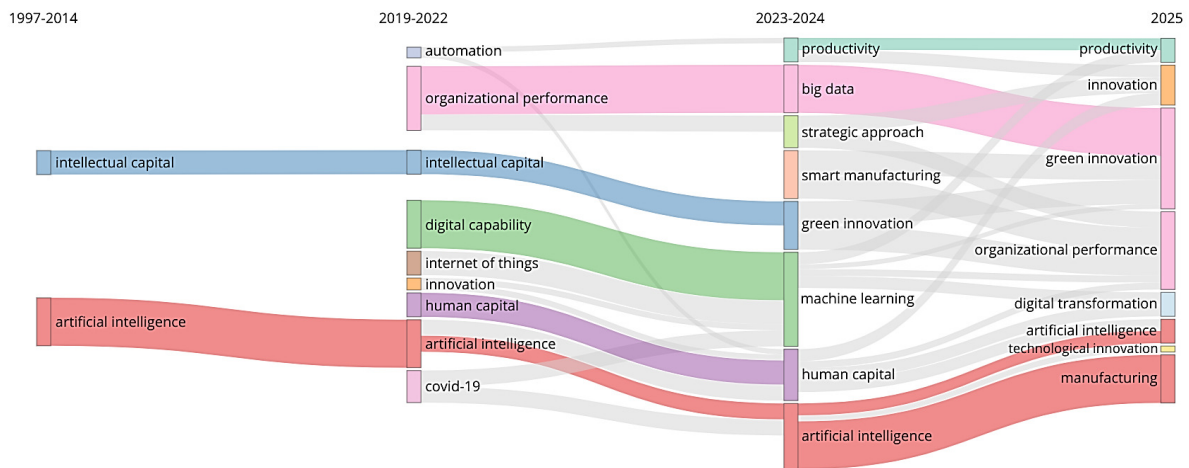


Figure 7. Thematic evolution.

Source: own study (based on Scopus data, Bibliometrix package).

Thematic evolution analysis (Figure 7) illustrates changes in the intellectual structure of the literature over different periods of time examining both continuity and shifts in research focus. The periodization reflects observed publication patterns: the pre-2014 period represents the emergence phase with sporadic publications, followed by a 4-year gap. The 2019-2022 period marks accelerated growth and thematic stabilization, while the subsequent shorter periods (2023-2024 and 2025) capture rapid thematic diversification driven by technological development. The accelerating publication rate in recent years may have contributed to greater thematic variability.

In the initial period (1997-2014), thematic activity is concentrated around two main concepts, namely intellectual capital and artificial intelligence. This reflects the relative novelty of the topic, as authors were only beginning to introduce these concepts into academic publications. Thematic diversity increases markedly in the period 2019-2022, during which thematic expansion and diversification can be observed. New topics emerge from a technology- and capability-based perspective. Beyond intellectual capital, its component human capital gains importance. Authors also introduce topics related to organizational performance and innovation. Moreover, technology-related themes gain prominence, including digital capability, artificial intelligence, Internet of Things, and automation. In the years 2023-2024, the thematic structure becomes more technologically specialized. The themes evolve toward machine learning, big data, and smart manufacturing, while at the same time sustainability-related concepts, such as green innovation, gain importance. The most recent publications emphasize an outcome-oriented approach through terms such as organizational performance and productivity. Alongside this, there is a growing focus on new ideas and innovations, including green innovation, technological innovation, and digital transformation.

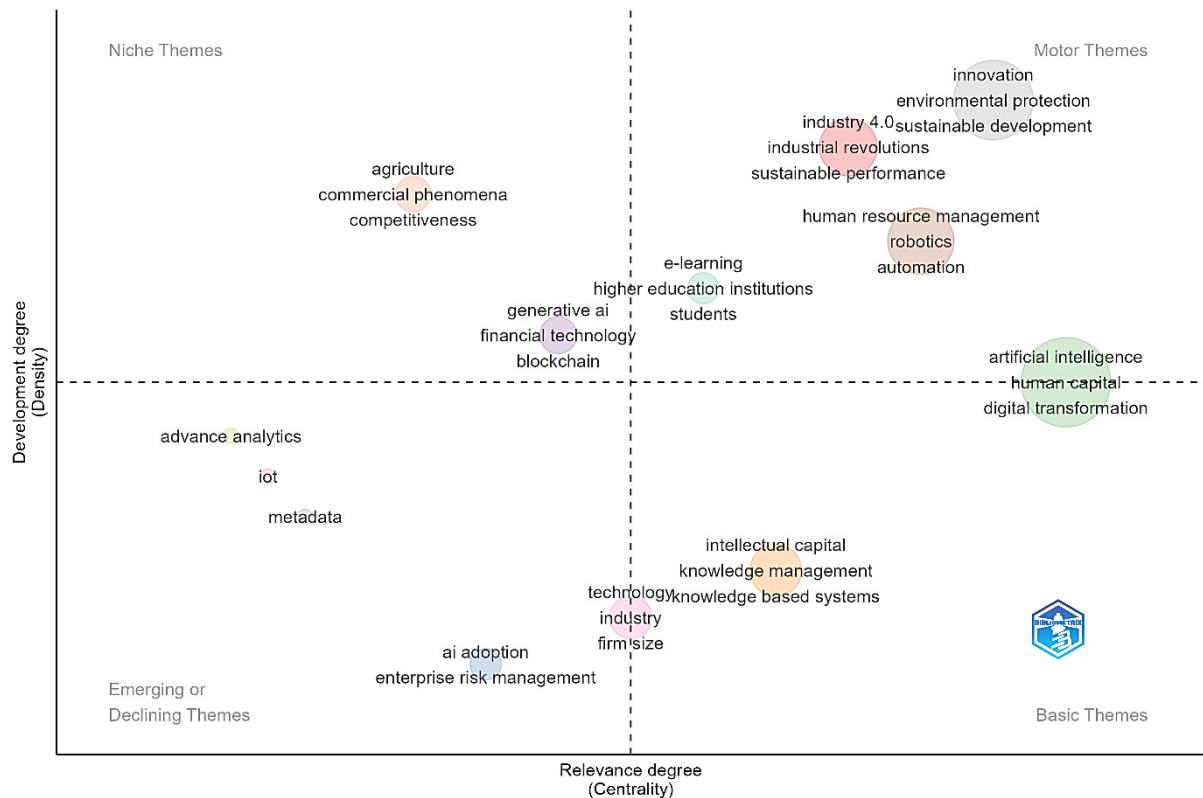


Figure 8. Thematic map of research themes.

Source: own study (based on Scopus data, Bibliometrix package).

Figure 8 presents the thematic map of the analyzed literature. These results allow us to assess the structural position and the relative importance of individual themes within the research field. The basic themes quadrant includes artificial intelligence, human capital, and digital transformation, which exhibit high centrality and medium density. This classification confirms their role as fundamental elements and reinforces their position as core concepts within the literature. Themes such as intellectual capital and knowledge management occupy a position of moderate density and lower centrality, indicating their continued presence in the research field, but a decreasing dominance as independent areas of investigation.

Within the motor themes quadrant, authors frequently refer to currently popular and topical issues, which can be described as trend-driven themes, such as environmental protection, sustainable development, and sustainable performance. In the short term these topics may act as key drivers of publication activity. However, themes that are widely discussed at present often tend to lose momentum over time as their novelty diminishes and research attention shifts to new areas. A second stream within the motor themes relates to technological transformation, including Industry 4.0, industrial revolutions, and innovation. In addition, the presence of robotics and automation in combination with human resource management may indicate growing scholarly interest in the substitutability of human resources by automated systems.

Emerging or declining themes such as AI adoption, advanced analytics, Internet of Things, and metadata display low centrality and density, pointing to research areas that are either at an early stage of development or losing prominence. In this case, these themes appear to have greater potential for emergence, as they reflect current technological aspects that may be further explored and analyzed by a broader group of researchers.

Finally, niche topics such as agriculture and competitiveness are characterized by high density but low centrality, suggesting specialized and internally coherent research streams with limited integration with the broader field. Overall, the combined data from the thematic map and quantitative cluster characterization indicate a growing focus of the research area on integrated, technology-driven, and performance-oriented topics, with innovation and sustainability being key drivers of thematic consolidation within the IC-AI-VC framework.

5. Qualitative literature synthesis

Following the quantitative mapping of the scientific field, this section provides a qualitative synthesis of the literature aimed at interpreting the main thematic structures identified by the bibliometric analysis, with particular emphasis on highly cited and thematically relevant contributions.

5.1. Intellectual capital, company performance and innovation

The qualitative analysis of the literature reveals a strong and consistent consensus that intellectual capital constitutes a fundamental driver of firm performance and innovation. Across diverse empirical contexts, intellectual capital is conceptualized as a multidimensional strategic resource whose economic value emerges primarily through its ability to enhance organizational capabilities, competitive positioning, and long-term value creation (Chen et al., 2005; Inkinen, 2015; Tan et al., 2007). Rather than functioning as an isolated asset, intellectual capital operates through complex internal mechanisms that shape how firms generate, apply, and renew knowledge in dynamic competitive environments.

The reviewed studies indicate that the relationship between intellectual capital and firm performance is rarely linear or purely direct. Instead, its impact is typically mediated through organizational learning, capability development, and innovation processes (Clarke et al., 2011; Hsu, Fang, 2009). Human capital emerges as the most influential component, as employee knowledge, skills, and competencies represent the primary source of knowledge creation and strategic flexibility. Empirical evidence further suggests that investments in human capital exhibit delayed effects on financial outcomes, implying that the value of intellectual capital unfolds over time rather than producing immediate performance gains (Clarke et al., 2011; Maditinos et al., 2011; Tan et al., 2007).

In contrast, the contributions of structural and relational capital display greater variability across studies and contexts. While structural capital provides the institutional infrastructure required to codify knowledge and stabilize organizational routines, its direct association with short-term financial performance is often weak or statistically insignificant, particularly when significant implementation costs are involved (Clarke et al., 2011; Hsu, Fang, 2009). Relational capital, by facilitating access to external knowledge, partners, and markets, strengthens innovation performance and new product development, yet its financial impact remains highly contingent on industry characteristics and market maturity (Chen et al., 2005; Tan et al., 2007).

A particularly robust finding across the literature is the central role of intellectual capital in driving innovation outcomes. Both human and relational capital enhance innovation performance primarily through the mediating influence of organizational learning capability, which converts dispersed knowledge resources into commercially viable outputs (Hsu, Fang, 2009). This evidence underscores that intellectual capital does not create value automatically, but requires deliberate managerial coordination and strategic integration to translate intangible resources into sustainable competitive advantage.

Despite the extensive body of empirical evidence, the literature remains fragmented regarding the precise mechanisms through which different components of intellectual capital interact to influence both financial performance and innovation. Many studies focus on isolated components or short-term performance indicators, leaving unresolved questions concerning the long-term dynamics of intellectual capital accumulation, cross-component complementarities, and contextual moderators.

5.2. Intellectual capital and artificial intelligence

The reviewed literature consistently portrays the relationship between intellectual capital and artificial intelligence as both interdependent and mutually reinforcing. Intellectual capital is widely recognized as a foundational resource that enables firms to successfully develop and implement artificial intelligence technologies, particularly in the form of advanced data analytics and AI-driven systems. At the same time, artificial intelligence reshapes the structure and economic role of intellectual capital by transforming how organizational knowledge is created, codified, and exploited for competitive purposes (Abdelfattah et al., 2024; Chen, Chen, 2022).

Empirical evidence indicates that high-quality human capital is a critical prerequisite for the effective development and use of AI capabilities. Skilled employees are essential for designing, interpreting, and strategically applying AI solutions, while continuous learning and upskilling determine the firm's ability to absorb and exploit new technological opportunities (Abdelfattah et al., 2024; Chen, Chen, 2022). As a result, the deployment of artificial intelligence does not reduce the importance of human capital but instead shifts its role toward more advanced cognitive, analytical, and decision-oriented functions (Shaffer et al., 2020).

Structural capital plays a complementary role by providing the organizational infrastructure necessary for AI integration. Flexible systems, knowledge codification mechanisms, and efficient internal processes facilitate the diffusion and scalability of AI-based tools within the firm. Without adequate structural capital, the benefits of AI adoption remain fragmented and difficult to sustain. Relational capital further strengthens this process by enabling firms to access external expertise, technological partners, and market knowledge that support AI development and commercialization (Abdelfattah et al., 2024; Chen, Chen, 2022).

The interaction between intellectual capital and artificial intelligence is dynamic rather than static and recursive. Investments in human capital lead to the creation of AI-based solutions, which are subsequently embedded into the organization as elements of structural capital. This transformation, in turn, generates new demands for skills and competencies, reinforcing the continuous evolution of human capital within the firm (Dal Mas et al., 2019; Popkova, Sergi, 2020). In this sense, artificial intelligence both depends on and reshapes intellectual capital, forming a feedback loop that progressively alters organizational structures and strategic capabilities.

Collectively, the literature suggests that intellectual capital and artificial intelligence should not be treated as separate drivers of firm performance, but rather as an integrated system of intangible resources and technological mechanisms that co-evolve in response to competitive and environmental pressures.

5.3. Artificial intelligence, company performance and innovation

Artificial intelligence is widely perceived as a major driver of firm performance and innovation, although the nature of this relationship is frequently described as complex and mediated rather than direct. Empirical studies consistently show that the adoption of artificial intelligence contributes to productivity growth, operational efficiency, and cost reduction by automating routine processes and enhancing the quality and speed of managerial decision-making (Dubey et al., 2020; Wamba-Taguimdje et al., 2020).

Rather than functioning solely as a technological tool, artificial intelligence is conceptualized as an organizational capability that strengthens firms' dynamic capabilities and their ability to adapt to volatile market environments. The reviewed evidence suggests that AI-based analytical capabilities improve internal integration, coordination between functional units, and the effectiveness of organizational processes, which in turn translate into superior performance outcomes (Bag et al., 2021; Chen, Chen, 2022). In this sense, artificial intelligence operates as a catalyst that transforms data into actionable knowledge, supporting more rational and informed strategic decisions.

Beyond operational efficiency, artificial intelligence is increasingly associated with innovation performance. The literature highlights that AI facilitates the generation of new ideas, accelerates product development, and enhances firms' capacity to recognize and exploit emerging opportunities. Recent studies further indicate that advanced AI applications

contribute to organizational resilience by strengthening knowledge bases and supporting firms in navigating uncertainty and external disruptions (Abbas et al., 2025; Kanbach et al., 2024). These effects suggest that the innovation-related benefits of artificial intelligence extend beyond immediate performance improvements and influence the long-term strategic positioning of the firm.

At the same time, the reviewed research emphasizes that the impact of artificial intelligence on performance is contingent upon organizational context. Without adequate managerial coordination, complementary resources, and employee competencies, AI investments may fail to generate the expected economic returns (Dubey et al., 2020). This reinforces the interpretation that artificial intelligence does not automatically produce value but requires alignment with organizational structures, skills, and strategic objectives.

Overall, the qualitative evidence portrays artificial intelligence as a transformative force that reshapes both performance mechanisms and innovation processes within firms. However, the literature offers limited insight into how these benefits unfold over time and how artificial intelligence interacts with other intangible resources in different organizational and industry settings.

5.4. Integrated conceptualization of the IC-AI-VC triad

The qualitative synthesis of the literature establishes strong, synergistic linkages across the core triad examined in this study. Intellectual capital functions as the fundamental enabling asset that determines a firm's capacity to adopt and leverage AI technologies. Simultaneously, AI serves as the transformative mechanism, converting existing human knowledge into codified structural assets, automating processes for efficiency, and demanding a shift in human skills toward high-value, interpretive functions (Popkova, Sergi, 2020; Shaffer et al., 2020). Ultimately, this interplay generates superior firm outcomes in the form of competitive advantage, enhanced profitability, accelerated innovation, and increased organizational resilience.

Despite these insights, the literature reveals that the precise nature of these relationships is complex, often relying on indirect mediating pathways, such as organizational learning capability (Hsu, Fang, 2009) or resilience (Abbas et al., 2025), rather than simple direct links. Moreover, empirical findings vary considerably across different economic and geographic contexts, while the rapid emergence of new AI tools continuously reshapes the research landscape. This complexity necessitates further research to clarify these dynamics.

6. Conclusions

The growing strategic importance of intellectual capital and artificial intelligence reflects a fundamental transformation of contemporary enterprises toward knowledge-driven and technology-enabled value creation. As firms increasingly compete through intangible resources and advanced digital capabilities, understanding how intellectual capital and artificial intelligence jointly shape performance and innovation becomes essential for both theory and managerial practice. This study responds to this need by offering a comprehensive mapping and qualitative synthesis of the rapidly expanding body of scientific research at the intersection of these domains, addressing four interconnected research questions.

The bibliometric results demonstrate a rapidly accelerating growth of scientific interest in the relationship between intellectual capital, artificial intelligence, and firm performance since 2019. This development corresponds with the large-scale adoption of artificial intelligence technologies in business practice. The qualitative synthesis further indicates that intellectual capital functions as a fundamental enabling resource for artificial intelligence adoption, while artificial intelligence operates as a transformative mechanism that reshapes knowledge utilization and organizational capabilities, ultimately influencing firm performance primarily through indirect and mediated pathways. The following sections address each research question in detail.

Regarding publication trends and geographical patterns (RQ1), the bibliometric results provide quantitative evidence that the IC-AI-VC research stream is undergoing rapid expansion and structural consolidation. After 2019, scientific output in this field increased sharply, reflecting a strong and growing scholarly interest in the analyzed problem. However, this expansion is geographically concentrated, with research output dominated by a small number of leading countries, particularly in Asia, Europe, and North America, while many economic regions and emerging markets remain relatively underexplored in this context.

With respect to publication outlets and core knowledge structures (RQ2), the publication activity is concentrated within a relatively small group of leading academic journals, which indicates the specialized and high-impact character of this research domain. This concentration follows Bradford's Law, with a distinct core zone of journals contributing disproportionately to the field's development.

Concerning thematic clusters and intellectual structure (RQ3), this expansion was accompanied by the formation of stable thematic directions that now structure the core of the literature. Beyond the central focus of the analyzed triad, the research is most frequently discussed in conjunction with broader thematic domains related to innovation and sustainability, digital transformation and technological change, knowledge management and decision-making processes, as well as environmental and green development perspectives. The identified thematic clusters reveal a clear internal organization of the field, with dominant

research streams focused on human-centered technological transformation, innovation performance, and sustainability-driven value creation, alongside emerging topics that continue to reshape the intellectual landscape. Notably, while human capital dominates the discourse, structural and relational capital dimensions remain underrepresented, indicating a conceptual imbalance relative to traditional intellectual capital frameworks.

Addressing the conceptual relationships and mediating mechanisms (RQ4), the qualitative synthesis indicates that the interaction between intellectual capital and artificial intelligence is widely interpreted as a central mechanism of organizational transformation and value creation, operating mainly through learning processes, capability development, and organizational adaptation rather than through simple direct effects on performance. Intellectual capital enables AI adoption while AI transforms intellectual capital through a dynamic and recursive relationship, converting human knowledge into structural assets and generating outcomes in innovation and competitive advantage. However, this relationship exhibits complexity and contextual variability, with empirical findings differing across industries, geographic contexts, and technological maturity levels, necessitating further integrative research.

Several methodological considerations should be taken into account when interpreting these findings. First, bibliometric techniques are designed to identify structural and thematic patterns in scientific knowledge rather than to test causal relationships. Moreover, such techniques reveal publication trends and conceptual structures but do not evaluate the quality of theoretical arguments or empirical evidence within individual studies. Second, the reliance on explicit keyword matching may exclude studies that examine IC-AI dynamics under different conceptual frameworks or employ domain-specific terminology that does not align with standard intellectual capital or artificial intelligence vocabulary. Third, the analyzed literature exhibits significant heterogeneity in how intellectual capital and artificial intelligence are operationalized, making cross-study comparisons complex and limiting the generalizability of findings. Furthermore, the study does not provide a systematic categorization of measurement approaches employed across the 129 analyzed articles. It could be developed to benefit from a structured coding of methodological designs.

Future studies should develop integrative empirical models that explicitly incorporate artificial intelligence into frameworks of intellectual capital and firm value creation. Improved measurement tools are essential to capture the contribution of AI to company value creation, particularly in financial terms. Comparative analyses across industries, institutional contexts, and countries would help clarify contextual differences in how intellectual capital and artificial intelligence jointly influence performance and innovation. Finally, increasing attention should be paid to ethical and social implications, including workforce transformation, skill displacement, and the long-term consequences of organizational transformation driven by AI adoption.

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LINGUISTIC READABILITY OF OCCUPATIONAL HEALTH AND SAFETY REGULATIONS

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Purpose: This study evaluates the readability and communicative effectiveness of Occupational Health and Safety (OHS/BHP) regulations as normative documents designed to protect employees' health and safety. It examines whether these documents fulfill their informational function for users with diverse educational and linguistic backgrounds and identifies linguistic features that affect comprehension.

Design/methodology/approach: The study adopts a mixed-methods approach combining quantitative readability assessment with qualitative linguistic analysis. A corpus of 40 authentic OHS regulations and instructions (approximately 85,000 words) from public administration, education, industry, logistics, and training sectors was analyzed. Readability was measured using the Jasnopis tool, and corpus-based analysis in SketchEngine examined sentence length, nominalization, impersonal and modal constructions, terminological density, and document structure. The findings were evaluated in relation to plain language and Easy-to-Read (ETR) principles.

Findings: The results show that 75% of the analyzed documents were classified as “difficult” or “very difficult.” High sentence complexity, frequent nominalization, impersonal and modal constructions, and unexplained specialist terminology were associated with reduced comprehensibility. Many documents also lacked clear structural organization and explicit attribution of responsibility, limiting practical usability in workplace settings.

Research limitations/implications: The study is limited to Polish-language OHS documents and does not include direct user testing. Future research may incorporate experimental studies with employees or cross-linguistic comparisons to assess the relationship between readability and actual compliance.

Practical implications: The paper proposes editorial recommendations, including sentence simplification, clearer agency marking, reduced nominalization, and improved structural design. A model for linguistic audits of OHS documentation is also outlined.

Social implications: Improving the readability of OHS regulations may enhance workplace safety and support inclusive communication for linguistically diverse worker groups.

Originality/value: The study offers one of the few corpus-based analyses of OHS regulations from a linguistic perspective, demonstrating that readability constitutes an important dimension of institutional responsibility and risk management.

Keywords: Occupational Health and Safety (OHS) regulations, readability analysis, plain language in institutional communication.

Category of the paper: research paper.

1. Introduction

Contemporary societies increasingly emphasize the need to ensure occupational safety and protect employees' health in the workplace. Alongside the development of legal regulations, technological solutions, and organizational standards, the importance of effective institutional communication in occupational health and safety (OHS) has also increased. In this context, particular attention must be paid to normative documents such as OHS regulations.

It is generally assumed that the effectiveness of such documents depends not only on their compliance with binding legal provisions but, above all, on their linguistic accessibility and comprehensibility for end users. Employees to whom these regulations are addressed constitute a highly heterogeneous group in terms of educational background, linguistic competence, professional experience, and cognitive abilities. For this reason, OHS texts should be designed with due consideration for the actual needs and perceptual capacities of their intended recipients.

Although the present study focuses on a single, seemingly narrow category of documents, namely OHS regulations and instructions, its findings have considerably broader relevance. Issues such as poor readability, excessive formalization, overuse of specialist terminology, and communicative ambiguity are characteristic of many other forms of institutional communication, including administrative acts, internal regulations, training materials, and legal documentation. In this sense, the conclusions drawn from the analysis may serve as a point of departure for a broader reflection on the linguistic quality and functional effectiveness of official texts in Poland.

The comprehensibility of normative texts is not merely a matter of linguistic aesthetics or stylistic correctness; rather, it is a problem deeply embedded in social and legal practice. An unreadable regulation may lead to misunderstandings of duties, errors in task performance, and, consequently, real threats to employees' health and lives. From this perspective, readability becomes an element of risk management, a tool for shaping organizational culture, and an expression of institutional responsibility.

In light of the above, the study examines which linguistic and editorial features enhance the effectiveness of OHS regulations and which hinder information reception. Do these documents adhere to the principles of plain language, or do they instead reproduce patterns of official administrative style that hinder communication with users? What role can linguistic and corpus-based analytical tools play in diagnosing and improving the quality of these documents?

In an era of digitalization, professional mobility, and multilingual work environments, the need to simplify and optimize written communication is no longer merely a technical editorial task, but also a broader civilizational challenge. In this sense, the present study contributes to the wider body of research on linguistic accessibility, public institutional accountability, and the communicative culture of a modern state governed by the rule of law.

Despite growing research on legal language, administrative discourse, and plain language initiatives, there remains limited systematic, corpus-based analysis of Polish Occupational Health and Safety regulations that integrates objective readability metrics with detailed structural linguistic examination. In particular, few studies examine how genre-constitutive features such as nominalization, deontic modality, and syntactic embedding correlate with measurable indicators of communicative load in workplace documentation.

To address the identified research gap, the study adopts a mixed-methods design combining quantitative readability assessment with qualitative linguistic analysis. A corpus of 40 authentic OHS regulations from diverse institutional and industrial contexts serves as the empirical basis for the investigation. Objective readability indicators are correlated with structural features characteristic of normative discourse, including nominalization, impersonal constructions, deontic modality, terminological density, and syntactic embedding. The study tests three main hypotheses. First, that the majority of OHS regulations exhibit high levels of linguistic difficulty according to standardized readability metrics. Second, that higher readability difficulty correlates with increased density of nominalization, modality, and clause complexity. Third, that clearer structural segmentation and explicit agency marking are associated with lower communicative load. By systematically linking quantitative measures with genre-based linguistic analysis, the study moves beyond purely descriptive readability scoring. Its novelty lies in integrating corpus-based methods with legal-linguistic reflection in the specific domain of workplace safety documentation. In doing so, the article contributes to ongoing debates on plain language, institutional accountability, and the balance between normative precision and communicative accessibility.

Although readability and plain-language approaches have been applied to various forms of institutional and legal communication, there remains limited systematic, corpus-based research on the readability of Polish-language Occupational Health and Safety (OHS/BHP) regulations as internal normative workplace documents. In particular, few studies combine objective readability metrics with a detailed linguistic diagnosis of genre-constitutive features such as nominalization, deontic modality, impersonal constructions, and terminological density across a sectorally diverse corpus. This study addresses this gap by integrating quantitative readability assessment (Jasnopis) with corpus-based linguistic analysis (SketchEngine) of 40 authentic OHS documents, linking difficulty ratings to specific structural patterns and translating the findings into evidence-based recommendations for linguistic auditing and document design.

2. Literature Review

Occupational health and safety (OHS) is an interdisciplinary field that encompasses legal, technical, organizational, psychological, and social dimensions, all aimed at protecting employees' health and life in the workplace (Tokarski, 2018). Its core objective is to identify and minimize occupational risks by implementing appropriate procedures, training programs, technical safeguards, and internal organizational regulations. OHS thus serves not only a preventive function but also an educational one, shaping the awareness of both employees and employers regarding workplace hazards and safe conduct principles. For this reason, documents regulating activities in this area, most notably OHS regulations, play a crucial role, as they define procedures, obligations, and recommendations applicable in the workplace (Żurawiecka, 2019).

Amid rapid technological change and rising occupational mobility, ensuring an effective OHS system has become a particular challenge. OHS documentation, and regulations in particular, must not only comply with legal requirements but also be accessible and comprehensible to users, regardless of their educational background or linguistic competence. Within the Polish legal system, the Labour Code (Kodeks pracy) is the fundamental basis for OHS provisions. Article 207 assigns employers overall responsibility for occupational health and safety. This responsibility includes organizing work safely, eliminating hazards, providing training, and supplying personal protective equipment. In this context, documents such as OHS regulations serve as instruments for fulfilling the legal obligation to inform employees about risks and health protection principles.

In addition to the Labour Code, executive regulations, such as the Regulation of the Minister of Economy and Labour of 27 July 2004 on training in occupational health and safety (*Rozporządzenie Ministra Gospodarki i Pracy z dnia 27 lipca 2004 r. w sprawie szkolenia w dziedzinie bezpieczeństwa i higieny pracy*), play a significant role by specifying mandatory training forms and the content to be communicated to employees. These requirements are often reflected in internal regulations and workstation-specific instructions, which, as workplace documents, must remain consistent with higher-level legal acts. Although legislation does not precisely define the formal structure of OHS regulations, such documents are generally considered binding and may serve as a basis for enforcing employee responsibility, provided they have been made available and explained in a comprehensible manner (Łyszczarz, 2020). Otherwise, their effectiveness, both formal and practical, remains questionable.

From the perspective of text theory, OHS regulations are official texts with a normative function and also serve as utilitarian texts that convey instructions, obligations, and prohibitions governing specific workplace behaviors (Marcjanik, 2016). They are typically characterized by a formal style, lexical precision, a predominance of the declarative mood, and impersonal linguistic constructions. Their compositional structure is also distinctive, as such texts are

usually divided into chapters or sections addressing, for example, employee responsibilities, procedures in hazardous situations, and final provisions. While this organization can enhance functionality, it does so only if linguistic and logical clarity are maintained (Witosz, 2004).

A characteristic feature of OHS regulations is the frequent use of prescriptive formulas, including imperative, impersonal, and infinitival constructions (e.g., *należy*, *zabrania się*, *powinien*), which reinforce the authority of the message and express obligation (Bralczyk, 2001). These texts also commonly include specialist terminology and numerous references to legal acts, further complicating comprehension. Problems arise when the language of regulations does not match the competencies of their intended recipients. An excess of nominalizations, syntactically complex sentences, specialist terminology, and formalistic expressions may substantially reduce textual comprehensibility (Kondratczyk-Przybylska et al., 2016). Consequently, OHS regulations should be analyzed not only for content but also for their linguistic and communicative form.

The linguistic properties of OHS regulations directly determine their communicative effectiveness. Overly complex syntax, excessive nominalization, and rigid formalism may prevent these documents from fulfilling their informative function. This makes reflection on readability and functional clarity indispensable. The addressees of OHS regulations are employees with highly diverse occupational profiles, cognitive abilities, and educational levels. In many workplaces, employees include individuals without secondary education, older workers, persons with cognitive or linguistic limitations, and foreign workers with limited proficiency in Polish (Kołodziejek, 2012). For these groups, standard administrative language often poses a significant barrier to accessing information.

This diversity of recipients poses serious communication challenges. OHS regulations must be clear, unambiguous, and comprehensible while remaining legally compliant. Inappropriate language, insufficient explanations of complex terms, unclear document structure, or excessive technical jargon can lead to misunderstanding and, consequently, non-compliance. The mode of presentation itself is also problematic: OHS regulations are typically lengthy, formatted as dense blocks of text, and lack visual aids such as infographics or icons that could facilitate comprehension. As a result, many employees read them superficially or not at all, treating them merely as a formal employment requirement.

For this reason, increasing attention is being paid to simplifying institutional language through plain language initiatives and to applying easy-to-read principles. These approaches advocate simple syntactic structures, unambiguous vocabulary, short paragraphs, and transparent text organization (Kondratczyk-Przybylska et al., 2016). Their aim is not only to improve accessibility but, above all, to enhance communicative effectiveness. In the case of OHS regulations, this entails drafting documents that not only meet formal legal standards but are genuinely usable by their intended audience. Achieving this goal requires cooperation among specialists in labor law, occupational safety, linguistics, and communication studies. From the perspective of speech act theory and pragmatic analysis, OHS regulations perform

multiple linguistic functions, of which the informational, directive, phatic, and legitimizing functions are paramount (Grzegorzczkova, 2008). Excessive emphasis on formal or legalistic language may weaken the informational function and, in turn, reduce the overall effectiveness of the message.

In recent years, increasing scholarly and institutional attention has been devoted to the accessibility of legal and administrative texts, particularly in the context of public accountability and risk communication. The publication of ISO 24495-1:2023, *Plain language — Part 1: Governing principles and guidelines*, represents an important milestone in the standardization of plain language principles at the international level. The standard emphasizes clarity of structure, transparency of agency, reader-oriented organization, and cognitive accessibility, while explicitly acknowledging that simplification must not compromise legal precision.

Recent empirical research further supports the need to examine readability in legal and regulatory contexts. Martínez, Mollica, and Gibson (2023) demonstrate that simplified legal formulations can significantly improve comprehension without necessarily reducing perceived enforceability. Their findings suggest that legal precision and linguistic accessibility are not mutually exclusive, but rather require careful calibration. Similarly, systematic reviews of readability metrics in legal texts (e.g., Han, Ceross, Bergmann, 2024) highlight both the usefulness and the limitations of quantitative readability tools, stressing the importance of combining metric-based assessment with linguistic analysis.

In the Polish context, contemporary research on plain language in institutional communication has expanded significantly. Piekot (2021) proposes methodological frameworks for simplifying administrative documents while maintaining normative accuracy. Cieśla (2021) analyzes contemporary official texts in light of plain Polish principles, demonstrating structural barriers to comprehension in public documents. These studies indicate that institutional language reform requires both linguistic sensitivity and awareness of genre constraints.

Readability has also been examined in safety-related documentation. Ho and Tenkate (2024), in their study of Safety Data Sheets as hazard communication tools, show that excessive technical density and structural complexity may undermine effective risk communication. Their conclusions are particularly relevant to OHS documentation, where misunderstanding may have direct physical consequences.

Taken together, recent research (2020-2025) underscores the importance of balancing legal precision with communicative clarity, especially in documents addressed to heterogeneous user groups. However, there remains limited corpus-based research specifically focused on the linguistic and readability characteristics of Polish Occupational Health and Safety regulations. The present study contributes to this emerging field by integrating objective readability metrics with detailed structural analysis across a sector-diverse dataset.

3. Methods

This chapter aims to analyze the readability of Occupational Health and Safety (OHS) regulations, which are normative documents whose effectiveness depends on the comprehensibility of their message. The central focus is on whether OHS regulations fulfill their communicative function for employees with diverse linguistic and cognitive competencies.

The study addresses the following research questions:

1. What linguistic and stylistic structures characterize the selected OHS regulations?
2. According to objective readability measures, what level of difficulty do OHS regulations exhibit?
3. Which linguistic features reduce their comprehensibility (e.g., nominalization and syntactic complexity)?
4. To what extent do the analyzed documents comply with the principles of plain language and the Easy-to-Read (ETR) concept?
5. How can corpus-based analysis with the SketchEngine tool support research on the linguistic quality of regulatory documents?

The study involved collecting and analyzing 40 Occupational Health and Safety (OHS) regulations and instructions from various sectors of the economy and from different types of public and private institutions. The selection of texts was intended to capture a representative linguistic and communicative cross-section of regulations governing occupational health and safety.

The materials were obtained from publicly available online sources, including: (1) websites of municipal, local, and regional authorities (Public Information Bulletins) – 15 documents (e.g. *OHS Regulations of the Nadarzyn Municipal Office*; *Work and OHS Regulations of the City of Tarnów*; *OHS Instructions in a public nursery in Rybnik*); (2) schools and educational institutions (general secondary schools, technical schools, vocational schools) – 10 documents (e.g. *OHS Regulations of the Mechanical School Complex in Gorzów*; *Safety Rules for Physical Education Classes*; *Evacuation Instructions for Teachers and Students*); (3) enterprises and production facilities (logistics, industry, energy sector) – 15 documents (e.g. *OHS Regulations of the logistics company XPO Logistics*; *OHS Instructions for Forklift Operators (DHL Poland)*; *Workplace Safety Instructions for Welders (Huta Pokój S.A.)*). The structure of the research material was as follows (Table 1):

Table 1.
Characteristics of the analyzed OHS document types

Document type	Number of texts	Average length	Lexical range
General OHS regulations	15	≈ 2500 words	general normative and statutory
Workstation-specific instructions	15	≈ 1800 words	technical, specialist
Emergency / evacuation procedures	10	≈ 900 words	warning-oriented, precise language

Source: own elaboration.

In total, the corpus comprised 40 texts, amounting to approximately 84,000 words (an average of 2,100 words per document). All documents were converted to TXT format and imported into the research environment (SketchEngine). The texts conformed to the formal scope of regulations or instructions, including a document title, statement of purpose, scope of application, descriptions of employee and employer responsibilities, procedures for specific situations (e.g., chemical hazards, fire, accidents), and, in many cases, annexes on personal protective equipment. Documents were selected according to the following criteria: (1) availability of the full text (not excerpts only), (2) currency (year of publication not earlier than 2015), (3) sectoral representativeness, and (4) diversity in editorial quality.

Each document was downloaded as a PDF or DOCX and then converted to TXT, preserving the original structure (headings, numbering, bullet points). The texts were then subjected to formal preprocessing, including the removal of personal data, signatures, and dates. The documents were organized and annotated with metadata specifying institution type, year, sector, text length, and source.

A dedicated working corpus was created in SketchEngine (Corpus_BHP_Readability_40docs). Morphosyntactic analysis was enabled using the UDPipe parser for Polish, and part-of-speech tags and lemmas were assigned. Analytical tools such as concordance, word sketch, collocations, and term extraction were applied.

An example of a research query is: [lemma="należy"] [tag="verb"], which enables the analysis of the most frequent modal patterns and formal collocations. All examples drawn from the Polish-language corpus of occupational health and safety regulations have been translated into English and provided in parentheses to ensure consistency with the language of the article.

4. Results

The quantitative analysis is based on six key textual parameters that influence the accessibility and comprehensibility of documents:

1. average sentence length (measured in number of words),
2. average word length (measured in number of letters),
3. difficulty classification according to the Jasnopis scale,
4. percentage share of sentences containing nominalization,

5. number of sentences with modal and impersonal constructions,
6. occurrence of specialist terminology.

The data were collected from 40 documents, which formed the research corpus. The texts originated in various sectors, including industry, logistics, public administration, education, and training.

The average sentence length in the analyzed corpus was 24.5 words, significantly exceeding the recommended level for instructional texts, as defined by the Polish Language Foundation as a maximum of 17 words per sentence (Kołodziejek, 2012). Only 4 of 40 documents (10%) met this standard, underscoring a problem with linguistic accessibility. The distribution of sentence length across sectors was as follows:

1. Industrial and logistics sectors: 26-29 words per sentence.
2. Public administration and education sectors: 22-25 words.
3. Training companies (some texts compliant with Easy-to-Read principles): an average of 18 words.

Excessively long sentences place a substantial burden on readers' working memory and hinder rapid comprehension of the intended message. Particularly problematic are multiple-clause sentences that include additional conditions, circumstantial modifiers, and formal qualifications. The longest sentences (exceeding 40 words) occurred primarily in official documents, regulations issued by public institutions, and internal directives of large industrial enterprises. Qualitative analysis identified numerous instances of sentences with unclear structure, composed of four or more subordinate clauses, that should be divided into separate statements.

Original example (45 words):

W przypadku konieczności przeprowadzenia ewakuacji z powodu wystąpienia zagrożenia pożarowego należy niezwłocznie poinformować odpowiednie służby ochrony zakładowej, a pracownicy powinni opuścić teren zagrożony zgodnie z planem ewakuacyjnym obowiązującym w danym obiekcie.

[In the event that evacuation is required due to the occurrence of a fire hazard, the appropriate internal emergency services should be notified immediately, and employees should leave the endangered area in accordance with the evacuation plan applicable to the facility.]

Simplified version (16 words):

Jeśli wybuchnie pożar: – Zadzwoń po służby ochrony. – Opuść budynek według planu ewakuacyjnego.

[If a fire breaks out: – Contact emergency services. – Leave the building according to the evacuation plan.]

The average word length in the analyzed corpus of Occupational Health and Safety (OHS) documents was 6.0 letters, exceeding the recommended threshold for instructional and general-purpose texts, typically estimated at 5.0-5.5 letters. A higher average word length indicates

a strong presence of specialist, formal, and technical vocabulary, a finding further confirmed by qualitative analysis.

The longest words occurred primarily in documents originating from industrial facilities and sanitary supervision institutions. Frequently recurring examples included terms such as: *eksploatacyjny* (operational), *zabezpieczający* (protective), *indywidualny* (individual), *narażeniowy* (exposure-related), *nadzorujący* (supervisory), *przystosowawczy* (adaptive), *kwalifikacyjny* (qualificational), and *ewakuacyjny* (evacuation-related). Recurrent specialist compounds were also identified, including expressions such as: *środki ochrony zbiorowej* (collective protective measures), *poziom narażenia zawodowego* (level of occupational exposure), *plan awaryjny ewakuacyjny* (emergency evacuation plan), and *kategoryzacja zagrożeń chemicznych* (chemical hazard categorization). Such constructions increase average word length at the corpus level, as corpus tools treat multi-word technical terms as syntagmatic units.

Document accessibility was further reduced by the lack of explanations for more complex expressions. Specifically, 89% of analyzed words with more than nine letters were neither defined in context nor accompanied by footnotes, glossaries, or other forms of linguistic support. This deficiency was particularly evident in legal and technical terminology. An example of a sentence containing long, specialist vocabulary is as follows:

Original example (45 words):

W przypadku stwierdzenia przekroczenia dopuszczalnych norm narażeńowych należy zastosować środki ochrony zbiorowej zgodnie z obowiązującymi procedurami oceny ryzyka zawodowego.

[In the event that permissible exposure limits are exceeded, collective protective measures should be applied in accordance with the applicable occupational risk assessment procedures.]

Simplified version:

Jeśli zagrożenie przekroczy dopuszczalny poziom, należy włączyć wspólne środki ochrony zgodnie z zasadami oceny ryzyka.

[If exposure exceeds the permissible level, collective protective measures should be activated in line with risk assessment rules.]

An assessment of the 40 regulatory documents using the Jasnopis readability scale shows that most are rated as very difficult or difficult. Fourteen texts (35%) were classified as very difficult, and a further sixteen documents (40%) fell into the difficult category, together accounting for three-quarters of the analyzed material. Only eight documents (20%) were rated at a medium level of difficulty, and only two texts (5%) were rated easy. These results indicate that the majority of the examined regulatory documents are likely to pose substantial comprehension challenges for non-expert readers.

Overall, 75% of the analyzed texts were at a level of difficulty that is inadequate for readers with primary or basic vocational education, that is, for a substantial proportion of manual workers. Such a degree of linguistic complexity is directly associated with the risk of misunderstanding key procedures and safety regulations.

Nominalization, the process of replacing verbs with deverbal nouns, poses a significant barrier for readers with lower linguistic competencies. The average number of nominalizations per document was 17.2, and in some cases their density exceeded 10 per page. Particularly high frequencies of nominalization were observed in legal and procedural documents, which were also characterized by the highest level of abstraction.

Original example:

Realizacja procedur ochronnych powinna następować z zachowaniem zasad obowiązujących w przepisach wewnętrznych. [The implementation of protective procedures should be carried out in compliance with the principles set out in internal regulations.]

Simplified version:

Pracownik powinien stosować zasady ochrony zgodnie z wewnętrznymi przepisami. [The employee should follow protective rules in accordance with internal regulations.]

Nominalization also reduced semantic clarity. In contexts where nominal constructions were used, the agent of the action was often unspecified, hindering clear attribution of responsibility.

In the analyzed corpus, an average of 52% of sentences were formulated in an impersonal or modal style, whereas in industrial and technical documents this proportion exceeded 65%. The most frequently used markers of deontic modality were: *należy* (*must / is required to*) (1,342 occurrences), *powinno się* (*should / ought to*) (884), *można* (*may / is allowed to / can*) (501), and *zabrania się* (*is prohibited / is forbidden / must not*) (479). The frequency of these forms correlated with the Jasnopis difficulty level: documents dominated by impersonal constructions achieved the highest readability difficulty scores.

Although impersonal forms and modal operators are characteristic of official administrative style, in the context of OHS instructions they do not facilitate effective communication. They hinder rapid comprehension of directives and may delay responses in emergency situations. From an editorial perspective, reducing their use in favor of clear constructions with explicitly identified agents (e.g., *operator* (*operator*), *supervisor* (*kierownik*), *pracownik* (*employee*)) is highly desirable. Supplementary analyses using SketchEngine revealed that only 18% of modal sentences contained an explicit reference to the responsible agent. The remaining 82% were impersonal, which may contribute to diminished accountability and reduced communicative effectiveness.

Only 8 of the 40 analyzed documents (20%) exhibited a clear, well-organized structure with a logical division into thematic sections. These documents featured explicit subheadings, well-structured bullet-point lists, hierarchical numbering, and graphic highlights (e.g., boxes, underlining, icons), which significantly improved readability and facilitated navigation.

The remaining 32 documents had an unclear, fragmented structure, dominated by long, dense blocks of text without clear segmentation. The most problematic features included:

1. the accumulation of multiple pieces of information in a single paragraph without prioritization,
2. the absence of typographic markers (e.g., bold type, italics),
3. the omission of discourse markers organizing the reading process,
4. the lack of operational headings that indicate the subject of a given section.

As a result, users experienced considerable difficulty quickly accessing information, particularly regarding emergency procedures and employee responsibilities. The absence of a transparent content layout led to the omission or misinterpretation of critical information.

Original example:

Ewakuację należy rozpocząć niezwłocznie po ogłoszeniu sygnału dźwiękowego, a pracownicy powinni kierować się do najbliższego wyjścia ewakuacyjnego zgodnie z zasadami ustalonymi przez kierownika obiektu, o ile nie zagraża to ich zdrowiu. [Evacuation should be initiated immediately after the alarm signal is announced, and employees should proceed to the nearest emergency exit in accordance with the rules established by the facility manager, provided that their health is not endangered.]

Simplified example:

UWAGA! W razie alarmu ewakuacyjnego: – Przerwij pracę. – Wyjdź najbliższym wyjściem ewakuacyjnym. – Słuchaj poleceń kierownika obiektu.

[WARNING! In the event of an evacuation alarm: – Stop work. – Use the nearest emergency exit. – Follow the instructions of the facility manager.

The analysis further demonstrated that documents prepared by private training companies, often compliant with Easy-to-Read (ETR) principles, more frequently incorporated visual elements such as pictograms, step-by-step tables, or infographics. By contrast, institutional and administrative documents almost entirely lacked such features.

5. Discussion

The analysis reveals a high level of linguistic and structural difficulty across the examined Occupational Health and Safety (OHS) regulations. According to the Jasnopis readability assessment, 75% of the texts were classified as difficult or very difficult, while only 5% were categorized as easy. Given that the primary users of these regulations often include manual workers and vocational school students, this level of complexity raises concerns regarding communicative accessibility in workplace contexts. These findings align with broader international discussions on institutional clarity and public accountability, particularly as

reflected in ISO 24495-1:2023, which emphasizes structural transparency, reader orientation, and cognitive accessibility while preserving legal precision.

From the perspective of legal linguistics, nominalization and impersonal deontic constructions are constitutive features of normative discourse. They enable abstraction, universality of obligation, and depersonalization of authority. In regulatory texts, such structures serve to generalize obligations beyond individual actors and ensure institutional continuity. However, recent empirical research suggests that legal precision and linguistic accessibility are not mutually exclusive. Martínez, Mollica, and Gibson (2023) demonstrate that simplified legal formulations can significantly improve comprehension without reducing perceived enforceability. This supports the view that genre-constitutive features need not automatically result in communicative opacity.

At the same time, the empirical findings of this study indicate that the analyzed OHS documents frequently display a level of linguistic density that may exceed what is required for normative precision. The accumulation of long multi-clause sentences, abstract nominal constructions, impersonal modality, and unexplained specialist terminology substantially increases cognitive load. Systematic reviews of readability metrics in legal texts (Han, Ceross, Bergmann, 2024) emphasize that quantitative indicators alone are insufficient but remain valuable when combined with structural linguistic analysis. The present study follows this integrative approach by correlating Jasnopis classifications with specific syntactic and lexical features.

This observation points to a structural tension between normative precision and communicative accessibility. The former demands stability and terminological consistency; the latter requires interpretability and manageable cognitive processing. Similar tensions have been identified in Polish plain language scholarship. Piekot (2021) argues that administrative simplification must preserve normative scope, while Cieśla (2021) demonstrates how structural density in official texts often impedes comprehension despite formal correctness. The present findings confirm that OHS regulations reproduce these broader institutional tendencies.

The communicative stakes are particularly high in safety-related documentation. Research on Safety Data Sheets (Ho, Tenkate, 2024) shows that excessive technical density may undermine effective hazard communication. In the context of OHS regulations, misunderstanding may have immediate physical consequences, reinforcing the need for calibrated optimization rather than indiscriminate simplification.

Within this framework, readability indicators such as those provided by Jasnopis should not be interpreted as absolute measures of textual dysfunction. Instead, they function as diagnostic tools signaling potential zones of communicative risk, consistent with international plain language standards (ISO 24495-1:2023). High difficulty ratings do not invalidate normative documents; however, they may indicate increased likelihood of misunderstanding in heterogeneous workplace environments.

The structural features identified in the analyzed corpus also correspond with earlier research on Polish legal and administrative discourse (Kondratczyk-Przybylska et al., 2016; Witosz, 2004; Kołodziejek, 2012), confirming the persistence of abstraction, depersonalization, and limited reader-oriented structuring. At the same time, by integrating objective readability metrics with corpus-based linguistic analysis across a sector-diverse dataset, the present study extends previous discussions beyond qualitative critique and provides a systematic empirical basis for evaluating communicative load in OHS documentation.

In sum, the study demonstrates that readability in OHS regulations should be understood not merely as a stylistic preference but as a dimension of institutional responsibility and risk management. Balancing legal precision with communicative accessibility requires calibrated linguistic design supported by both quantitative and qualitative evaluation methods.

6. Conclusions

Sentence length is a central indicator of readers' cognitive load, as overly information-dense sentences obscure meaning, reduce engagement, and increase the risk of misinterpretation. For this reason, reducing sentence length should be a priority when drafting occupational health and safety documentation. This can be achieved by limiting sentences to a maximum of two clauses, restructuring content into lists with clearly defined points and subpoints, supplementing text with graphic boxes that provide step-by-step instructions, and empirically testing simplified versions with representative users, such as manual workers or vocational school students. Sentence length should therefore be understood not merely as a syntactic feature but also as a strong predictor of comprehensibility; in workplace environments that require rapid interpretation and response, concise, unambiguous formulations substantially contribute to improved safety and operational efficiency.

Several measures are recommended to enhance the accessibility of occupational health and safety regulatory documents, including the use of shorter or less-technical equivalents of specialist terms wherever possible, the inclusion of glossaries in texts containing more than 10 complex terms, and the addition of parenthetical definitions or brief usage examples to support interpretation. Furthermore, systematic testing of document versions with individuals exhibiting lower linguistic competencies, using established comprehensibility assessment methods, should be incorporated into the drafting process. The implementation of these measures has the potential to substantially improve the accessibility and practical usability of OHS documentation for a broad and diverse range of employees.

These recommendations should be understood as calibrated optimization rather than the elimination of genre-constitutive legal features. Normative precision remains essential for enforceability and institutional consistency. Simplification efforts must therefore preserve legal

scope, conditional specificity, and clarity of obligation. In this context, a layered documentation model, combining a legally precise master version with operationally optimized summaries or task-oriented formats, may provide a balanced solution reconciling precision with accessibility.

The findings suggest that all newly drafted occupational health and safety documents be systematically verified using established readability tools, such as Jasnopis, and that their linguistic register be aligned with the intended users' actual language competencies. In addition, simplified document versions, including Easy-to-Read formats or concise operational summaries, should be considered to enhance accessibility. These measures should be complemented by pilot readability studies with representative end users, such as production workers, to empirically validate comprehensibility and ensure the practical effectiveness of OHS communication.

This paper argues for a standardized structure for occupational health and safety documentation, incorporating a title page with the document name and date, a table of contents or a clearly organized system of headings, and sections marked with consistent, transparent titles. In addition, the use of graphic highlights, including warning colors and safety symbols, as well as summaries or checklists at the end of individual sections, should be considered integral elements of the document design. The implementation of such solutions increases the likelihood that instructions will be effectively consulted and applied in hazardous situations and supports compliance with established guidelines on linguistic and informational accessibility.

The results indicate a clear need to continue efforts to improve communication in occupational safety and health. Potential directions for further research include comparative analyses of OHS regulations from other European Union countries (e.g., Germany, Sweden, and the Netherlands) regarding linguistic accessibility, as well as investigations into the impact of document readability on employees' actual compliance with safety rules, using experimental designs or survey-based methods. In addition, future studies may focus on developing automated tools to assess and revise OHS documents in accordance with plain language principles.

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THE USE OF AI IN THE TRAINING ACTIVITIES OF POLISH BANKS – AN EMPLOYEE’S PERSPECTIVE

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Purpose: The aim of the study was to examine how bank employees of varying ages and lengths of service evaluate the AI-based training sessions in which they participated.

Design/methodology/approach: The empirical study employed an online survey technique. Statistical analysis of the results was conducted using JASP software, which was used to calculate mean values, standard deviation, Pearson’s linear correlation coefficient (r), and Yule’s contingency coefficient (ϕ). The practical study was supplemented with a literature review.

Findings: It was found that there is a strong positive linear relationship between the respondents’ age and length of service and their satisfaction with AI-based training, as well as their assessment of its effectiveness. With regard to gender, further in-depth research is recommended.

Research limitations/implications: The study was pilot in nature and covered only a portion of banks and a small number of employees; therefore, its findings should not be generalized to the entire sector. A broader and more in-depth examination of the issues discussed in the article is recommended.

Practical implications: Most publications and the studies presented in them focus on attitudes toward AI or on factors determining the level of digital competence. The results obtained can therefore be considered a complement to existing analyses.

Social implications: The study’s findings indicate the need for greater personalization of AI-supported employee training processes, taking into account their prior professional experience as well as the differing expectations of women and men. This will make it possible to create and sustain an organizational culture in banks that is based on employee empowerment and openness to innovation in human resource management.

Originality/value: The analysis aligns with the current body of research while also contributing new insights. Women more often perceived AI training as interesting and informative, yet they also more frequently indicated that it did not meet their expectations and did not enable them to effectively develop practical skills. This may suggest that women have higher expectations toward such training.

Keywords: artificial intelligence (AI), bank, employee, employee training, satisfaction.

Category of the paper: Research paper.

1. Introduction

The concept of artificial intelligence, or more precisely artificial intelligence systems, is understood in different ways and continues to evolve along with the development of various techniques and approaches based on machine learning, deep learning, or natural language processing (Soori et al., 2023; Olabiyi et al., 2025). For specific human-defined purposes, AI can generate outputs such as content, predictions, recommendations, or decisions that affect the environments with which it interacts. In the banking sector, its use is visible in three main areas (Dziedzic, 2022):

1. Relations with retail and corporate clients.
2. Relations with other banks and non-bank financial service providers.
3. Internal applications not related to regulated banking activities.

A significant portion of publications concerning its application focuses on the first two areas and issues related to cybersecurity (Gopalakrishnan, 2023; Simhadri, Polireddi, 2023; Ziółkowska et al., 2023). In this article, however, the focus will be on the last of these areas, specifically on activities related to the implementation of a human resources process element – employee training. Artificial intelligence enables the automation and robotization of processes carried out by banks (Ślęzak, 2024; Alassuli, 2025) during the identification of current training needs, planning and organizing, as well as conducting and evaluating the results associated with enhancing employee qualifications (Dziedzic, 2022; Bell et al., 2025; Nocoń et al., 2025). This practically eliminates the need for teams of people who were responsible for these processes prior to its introduction (Kozmiński et al., 2024; Cieślak-Wróblewska, 2024). It also provides wide opportunities for the individualization of training systems and programs. However, the question arises as to whether this indicates a higher level of satisfaction with participation in such training and a greater sense of its effectiveness compared with training delivered using traditional methods. In seeking an answer to this question, the practical objective of the study (Such, 1978) was defined as examining how employees' age, length of service, and gender influence their evaluation of AI-based training compared with traditional training methods. To achieve this objective, the following hypotheses were established (Bsoul-Kopowska, Sztumski, 2025):

- higher age and longer tenure in the bank are predictors of lower satisfaction with participation in AI-based training and lower assessments of its effectiveness,
- the female gender of the respondent is associated with lower evaluations of AI-supported training compared with traditional training.

2. Methods

To verify this hypothesis, a survey was conducted among employees of three out of the five WIG20 group banks: mBank (MBK), PKO Bank Polski (PKO), and PeKaO SA (PEO). Results were processed using statistical software supported by the University of Amsterdam – Jeffreys's Amazing Statistics Program (JASP). The survey was carried out electronically, and employees responded to 10 single-choice questions and 4 demographic questions concerning gender, age, education, and length of service in the bank. The substantive questions were constructed in such a way that the responses followed a five-point Likert scale, in which the value 1 corresponded to the highest ratings and the value 5 to the lowest. The questionnaire was created using Google Forms and then shared with bank employees via their intranet. The study involved employees who were sent a link to the questionnaire and who completed it voluntarily; therefore, the sample is random and not representative of the population. The survey was conducted from April 15 to April 28, 2025. The completed questionnaires were verified for accuracy and completeness. Of the 276 returned, 11 were rejected because they were not fully completed. Ultimately, the sample consisted of 267 respondents – 96 from MBK, 85 from PKO, and 86 from PEO.

For statistical processing, the collected data were first entered into an Excel spreadsheet and then imported into the JASP software. During the analysis, the standard deviation (σ) and Pearson's linear correlation coefficient (r) were calculated to examine the correlations between respondents' age and length of service and their answers. It was also examined whether a correlation existed between the expressed opinions and the respondents' gender. For this purpose, Yule's phi (ϕ) coefficient of contingency was used, which makes it possible to determine the significance of the observed relationship. The obtained results and their interpretation are presented in the following section of the article.

3. Results

The analysis of the survey results was preceded by a characterization of the participants, developed based on demographic information. Among the respondents, women constituted the majority – 161 in total, including 59 employed at MBK, 49 at PKO, and 53 at PEO. Men represented slightly less than 39.7% (106 individuals), with 37 from MBK, 36 from PKO, and 33 from PEO. Only two respondents had completed secondary education, while all others held higher education degrees. A total of 72 participants had completed a bachelor's program, and the remaining 193 held a master's degree. To describe the respondents in terms of age and length of service, the data concerning these two characteristics were aggregated. For the age

category, the following groups were distinguished: up to 30 years, 31-40 years, 41-50 years, and over 50 years. For length of service, the groups were: up to 5 years, 6-10 years, 11-15 years, 16-20 years, and more than 20 years of service. Based on the provided data, it was found that the average age of the respondents was 39.4 years ($\sigma = 7.22$). Based on the provided data, it was determined that the smallest group of respondents was those aged up to 30 – 9 people, including 3 employed at MBK, 2 at PKO, and 4 at PEO. The largest group consisted of respondents aged 31 to 40 – 150 individuals, with 64 at MBK, 41 at PKO, and 45 at PEO. There were significantly fewer respondents in the remaining two age groups. A total of 81 participants were aged 41-50: 22 employed at MBK, 31 at PKO, and 28 at PEO. The oldest group, those over 50, comprised 27 respondents – 7, 11, and 9 respectively. The final demographic characteristic used to describe the study participants was their length of service. The dominant group consisted of individuals working in the examined bank for 6 to 10 years – 144 respondents. The same number of participants – 43 – reported working at the bank for 11 to 15 years and for 16 to 20 years. The longest tenure, more than 20 years, was declared by 19 respondents, while the shortest, up to 5 years, by 18 respondents. The average work experience of the respondents was 10.88 years ($\sigma = 5.31$) (Table 1).

Table 1.
Demographic characteristics of the respondents

Characteristics		Bank			Σ (N = 267)
		MBK (n = 96)	PKO (n = 85)	PEO (n = 86)	
Sex	women	59	49	53	161
	men	37	36	33	106
Age (in years)	≤ 30	3	2	4	9
	31-40	64	41	45	150
	41-50	22	31	28	81
	>50	7	11	9	27
	$\bar{x}$ (σ)	38.4 (6.73)	40.45 (7.5)	39.34 (7.44)	39.4 (7.22)
Education	secondary	0	1	1	2
	bachelor	24	27	21	72
	master	72	57	64	193
Work experience (in years)	≤ 5	6	3	9	18
	6-10	61	45	38	144
	11-15	12	17	14	43
	16-20	13	11	19	43
	>20	4	9	6	19
	$\bar{x}$ (σ)	10.08 (4.93)	10.99 (5.1)	11.57 (5.89)	10.88 (5.31)

Note. $\bar{x}$ – mean; σ – standard deviation.

Source: Author's own elaboration based on survey data.

The participants' demographic characteristics enabled further analysis of the results, in which the existence of a correlation between the respondents' age and their evaluation of the AI-based training they had attended was examined. The first part of the statistical analysis, based on comparing the respondents' opinions with their age and length of service in the bank, is presented in Table 2.

Table 2.

The relationship between age and work experience and the assessment of the effectiveness of AI-based training

Characteristics		Bank			Σ (N = 267)
		MBK (n = 96)	PKO (n = 85)	PEO (n = 86)	
Age (in years)	$\bar{x}$	28.57	28.57	28.69	28.61
	σ	8.17	7.78	8.39	8.11
	<i>r</i>	0.68	0.62	0.67	0.66
Work experience (in years)	$\bar{x}$	28.57	29.12	28.69	28.79
	σ	8.17	7.59	8.32	8.03
	<i>r</i>	0.67	0.57	0.67	0.64

Note. $\bar{x}$ – mean; σ – standard deviation; *r* – Pearson's correlation coefficient.

Source: Author's own elaboration based on survey data.

The responses of the participants across all surveyed banks were very similar. Out of a possible 50 points indicating a completely negative evaluation of AI-based training, the respondents scored an average of 28.61 points ($\sigma = 8.11$). An identical average score was recorded for respondents working at mBank and PKO BP – 28.57 points ($\sigma = 8.17$ and 7.78, respectively) – while those employed at PeKaO SA scored an average of 28.69 points ($\sigma = 8.39$). The average value of the Pearson linear correlation coefficient ($r = 0.66$), as well as the correlation values for respondents from each bank exceeding 0.6, indicate the existence of a strong positive correlation between the respondents' age and their evaluation of AI-based training.

A slightly greater variation in the data used for statistical analysis was observed in the relationship between length of service in the bank and respondents' opinions. The highest ratings for AI-based training were given by employees of MBO – 28.57 points ($\sigma = 8.17$), followed by PEO – 28.69 ($\sigma = 8.32$), and the lowest by PKO – 29.12 ($\sigma = 7.59$), with an overall average of 28.79 points ($\sigma = 8.03$). The Pearson linear correlation coefficient values were as follows: MBO – 0.67, PKO – 0.57, and PEO – 0.67, with an average value of 0.64. This means that the average value, as well as those for respondents employed at mBank and PKO SA, indicate a strong positive linear correlation, while for participants employed at PKO BP, a moderate correlation was observed. The conducted statistical analysis, the results of which are presented in Table 2, made it possible to positively verify the first research hypothesis, which assumed that higher age and longer work experience in the bank are predictors of lower satisfaction with participation in AI-based training and lower evaluations of their effectiveness.

In turn, the examination of statistically significant relationships between the respondents' gender and their opinions on the effectiveness of AI-based training compared to training conducted using traditional tools and methods is presented in Table 3.

Table 3.

Values of ϕ , χ^2 , and their significance by gender for the evaluation of employee training involving AI in the surveyed banks

AI-based training compared to traditional training	Measure		
	ϕ	χ^2	p
<i>were more interesting</i>	0.262	37.681	0.000
<i>provided more information</i>	0.139	10.492	0.001
<i>allowed for better skill practice</i>	-0.098	5.397	0.021
were more effective	-0.045	0.942	0.333
were better tailored to the individual needs of the respondent	0.056	1.703	0.194
<i>provided more knowledge needed by the respondent for their work</i>	0.086	4.125	0.043
<i>did not meet the respondent's expectations</i>	0.209	24.046	0.000
did not change the way of working	-0.023	0.246	0.624
<i>were useful for the respondent</i>	-0.269	39.821	0.000
allowed passive participation in the training process	0.023	0.272	0.606
overall positive assessment of AI-based training compared to traditional training	0.129	13.053	0.141
overall negative assessment of AI-based training compared to traditional training	0.048	1,714	0,089

Source: Author's own elaboration based on survey data.

Based on the conducted statistical testing, a statistically significant positive relationship was found between gender (female) and the assessment of AI-based training compared to traditional training as being more interesting ($\phi = 0.263$; $p < 0.001$), providing more information ($\phi = 0.139$; $p = 0.001$), and delivering more job-related knowledge ($\phi = 0.086$; $p = 0.043$). It was also found that women significantly more often indicated that such training did not meet their expectations ($\phi = 0.209$; $p < 0.001$).

The reason for this evaluation may be that a statistically significant negative relationship was observed for their opinions regarding the possibility of better skill practice within AI-based training ($\phi = -0.098$; $p = 0.021$). Women also significantly less often believed that this type of training was more useful to them than traditional training ($\phi = -0.269$; $p < 0.001$).

In turn, no statistically significant relationship between gender and the assessment of AI-based training compared to traditional training was found for such aspects as greater effectiveness than traditional methods, better adaptation to respondents' needs, no change in work style, and allowing passive participation in the training process.

Overall, a statistically significant positive relationship was found between female gender and the overall positive assessment of AI-based training compared to traditional training ($\phi = 0.129$; $p < 0.141$), with no such relationship observed for negative evaluations. This means that the hypothesis assuming that female respondents would rate AI-based training lower than traditional training was not confirmed.

4. Discussion

A review of the literature indicates that in recent years AI has become a key element of the digital transformation and the development of both the Polish and global economy, including the banking sector (Iwanicz-Drozdowska et al., 2023; Klimontowicz, 2024; Ślęzak, 2024; Ledo, 2025). At the same time, the level of technological advancement of the Polish banking system allows it to be considered one of the leaders in the European Union (Król, 2023; Koźmiński et al., 2024), as Polish banks are increasingly investing in AI technologies in areas related to internal processes, while also placing emphasis on employee training and development (Artificial Intelligence..., 2024; Mika, 2025). The implementation of AI in banks is also significantly influenced by the EU Artificial Intelligence Regulation and the AI Act, which outline guidelines for the safe, ethical and rights-respecting deployment of this technology, taking into account the individuals affected by it (Wilczyńska-Baraniak, 2024).

As shown by existing literature on the perception of artificial intelligence technologies in the workplace, from the employees' perspective the implementation of AI in training activities brings both opportunities and challenges (Dwivedi et al., 2023; Russo et al., 2025; Bell et al., 2025). This conclusion is reflected in the findings of the study presented in the article. Similar to this study, other Polish and international sources also indicate age and length of service as factors differentiating attitudes toward AI-based solutions (Russo et al., 2025). In other recent publications on this topic (Gillespie et al., 2025), the authors state that older employees exhibit a noticeably lower level of trust in AI-based tools and are less likely to use such solutions in educational and professional contexts. Similar conclusions were presented in the Generation organization's report "Age-Proofing AI" (2024), which emphasizes that individuals over the age of 45 are less inclined to engage in learning processes that involve new technologies, including AI. These findings are consistent with the observations made in the analysis of the study described in the article. Although older and more experienced respondents constituted a relatively small proportion of the overall sample, a clear trend emerged: satisfaction with participation in AI-supported training and the perceived effectiveness of such training decreased as respondents' age and length of service increased. In both the study described and other sources, a relationship can also be observed between gender and the evaluation of AI-based training.

Research published by Armutat et al., (2024) shows that women generally display greater caution toward AI technologies and more often report lower levels of digital competence as well as less interest in technology-oriented training. Meanwhile, the authors of the OECD report "Algorithm and Eve: How AI Will Impact Women at Work" (2024) note that women in the workplace are often less exposed to the use of AI-based tools, which may influence their experiences and opinions in this area. The analysis presented in the article aligns with the existing body of national and international research while also contributing new insights.

Women, although more likely to consider AI training more interesting and informative, also more frequently indicated that it did not meet their expectations and did not enable them to effectively develop practical skills. This may suggest that women have higher expectations regarding the quality of content and the way such training is delivered, which differentiates their perspective from that of men. However, this remains only a hypothesis requiring further investigation, as the literature lacks studies that analyze the assessment of training quality and expectations toward such training with gender-related differences in mind. As indicated in the literature review presented in the article, most publications focus on attitudes toward technology or on factors determining levels of digital competence. The findings obtained may therefore be considered a valuable complement to existing analyses.

It should be emphasized, however, that both in the literature and in the study presented, a common conclusion emerges: demographic factors such as age, length of service, and gender significantly shape how modern forms of learning are perceived. Age and professional experience are associated with greater distance toward AI-based tools, while gender differences reveal a more complex picture, indicating that women are inclined to appreciate the cognitive value and attractiveness of such training, yet at the same time expect it to be more practical. This implies the need for greater personalization of AI-supported employee training processes, including broader consideration of workers' levels of professional experience and of the diverse expectations associated with gender.

Summary

To sum up, the use of AI in the training activities of Polish banks guarantees a range of benefits, such as personalized learning, process automation, and increased training effectiveness. However, from the employee's perspective, in order to fulfill its function, it must be individualized and supplemented with support, education, and trust-building toward new technologies.

Banking and AI experts agree that in the coming years we can expect further development of AI-based training tools, as well as virtual reality (VR) and augmented reality (AR), which when combined with artificial intelligence may revolutionize the way employees learn and develop their competencies. Yet this will not be possible without comprehensive support and education that will enable employees to fully leverage the potential of this technology. Only under such conditions will it be possible to make full use of AI's potential in building and developing the competencies of banking sector employees. Especially since, as indicated by the presented study, there is a clear need for greater personalization of AI-supported training processes. Employees expect their prior professional experience to be taken into account, as well as differences in expectations conditioned by gender. This will make it possible to build

and sustain over time an organizational culture based on a subject-oriented approach to employees and openness to innovation in human resource management.

It should also be emphasized that the changes taking place in human resource management, related to the improvement and training of employees in the Polish banking sector, will continue to pose challenges and bring new areas for research for many years to come. Therefore, the study results presented in the article serve merely as a starting point and an introduction to further analyses and inquiries. They also indicate the need for their continuation in the coming years based on a representative sample, allowing the results to be generalized to the entire population of banking sector employees in Poland.

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MEGATRENDS AND THE TRANSFORMATION OF POLICY- MAKING: TOWARDS THE POLICY 4.0 PARADIGM

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Purpose: The aim of this article is to examine whether contemporary global megatrends act as drivers of deeper transformations in public policy theory and practice, leading to the emergence of Policy 4.0 as a new policy-making paradigm. The study considers these changes from the perspective of organizational change and change management in public governance. It addresses two questions: whether megatrends stimulate fundamental transformations in policy-making processes, and what distinctive features Policy 4.0 may develop in response to these trends.

Methodology and approach: The paper adopts a conceptual and analytical approach, based on a qualitative analysis of global megatrends and a literature review in public policy, governance, and management. Using deductive reasoning, it explores how megatrends may influence transformations in policy-making theory and practice and contribute to the emergence of Policy 4.0.

Findings: Technological, economic, environmental, social, and political megatrends influence the evolution of public policy-making and may lead to the emergence of Policy 4.0. Future public policies are likely to become more holistic, transnational, inclusive, and increasingly based on digitalisation, automation, and evidence-based governance, while also placing greater emphasis on environmental sustainability and security. The study highlights key dilemmas of Policy 4.0, concerning the democratic character of policy-making in the digital age and the inclusiveness of actors in globalised and complex policy environment.

Practical implications: Public organizations and enterprises must adopt adaptive governance, change management, and organizational flexibility to respond effectively to complex, fast-changing environments. Policies and strategies should integrate digital technologies, cross-sector collaboration, and sustainability considerations.

Social implications: The analysis highlights the growing role of technology, data, and automation in policy-making, encouraging engagement with digital governance and demand for transparency. It also emphasizes implications for corporate social responsibility, environmental policy, resource efficiency, public-private collaboration and democracy.

Originality/value: The paper shows how megatrends transform public policy, governance, and organizational practices, leading to the emergence of Policy 4.0 as a new paradigm. It is addressed to scholars, policymakers, and practitioners interested in policy innovation, governance transformation, and strategic responses to global megatrends.

Keywords: change management, governance transformation, megatrends, organizational change, public management.

Category of the paper: Conceptual paper, Viewpoint.

1. Introduction

Contemporary global trends, also known as megatrends, affect every aspect of state, economy and society. The term was introduced by J. Naisbitt (1982) who first defined it as socio-economic or structural processes that take shape slowly, but, once they occur, they affect all areas of life over a period of time. Several years later, Naisbitt further clarified them as “large social, economic, political, and technological changes [that are] slow to form, and once in place, influence us for some time – between seven or ten years, or longer” (1990). What distinguishes megatrends from ordinary trends and fashions is that they are more significant, last longer, and cause more profound effects (Mittelstaedt et al., 2014). They are also conceived as complex macro-scale phenomena, driving change that is broad, global and supra-regional in scope and occurs in a variety of areas.

The literature recognises a significant number of trends that are designated as megatrends. These include long-observed worldwide processes with various origins, dynamics, and variability in the fields of technology, the economy, the environment, society, and politics, as well as those induced by the recent Covid-19 pandemic.

Many of today’s megatrends can be traced back to technological change occurring as part of the Fourth Industrial Revolution (4IR), which originated from the idea of Industry 4.0. The German term *Industrie 4.0* was first used at the Hanover Fair in 2011 (Drath, Horch, 2014) and in 2013 it was operationalised by a working group of the German National Academy of Science and Engineering (2013). The aim of *Industrie 4.0* is to generate greater productivity through resource efficiency and investments in people and technology (Buhr, 2015).

The Fourth Industrial Revolution (4IR) has become a focal point for analysis within scientific, economic, and public discourse, evidenced by an increase in related scientific publications and public programs evaluating its impacts. The designation 4.0 is used to describe various sectors affected by 4IR, e.g. Economy 4.0 for economic changes, Commerce 4.0 for trade, Finance 4.0 for financial services, and likewise for sectors like Service, Energy, Transportation, Agriculture, Telecommunications, Work, Skills, Education, Health, Science, and Social Policy. Furthermore, societal ageing and online security are captured in Ageing 4.0 and Cybersecurity 4.0, respectively, while Corporate Culture 4.0 reflects organisational changes. The public sector has also integrated the 4.0 designation through terms such as Government 4.0.

Despite the broad implications of 4IR, research on its influence on policymaking remains limited, highlighting a gap in understanding how contemporary megatrends may shape public policies and the advancement of policy sciences in the future.

The aim of the article is to answer two fundamental questions:

1. Do contemporary megatrends provide the impetus for deeper changes in policy-making theory and practice and the consequent emergence of Policy 4.0 as a new policy-making paradigm?
2. What distinctive features will Policy 4.0 have in response to the trends set by contemporary megatrends?

The author contends that contemporary megatrends of a technological, economic, environmental, social, and political nature redefine the rules of public policy-making, creating demand for new theories and leading to the emergence of Policy 4.0 as a new paradigm.

2. Determinants of Policy 4.0

The discussion below is based on the assumption that Policy 4.0 results from the interaction of three groups of factors:

1. The principles of policy sciences and public policy theory.
2. Public policy implementation practices.
3. Contemporary megatrends.

2.1. The principles of policy sciences and public policy theory

Policy 4.0 is unlikely to challenge the traditional assumptions of policy sciences or most existing theoretical concepts of public policy. The conceptual framework for policy sciences was established by H.D. Lasswell in his 1951 essay *The Policy Orientation of Political Science*, in which he provided a comprehensive account of its aims, methods, and tools (Lasswell, 1951). He derived the concept of public policy from an underlying understanding of politics, which he defined as “the most important choices made either in organised or in private life” (Lasswell, 1951). Later, T. Dye framed public policy as “anything a government chooses to do or not to do” (1987), whereas J. Anderson construed it as a “relatively stable purposive course of action or inaction followed by an actor or a set of actors in dealing with a problem or matter of concern” (2011).

H.D. Lasswell (1951) defined the expectations of policy sciences, which included making public-sector decisions as transparent and fully informed as feasible. He also mentioned evaluating the impact of the policies chosen for execution as one of the aims of public policy studies. In his opinion, policy sciences should combine theoretical knowledge in social sciences, the practice of governance, and the world of politics. In his view, public policy sciences should be characterised by:

- problem-orientation – a focus on the most relevant issues to be dealt with by public authorities,
- multidisciplinary – drawing on all possible scientific disciplines whose methodologies and achievements can contribute to solving the key problems,
- methodological specificity – the individualisation of research methods in order to match them as closely as possible with the problems at hand,
- theoretical specificity – attempts to understand interconnected social, political, and economic systems in as much depth as possible,
- value orientation – maximising democratic values (Lasswell, 1951).

Theoretical concepts of public policy comprise a large and diverse collection of achievements in policy sciences or adapted to their needs. They are either descriptive, i.e. they assist in understanding certain public policy phenomena (explanatory concepts) or prescriptive, i.e. they recommend specific actions under given circumstances (normative concepts). Policy sciences identify a range of fields and their associated research questions (Smith, Larimer, 2009), such as public policy vs. politics (e.g. does politics determine public policy or vice-versa?), processes (e.g. how are public policy alternatives formulated?), analyses (e.g. what alternatives may contribute to solving a specific problem?), evaluations (e.g. what is the impact of implemented public policy?), models (e.g. whose values does public policy represent?), decision-makers and institutions (e.g. who makes public policy decisions?), and implementation research (e.g. why does public policy succeed or fail?).

Despite the fact that policy sciences have been around for several decades, their theoretical underpinnings and study domains remain relevant due to their universality. Therefore, it seems reasonable to expect that their objectives, areas of study, and some of their theoretical concepts will be suitable for examining the core ideas of Policy 4.0.

2.2. Public policy implementation practices

The concept of Policy 4.0 should also take into account some of the practical policy-making achievements. Policy implementation is not a static process; it embodies evolving knowledge, skills, and institutional memory that develop through continuous learning, experience, and iterative practice. Over time, public organizations refine their approaches by drawing on past successes and failures, adapting to changing conditions, and integrating new tools and technologies.

In this context, the aggregated knowledge base of policymakers, administrators, and institutions becomes a critical driver of Policy 4.0. It enables more adaptive, evidence-informed, and responsive policy processes, reinforcing the transition toward more complex and integrated governance models. Thus, Policy 4.0 is not only shaped by policy theory and megatrends but also emerges from the cumulative learning embedded in policy implementation practices, which strengthens its conceptual and practical foundations. Due to the fact that public

policy implementation practices are the subject of numerous scientific publications, their in-depth analysis falls outside the purview of this article.

2.3. Contemporary megatrends

The most commonly identified modern megatrends are traditionally classified into technological, economic, environmental, social, and political ones.

Technological megatrends

Technological megatrends are usually referred to by the term Fourth Industrial Revolution (4IR), which affects every aspect of state, economy, and society as the boundaries between the public, private, and non-profit sectors become increasingly blurred. The search for innovative ways to increase efficiency by public authorities leads to the growth of a mixed economy involving public, private, and non-profit public service providers, as well as increased participation of private and non-profit actors in addressing problems traditionally thought to fall under the purview of public policy (Barber, Levy, Mendonca, 2007).

A key driver of the policy-making transformation is the dynamic technological development taking place within the 4IR (PwC, 2016). This revolution stimulates the advances of science and technology, in which the Internet of Things (IoT) and its supporting technologies serve as backbones for a range of Cyber-Physical Systems (CPSs), and smart machines are used to optimise production chains (Liao et al., 2018). CPSs, which combine computer systems, software and humans in work processes (Baldassari, Roux 2017), have become the mainstay of the revolution (Liao et al., 2017). Self-learning robots, preventive maintenance technologies, self-reconfiguring machines or intelligent environmental technologies (Brekelmans, 2016) are just a few examples of these integrated systems.

Among the key technologies disseminated as part of the 4IR, two are close to achieving breakthrough status: the blockchain technology & artificial intelligence (Girasa, 2020). Both have the potential to significantly affect both our behaviour and daily lives. The technologies that characterise the 4IR also include: automated manufacturing and service processes, self-learning machines, sensors that collect a variety of information and data linked to supercomputers that process them, and the universally accessible internet. The 4IR manifests itself in the physical (autonomous vehicles, 3D printing, new materials, advanced robots), digital (Internet of Things, cyber-physical systems), and biological (genetic engineering and sequencing, synthetic biology and genome editing) spaces (Kuruczleki et al., 2016; Buhr, 2015). Such advancements transcend organisational and territorial boundaries, comprising agility, intelligence, and networking (Liao et al., 2018).

The 4IR is an era of learning, gaining and integrating knowledge (Puncreobutr, 2017). It provides strong incentives for the convergence of research disciplines, sciences and technologies, systems, information and communications technologies, production technologies or manufacturing systems (OECD 2017). This convergence is advancing particularly rapidly at

the nanoscale level in material sciences, condensed matter physics, and biology (Roco, Bainbridge, 2002). The interactions among key technologies such as nanotechnology, biotechnology, advanced materials and ICT has led to device-level integration with technologies combined in ways that offer new functions and applications (EC, 2015a). The convergence of information and communication technologies enables the networking and integration of numerous components of industrial and infrastructure systems (energy, transport, power, and factory and production networks) (OECD, 2017).

Future public policies will need to consider the technological, legal-ethical, and political consequences of the Internet of Things and its evolution into the Internet of Bodies. The latter involves the creation of networks of human bodies whose integrity and functionality will rely, at least in part, on the Internet and related technical solutions such as artificial intelligence (Matwyshyn, 2019).

The technological revolution is, moreover, an era of creativity and innovation (Puncreobutr, 2017), which is triggering profound changes in the work environment as a result of digitisation and automation (PTPS, 2021). These have been accelerated by the rise of remote working amid lockdowns and employer decisions in response to the Covid-19 pandemic as well as the spread of flexible employment (Gupta, 2020; Leonardi, 2021; Linthorst, de Waal, 2020).

On the other hand, the negative consequences of the 4IR include an increased threat of advanced technologies being used as weapons by states, terrorists, and hackers (Tan, Shang-su, 2017; Žuk, Žuk, 2016).

Economic megatrends

Economic megatrends are a consequence of both contemporary technological change and historical processes taking place in the global economy. Economists emphasise that the key distinctive feature of these processes is the shift of forces in the global economy (Linthorst, de Waal, 2020; PwC, 2016). The Western world is losing its hegemony, even as a new international order is being created around the so-called BRICs, comprising Brazil, Russia, India and China, or Asia conceived in broader geographic terms (Cox, 2012; Schwarzer, 2017; Khanna, 2019).

At the same time, the global economy is becoming more and more interconnected, as manifested by the growth of international trade and capital flows. Economic systems are becoming increasingly complex and unpredictable, leading to increased fragility in the economy and volatility across business ecosystems. The globalisation of value chains, accelerated production lifecycles, digitalisation and changing consumer habits are impacting manufacturing systems, constantly redefining the sources of competitiveness (Dickens, Kelly, Williams, 2013; UNIDO, 2013). The corporate sector is striving to respond by emphasising high value-added services, user participation, sustainability, and responsible innovation (OECD, 2017).

The prospect of increases in public debt has a significant impact on the uncertainty surrounding future government policies. It was already recognised in the middle of the second decade of the 21st century, when it was expected to become a major constraint on fiscal and policy options before 2030 and beyond (KPMG, 2016). This trend was exacerbated by the Covid-19 pandemic, which resulted in the highest levels of budget deficits as a share of GDP in EU Member States since the beginning of the millennium. According to Eurostat (2021), after reaching –6% of GDP in 2009 and 2010, the deficit-to-GDP ratio decreased to –0.4% in 2018 and –0.6% in 2019. Then, in 2020, the ratio rose sharply to –6.8%, mainly due to the effects of the Covid-19 pandemic. In 2021, the largest government debt ratios were observed in Greece (193.3%), Italy (150.8%), and Portugal (127.4%), whereas the lowest in Estonia (18.1%), Luxembourg (24.4%), and Bulgaria (25.1%).

Evolving cryptocurrencies compete with state-issued currencies (Şen, 2019), while the popularity of cashless payments reduces cash circulation. The growing demand for energy (PTPS, 2021) has economic, environmental, social and political implications.

Environmental megatrends

In this area, two megatrends are considered crucial. The first one is climate change (PwC, 2016) caused by increasing greenhouse gas emissions, which leads to unpredictable environmental changes and undermines the resilience of natural and artificial systems.

The other prominent trend in the near future will reflect the rising demand for natural resources (PwC, 2016), driven by population growth, economic growth, and climate change. The highest upward pressure on consumption affects such basic natural resources as water, food, agricultural land, minerals, and energy (Pieregud, 2015). The dramatic increase in global consumption over the past century, which has affected the demand for and use of natural resources, is considered a key reason behind their scarcity (Retief et al., 2016).

Environmental megatrends also include pollution, anthropogenic environmental decline, and biodiversity loss (PTPS, 2021; Z-Punkt, 2021).

Social megatrends

Demographic change is at the forefront of societal megatrends. Its main manifestation is the growth of the world's population (UNDESA, 2019; PTPS, 2021) as a result of increasing life expectancy and high birth rates in Africa and other developing countries. The global population is projected to increase to 9.7 billion by 2050, according to the 2021 edition of the World Population Data Sheet (2021). This represents a nearly 24% increase over 2020, although it is lower than was expected in 2020 (PRB, 2021). The global total fertility rate is 2.3, which is above replacement-level (2.1 births per woman), but lower than it was in 1990 (3.2). Global life expectancy is 75 years for women and 71 years for men (PRB, 2021).

At the same time, the ageing of populations in developed countries is progressing (PTPS, 2021). The number of older people worldwide is projected to grow from 901 million in 2015 to 1.4 billion in 2030 and to 2.1 billion in 2050 (UNDESA, 2015). The latter trend is already undermining the viability of welfare systems, including pensions and health care. Some countries also face the challenge of integrating large youth populations into saturated labour markets (KPMG, 2016).

Recent research suggests that the COVID-19 pandemic may affect some demographic trends. According to emerging evidence, densely populated areas are more likely to experience an early outbreak of COVID-19, though not necessarily a severe one; moreover, the coronavirus does not impact all population groups equally. Higher risk factors include older age, certain ethnicities, male gender, underlying health conditions, socioeconomic marginalisation, and specific occupations (Wahba et al., 2021).

Increasing migration will be a key factor in future public policies (UNDESA, 2019; PTPS, 2021; Wahba et al., 2021). The existing large flows of people will accelerate as shifts in both skilled and unskilled labour pose new challenges for both source and target countries (Linthorst, de Waal 2020). Migration patterns and demographic transitions will result in even more significant changes in labour composition (Rudolph et al., 2018).

The primary consequence of technological development and migration processes is growing inequality and social polarisation (PTPS, 2021). Particularly at risk are low-skilled individuals, whose jobs may disappear due to automation, as well as the self-employed and those with a migrant background (Rubery et al., 2018).

An important determinant of Policy 4.0 will be accelerating urbanisation (UNDESA, 2019; PwC, 2016; PTPS, 2021). It is estimated that currently, 180,000 people move to cities every day (Poblocki, 2017). In 2050, urban populations will have grown by 59% and will account for nearly 70% of the world's population. By that year, they will reach nearly 6.7 billion people, compared with 4.2 billion in 2020. By 2030, the world will have 43 megacities compared with 31 in 2020. Their populations will exceed 10 million each. Most of these megacities will be located in developing countries, with 22 in Asia (mostly in India and China). Africa will be home to six megacities of more than 10 million people by 2050 (Rabier, Djoufelkit, 2021).

Their ramifications for future public policies will include lifestyle diversification and the rise of individualism (KPMG, 2016). The latter is defined as the desire to distinguish oneself from others as a result of the transition from a collectivist to an individual-centred society, as well as the growing expectation of instant availability of goods and services (Linthorst, de Waal, 2020). On the other hand, diminishing food security will threaten the livelihoods of societies (PTPS, 2021).

Political megatrends

The boundaries separating the public, private, and non-profit sectors are becoming increasingly blurred. The search by public authorities for innovative ways to increase efficiency leads to the growth of a mixed economy involving public, private, and non-profit providers of public services, while promoting the participation of the latter two in addressing issues traditionally considered to be within the domain of public policy (Barber, Levy, Mendonca, 2007).

It is also becoming clear that as the 4IR moves through its many stages, high-tech businesses will become more and more influential in social, political, and economic terms. Government influence as it has historically been understood is gradually being eclipsed by a small group of these enterprises (Tan, Shang-su, 2017).

The complexity of problems facing states contributes to the tendency for national governments to engage in international, regional and judicial fora to resolve them (KPMG, 2016). Shifts in international balance and rising global tensions (PTPS, 2021) give rise to a new political (dis)order (Z-Punkt, 2021), democracy crises, and the emergence of new governance models. The consolidation of the European power centre occurs at the expense of diminishing sovereignty of the EU Member States, as aptly captured by the phrase “from Nation-States to Member States” (Bickerton, 2015).

3. Conceptualisation of Policy 4.0 Paradigm

In his discussion of the origins and essence of Policy 4.0, the author adopted the following conceptualisation (Figure 1), according to which Policy 4.0 results from the interaction of three types of factors:

1. The principles of policy sciences and public policy theories (policy-making continuity factors).
2. Public policy implementation practices (policy-making continuity factors).
3. Contemporary megatrends (policy-making transformation factors).

In the author’s approach, the principles of policy sciences and public policy theories, and public policy implementation practices are seen as continuity factors, i.e. they also contribute, albeit to a limited extent, to the idea of Policy 4.0. After all, the concept itself cannot emerge in opposition to all the scientific achievements of policy sciences or the practical experience of policy-making.

Contemporary megatrends comprise the most significant transformations and processes that are global in scope and critical to the future of the world. In the author’s view, they constitute transformative forces in existing policy-making theory and practice. The assumptions of policy

sciences and public policy theories encompass their objectives and methods as formulated by the discipline’s founders and its theoretical output to date, whereas the practice of public policy-making is the body of existing experience accumulated through the implementation of detailed public policies.

How then should Policy 4.0 itself be defined theoretically? The author assumes that Policy 4.0 is a new paradigm, emerging from the interactions between the transformative factors and the continuity factors. In the proposed conceptual model, Policy 4.0 consists of the following elements (Figure 1):

- 1. Hallmarks
- 2. Theoretical concepts
- 3. Implementation practices.

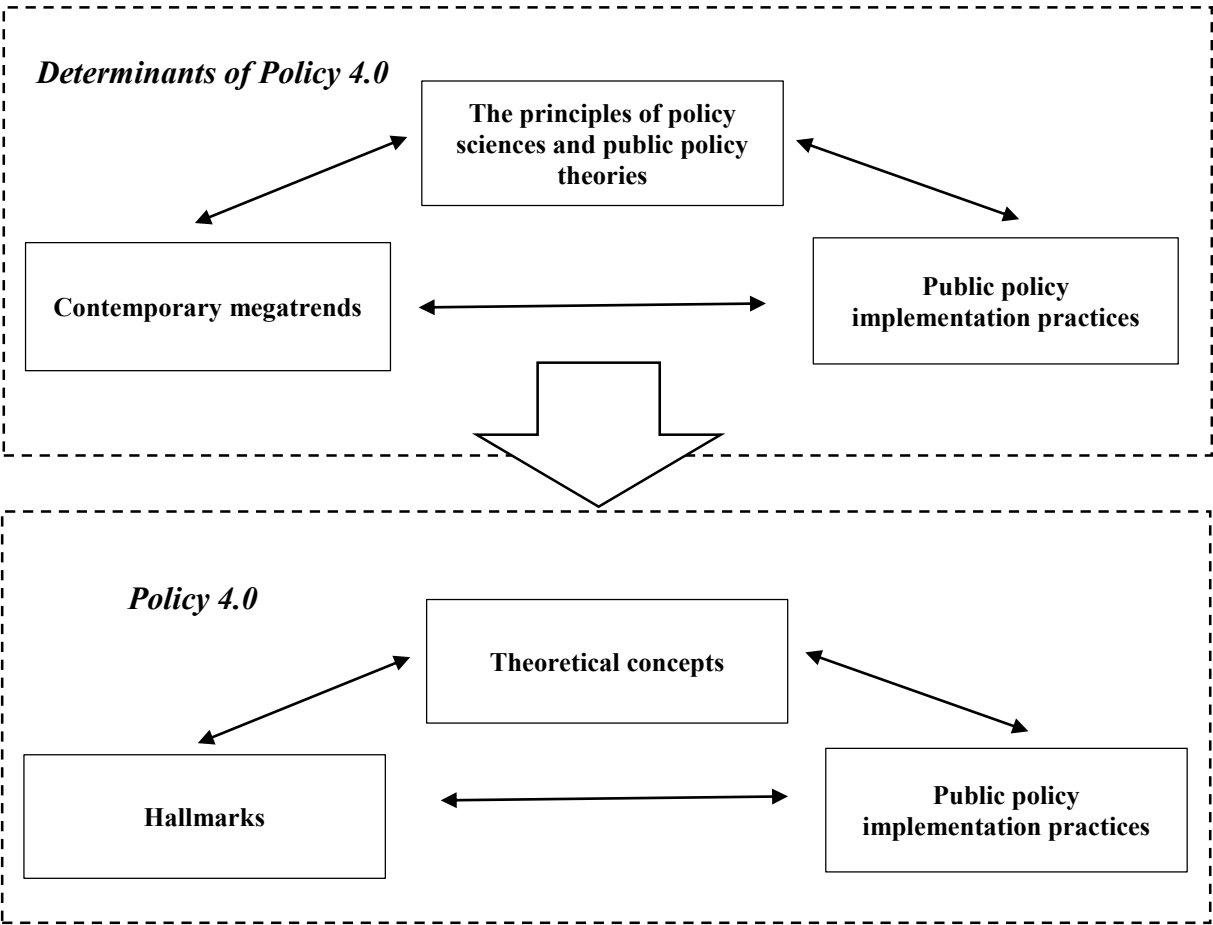


Figure 1. Conceptualisation of Policy 4.0 Paradigm.

Source: own study.

Policy 4.0’s hallmarks are understood to be the key, distinctive and common features of all future public policies. They are horizontal in nature, which means that they will apply to a broad spectrum of detailed public policies in the future.

The theoretical concepts of Policy 4.0 are conceived as theoretical achievements of policy sciences resulting from the crystallisation of Policy 4.0 theory, arising from the revision of old theories and concepts, or the formation of new theories and concepts to meet future needs.

Policy 4.0 implementation strategies involve changes in how certain public policies are implemented as a result of its emergence.

The subsequent stages of the analysis will be carried out based on the proposed model of the conceptualisation of the Policy 4.0 paradigm.

4. Policy 4.0 Paradigm

4.1. Hallmarks of Policy 4.0

Contemporary megatrends drive the emergence of new patterns in policy-making. Analysing their nature enables us to identify certain characteristics shared by all public policies of the future, referred to here as Policy 4.0 hallmarks. The author identified twelve such hallmarks, whose names indicate the projected direction of change (more represents intensification, whereas less denotes weakening). However, the proposed selection is by no means complete and should only be viewed as the author's contribution to the discussion of the evolution of public policy theory and practice.

More holistic and integrated

Policy 4.0 is characterised by a holistic and integrated approach, driven by interconnections between economic actors and public authorities, the merging of public and non-public spheres, rapid knowledge advancement, and the complexity of social dynamics. This environment fosters collaboration between public and private sectors, aiming for inclusive and sustainable solutions that cater to various stakeholders. Interdisciplinary research aids in uniting scientific disciplines within policy sciences, as many societal issues require scientific and technological responses, such as strategies for climate change that blend adaptive and mitigating policies.

The push for comprehensive solutions is exemplified by contemporary industrial policies inspired by Industry 4.0, which combine traditional sectors like industry, economics, innovation, and education. Likewise, the emerging Ageing 4.0 policy reflects a comprehensive approach encompassing social, pension, health, labour market, and economic aspects (Leichsenring, 2018). Future trends are likely to involve greater integration of scientific and expert resources to address public challenges and convergence of technological and policy instruments, in response to a growing demand for multi-layered policies.

More transnational and global

Policy 4.0 is expected to be more transnational and globalised, as evidenced by recent EU proposals from 2021, including trans-European taxation, an EU finance minister, expanded competencies in health and education, and direct funding for NGOs by the European

Commission. By late 2023, discussions on federalizing the EU – transforming it into a single federal state – intensified. The transnationalisation of public policies is also driven by globalisation, which promotes international treaties aimed at equitable economic development and enhances competition. (KPMG, 2016).

Since the 1990s, globalisation has had an impact on public goods, resulting in the formation and consolidation of global public goods, which are defined as the emanation of public goods outside the boundary of a sovereign state (Kleer, 2016). These goods are classified into three categories: natural commons (e.g. Earth's atmosphere, seas, and oceans), man-made goods (e.g. internet, international regimes, norms, knowledge), and policy results (outcomes and conditions) (Kopiński, Wróblewski, 2020). Moreover, the recent Covid-19 pandemic has clearly empowered the World Health Organisation in its role as a coordinator of the fight against pandemic threats at the transnational level.

More public-private mix

It is reasonable to expect that Policy 4.0 will involve a greater public-private mix, which is primarily due to the fact that large transnational corporations and other private companies own the technological solutions needed to implement an increasing number of policies.

International NGOs, such as the Bill and Melinda Gates Foundation, implemented public health projects in the first half of the 2000s, prompted by, among other things, unsuccessful intergovernmental efforts. There are also various examples of the commercialization of policies enacted for sustainable development, including access to potable water, microfinance instruments, and low-carbon technologies (Beshouri, 2006). A strong impetus for mixed public-private efforts was provided by the Covid-19 pandemic, which was contained thanks to coordinated efforts of state governments, transnational organisations, as well as pharmaceutical and technology corporations.

More inclusive

Policy 4.0 will have to meet the expectations for inclusiveness in the face of growing inequality and social diversity. The threat of technological unemployment and the economic deterioration of certain groups of workers highlight the importance of social and legal protection for vulnerable people (Colombino, 2019). On the other hand, the implementation of regulations mandating firms to protect workers at risk of losing their jobs (e.g. by training programmes) increases labour costs and administrative burdens (Kiss, 2017). A common challenge for many public policies of the future in both developed and emerging countries will be addressing skills shortages and gaining access to new labour resources (Barber, Levy, Mendonca, 2007).

Another factor driving future more inclusive governmental policies is the melting away of majority groups, mostly due to migration and the introduction of new cultural trends. Whereas in recent decades democratic choices in public policy have been based on the voice of the

majority and respect for minority positions, Policy 4.0 will have to face increasing pressure to make decisions that take into account the dispersion and diversity of society, including in terms of race, ethnicity, language, religion, culture, and material circumstances. The rules for the implementation of Policy 4.0 will thus have to reflect societal changes, such as increased fragmentation, in which majority groups disappear or play less significant social and political roles.

More personalised

Individuals and organisations increasingly expect tailored products, services, and other solutions (Tinnilä, 2012). The growth of digital technology has significantly increased the number of options available for customising all electronic public services. Their delivery is changing as a result of new technologies, both in terms of content (administrative, social, and technological) and process (public procurement). Typical recommendations for the personalisation of administrative services include (Andrzejewska et al., 2018):

- electronic application forms pre-filled with the data already held by the service provider,
- in the case of services where no application is necessary, the relevant office automatically handles the case to the extent appropriate to the life situation of the service recipient,
- where a payment is required, the service provider redirects the recipient to the appropriate intermediary while preserving the event's context; the service provider's system automatically completes all necessary fields, such as transfer data.

Personalisation is thus defined as the individualisation of services and the automation of delivery procedures. The 'tailor-made' approach as opposed to 'one-size-fits-all' tactic broadens the range of options for implementing all individual-oriented policies, which, according to T. Lowie's (1972) typology of public policies, are regulatory and distributive ones. Personalisation will thus advance not only in e-government, but also in the area of social and technical services. Various personalisation technologies have already been successfully employed in interactions with taxpayers, insured individuals, patients, road users, and municipal service recipients, hence further progress in this area appears inevitable.

Personalisation technologies are also becoming crucial to Education 4.0, which entails providing individualised tuition and freedom of choice. Pupils and students will be given the opportunity to learn at their own pace (asynchronously), whereas learning tools will be adaptable, allowing those with advanced skills to learn faster and accomplish more challenging tasks, while beginners can take their time mastering basic skills. Since learning styles vary considerably, students will be able to select their own combination of tools and approaches from various available devices, programmes, and methodologies (Fisk, 2017).

Personalisation technologies also have an enormous potential for use in the healthcare sector. First and foremost, Internet of Bodies technologies make it possible to evaluate each patient's health in real time. The available functionalities include monitoring, cloud-based

collection and processing of data on patients' lab test results, treatment administered, medications taken, and therapy prescribed, patients' health parameters, and compliance with medical recommendations (e.g. medication dosage monitoring).

More oriented towards digitalised, automated, and robotic work

Policy 4.0 must adapt to emerging employment trends resulting from digitalisation, automation, and robotisation within manufacturing and services. The Work 4.0 revolution is expected to greatly impact public policies due to the displacement of routine jobs by robots and the potential rise in technological unemployment. While new technologies may create new professions and enhance productivity, they also necessitate policy responses to the challenges of future labour markets, especially as many children today will be employed in jobs that have yet to be defined. As machines take over repetitive, routine physical and mental tasks, humans will need to focus on areas such as interpersonal collaboration and creative problem-solving. Technical skills may become less relevant, emphasising the need for individuals to learn how to work alongside machines. The anticipation of a diverse array of working arrangements, including self-employment and flexible gig economy roles, further complicates the employment landscape. Future policies must therefore accommodate these shifts, ensuring they support evolving work practices and arrangements (Anani, 2018; Anthes, 2017).

The growing influence of technology companies raises various expectations of governments, one of which involves preventing the negative consequences of technological unemployment.

More environment- and resource-oriented

Policy 4.0 will have an even greater focus on environmental issues. Climate change is expected to have a significant detrimental effect on future economic growth. Mitigating it will necessitate major investment to lessen the environmental impact of people and businesses, as well as addressing migration from nations at risk of flooding and sea level rise (Peetz, 2019).

More urban and less territorially balanced

Policy 4.0 will also have to address the transformation of settlement patterns, particularly increasing numbers of metropolises coupled with the depopulation of peripheral areas and small/medium-sized cities. Predictably, urban areas will have greater development potential than less urbanised locations. Rural communities are already dealing with the challenge of outflow of qualified workers. This gap will not be easily bridged by remote work, because it will be hampered by the lower accessibility of services outside urban areas. However, urbanisation will provide opportunities for both skilled workers, such as those employed in the professional services sector, and less skilled ones, e.g. in construction. On the other hand, in congested metropolises, the cost of living and competition for jobs are rising, with

unsustainable living conditions producing a number of health concerns (Malik, Janowska, 2018).

Rapid urbanisation also poses new challenges for public policies of the future. These concern, above all, the provision of public services to growing populations, the search for new territorial development models and administrative policies that can successfully address the loss of functions of peripheral areas, including through a policy of controlled shrinkage, the provision of public services in areas at risk of depopulation (e.g. welfare, health care, transport, municipal services), reforms of the territorial division, and the public administration system to adapt them better to the consequences of migration to big cities.

According to analysts who see globalisation as inevitable, it is the cities that are the biggest contributors to it. As J. Bartlett argues, “Power in the 21st century belongs to the problem-solvers. National governments debate and dither. Cities act, cities do”. He also proposes that the remedy to the historical underdevelopment of nation-states may be the restoration of the city-state (Bartlett, 2017).

More security-oriented

The risks associated with employing modern technologies as weapons will raise expectations of the state to ensure security. Whether these dangers come from nations, terrorists, or hackers, the state’s role in providing security will become increasingly vital in the future. Security is a public good, hence private firms are unlikely to be able to supersede state authorities in their provider function (Tan, Shang-su, 2017). In the future, this role may be taken over by supranational political power structures if integration processes that transfer nation-state competencies to transnational and global power structures continue.

It will also be necessary to develop solutions that protect stakeholders using specific technologies. This includes the security of technology, information systems, transactions, data, as well as individual and collective rights. Challenges in this area will have far-reaching implications of a geopolitical nature for many governments worldwide.

Public policy of the future will have to develop proactive and reactive legislation (Berger-Walliser, Østergaard, 2012) that should keep pace with innovative solutions emerging in various economic sectors and public services. For example, physical and digital security standards should be continually updated to meet the changing needs of consumers.

Specific expectations of public authorities are also generated by the growing dominance of private enterprises, which by their nature focus on maximising profits rather than the well-being of citizens. Mitigating adverse effects of technological unemployment is one example. These expectations cannot be met by technology companies, as the policy tools and planning capabilities to contain mass unemployment, if it occurs, remain solely in the hands of government (Tan, Shang-su, 2017).

Rising public debt will likely make it much more difficult for governments to provide acceptable levels of public security while simultaneously expanding the range of public services. Additionally, it will increase pressure on governments to raise taxes and limit their capacity to address pressing social, economic, and environmental issues.

More evidence-based

Policy 4.0 is expected to be far more evidence-based than its current counterpart. This will be aided by the continued development of monitoring and data processing technologies such as sensor networks based on the Internet of Things, the Internet of Bodies, and AI-powered supercomputers. Policy 4.0 will be executed using sophisticated information resources gathered from numerous databases and integrated online. For several years, there has been a growing demand for high-quality, evidence-based policies based on accurate data and advanced analytics (KPMG 2016). The outcomes of this research will be used to identify issues of public concern, track policy implementation, and assess policies.

The post-truth pandemic, which promotes an emotive perspective of social reality and blurs the lines between fact and fiction, will be a barrier to the spread of evidence-based policy. The impact of this factor will be difficult to reduce due to its significant role in the political arena.

Less inert and more responsive

Policy 4.0 can be expected to be less inert and more responsive than the policies implemented so far. This will be fostered by Internet of Things and Internet of Bodies-based sensor systems integrated in networks with supercomputers collecting various data and analysing and processing them in real time based on algorithms. In this way, more and more Cyber-Physical Human Systems (CPHS) (Sowe et al., 2016) will be ‘communicating’ across space and time, and allowing other systems, devices, and data streams to connect and disconnect (Smirnov et al., 2014).

CPSs are used, among others, in transport, energy, environment, weather monitoring, and utility infrastructure management systems, whereas CPHSs are most commonly found in health and security. CPSs and CPHSs enable fast responses to requests for action, resulting in less inertia and more agile public policies.

Less democratic

The development of e-democracy and the digital tools used in this area not only can, but already has undermined the fundamental tenet of democracy, which is government for and by the people. A very serious and present threat is the prospect of skewing election results by exploiting vulnerabilities in voting machines, hacking electoral rolls, and using divisive propaganda or social media to question their validity (Unruh, Kiron, 2018).

A source of insightful and timely observations on the threats posed to democracy by the digital revolution is the report *Many Experts Say Digital Disruption Will Hurt Democracy* prepared in 2020 by the Pew Research Center and Elon University based on a survey of 979 technology innovators, developers, business and policy leaders, researchers and activists. According to the study participants, their greatest concerns about the future of democracy are due to the following (Anderson, Rainie, 2020):

- empowering the powerful – corporate and government agendas generally do not serve democratic goals and outcomes, but rather the goals of those in power,
- diminishing the governed – a lack of digital fluency and a high level of apathy among public procedures an ill-informed and/or dispassionate citizenry, weakening democracy and the fabric of society,
- waging info-wars – technology will be weaponised to target vulnerable populations and engineer elections,
- trust issues – the rise of misinformation and disinformation erodes public trust in many institutions,
- sowing confusion – tech-borne reality distortion is crushing already-shaky public trust in the institutions of democracy,
- weakening journalism – there seems to be no solution for problems caused by the rise of social media-abetted tribalism and the decline of trusted, independent journalism,
- responding too slowly the speed, scope and impact of the technologies of manipulation may be difficult to overcome as the pace of change accelerates.

Kevin Gross, one of the participants in the study, summarises his concerns: “Technology can improve or undermine democracy depending on how it is used and who controls it. Right now, it is controlled by too few. The few are not going to share willingly. I don’t expect this to change significantly by 2030. History knows that when a great deal of power is concentrated in the hands of a few, the outcome is not good for the many, not good for democracy” (Anderson, Rainie, 2020). A similar view of the future of democracy in the digital age is held by Y.N. Harari (2018): “Artificial intelligence could erase many practical advantages of democracy, and erode the ideals of liberty and equality. It will further concentrate power among a small elite if we don’t take steps to stop it”.

The emergence of legally and morally dubious Internet of Bodies technology raises serious concerns about the democratic nature of future public policies. Linking human bodies together and entwining them with bits, hardware, software, and algorithms puts existing social norms and values to the test, and it most importantly threatens human autonomy and people’s right to self-determination (Matwyshyn, 2019).

4.2. Theoretical concepts of Policy 4.0

The transformations unleashed by contemporary megatrends create a demand for theories in policy sciences that respond to the challenges facing public policies of the future. Here, only two theoretical fields will be identified, where the need to reflect on the validity of the theories and concepts is clearly visible.

Policy process

The development of CPSs and CPHSs offers a new perspective on the concept of the public policy process as a sequence of heuristic stages. Indeed, new technologies enable the integration of public policy analysis (diagnosis, selection, approval for implementation) with monitoring and evaluation, and thus their simultaneous performance in real time. In this way, ongoing monitoring of the implementation of various public policies by means of CPSs and CPHSs, thanks to their rapid and algorithm-based analysis, will inform each and every evaluation domain – from on-going and mid-term to ex-post and ex-ante. Consequently, due to the potentially unlimited number and frequency of iterations of public policy cycles (analysis-implementation-monitoring-evaluation), it will be possible to modify or update on the fly many parameters of Policy 4.0 automatically – read: without human intervention.

These developments will be extremely important in explaining the nature of the public policy process under Policy 4.0. The new technological capabilities of implementing public policies undermine not only the point of their axiological staging, but also the role of the human being as an indispensable participant in the activities undertaken at each stage of the process.

Public policy actors

Contemporary megatrends also prompt a rethinking of theories explaining the structures and roles of public policy actors. Technology corporations, which have traditionally been treated as interest groups vying for influence from the position of co-creators of the public agenda, are at the same time becoming key creators of the media agenda and, above all, co-creators of the political agenda, which until now has been the exclusive preserve of public authorities and other political circles. Large corporations' growing influence in each of the three fields is not only perceptible at the transnational and global policy level, but also at the nation-state level, and, in the case of the media agenda, whose proliferation through social media and ICTs is virtually unrestrained, at every level of public policy from local to global.

Another group of actors whose agency in public policy is steadily increasing are transnational and international political, military, economic and social organisations (e.g. EU, UN, NATO, WTO, WHO) and NGOs with a global reach. Like technology corporations, transnational and international organisations also co-create the political agenda, including at the nation-state level.

The rise of social diversity and individuality, which exacerbates social and political atomisation, provides additional justification for redefining the theory of public policy structures and actors. Both factors limit civic participation to collective political actions and, more importantly, impede the processes of developing public policy goals that have the capacity to unite increasingly diverse social groups.

The automation of public policy implementation processes also inspires reflection on the future of actors and decision-makers. The roles of political, administrative, and social agents in the implementation of public policies are clearly evolving – in the future, they will likely set the system parameters and supervise the implementation processes.

What appears indisputable, however, is the further entrenchment of network theory as fundamental to the overall theoretical concepts of the policy sciences explaining the implementation of public policies of the future. Nevertheless, in this area, the space for new analyses still remains open.

4.3. Policy 4.0 implementation practices

Contemporary megatrends have an impact on a wide range of detailed public policies. Let us review some examples of these policies using one of the traditional typologies, which divides them into substantive and procedural categories.

Substantive Policies 4.0

Substantive policies are concerned with the content of public policies and are implemented with the purpose of accomplishing specified objectives in specific areas of intervention (Birkland 2011). Starting from this definition, the totality of public policies implemented with the purpose of attaining the stated objectives in specific areas of intervention and informed by the hallmarks of Policy 4.0 will be called Substantive Policies 4.0.

The material scope of Substantive Policies 4.0 will be determined, above all, by specific public policies addressing the challenges posed by technological change. An attempt to identify such policies was made by a team of Brazilian researchers (Liao et al. 2018), who analysed the content of 18 4IR-related programmes prepared by the European Union and 17 highly industrialised countries in North America, Asia and Europe¹. These programmes included, among others, the US *Advanced Manufacturing Partnership* of 2011 and 2014, China's *Made in China 2025* of 2015, Germany's *Industrie 4.0* of 2013, and Mexico's *Crafting the Future* of 2016. The policies considered as key in the context of the new civilizational challenges (Liao et al., 2018) are as follows:

¹ These countries are: Canada, China, France, Germany, India, Japan, Malaysia, Mexico, Netherlands, Singapore, South Korea, Spain, Sweden, Taiwan, United Kingdom, and the United States.

- research and innovation – to develop cutting-edge technologies, enable interdisciplinary cooperation and create new industrial production testbeds,
- work, education and training – to organise and design work, instruct engineering students, and prepare skilled workforces,
- infrastructure modernisation – to support the digital transformation of small and medium enterprises and build best-in-class manufacturing infrastructure,
- business environment – to develop policies and provide preferential policies to support organisations that either embrace or are most impacted by the Fourth Industrial Revolution,
- reference architecture, standards, and norms – to standardise Machine-to-Machine communication and create new infrastructure for the manufacturing sectors,
- green manufacturing – to enable sustainable value networks and increase energy efficiency,
- legal framework – to protect Intellectual Property and data,
- security of networked systems – production data security and cyber security,
- internationalization – to promote international collaboration and create national production brands,
- industry showcasing – to promote national industrial excellence abroad.

Substantive Policy 4.0, exemplified by the concept of Education 4.0, is currently under examination regarding the necessary competencies, educational programs, and methods essential for future learning at all educational levels. There is a consensus among policymakers that existing education systems require modernisation, although approaches vary due to differing national educational frameworks, curricula, and teaching traditions. In higher education, policies are adapting to better align with the needs of future graduates, emphasizing flexibility, individualised learning, choice in study materials, project-based approaches, and field experiences. Key trends include the incorporation of e-learning, flipped classrooms, and adaptive technologies that cater to diverse abilities. Moreover, there is a shift from traditional memorisation to practical application in assessments, empowering students to take ownership of their learning journeys (Fisk, 2017).

As the exact consequences of technology development are difficult to predict, the role of the state will be to devise policies that reduce the uncertainty caused by the development of new technologies in the social, economic, political, and security spheres. These policies, without being tied to specific technologies, should respond to the following key concerns (Tan, Shang-su, 2017):

- social: income inequality, erosion of privacy,
- economic: technological unemployment, disruption of traditional business, monopolisation,

- political: increasing xenophobia, fomenting instability, leaking sensitive data abroad, becoming dependent on one or two sources of essential resources,
- security: citizens adopting alternative views, increase in online fraud, proliferation of weapons, digital sabotage, terrorism, espionage, human trafficking.

Procedural Policy 4.0

This group of policies provides a framework for the implementation of substantive policies and determine the mechanisms of action of public authorities in individual public policy areas (Birkland, 2011). They may include rules and technological solutions for e.g. administrative procedures, public procurement, consultation, and public participation.

The evolution of ICT and big data leads to modifications in numerous procedural regulations. A2A, A2B, and A2C public e-services require progressive digitalisation of administrative processes through the creation of public databases and registers, the streamlining of data exchange between public administration units and their clients, the reduction of processing times, and the limitation of abuse opportunities. Changes in internal procedures and administrative procedure codes in public organisations are prompted by new technology and affect case handling deadlines among other things.

ProZorro, Ukraine's electronic procurement system launched in 2016, exemplifies an innovative application of blockchain technology in Procedural Policy 4.0. It is a hybrid, public-private electronic system based on open source code. 'Hybrid' means that while all transactions take place in a central public database, any number of certified private marketplaces can interact with end-users, upload tender documentation, and support the tender process. All tender notices are available online without any restrictions as soon as they have been published. Once the tender is completed, all data are disclosed and made available online, and no registration or login is required to view it. Cooperation between companies, the state, and civil society that participate in the system guarantees independence and establishes a system of mutual checks and balances (Prozorro, 2021). The cost of implementing the system was approximately €4.69 million (Vissapragada, 2017), which does not seem excessive considering that the procurement market in Ukraine is worth approximately 15% of GDP (Kovalchuk, Kenny, Snyder, 2019).

The digital revolution is also driving change in many aspects of e-democracy. Its fundamental goal is to promote and develop democracy, democratic institutions, and processes through digital means. E-voting, such as e-elections and e-referendums, and various forms of e-participation, including e-complaints, e-consultations, e-discussions, e-legislation, e-petitions, and e-spatial planning, are just a few of the numerous instances of the application of information technology in the field of e-democracy. In the Council of Europe's *E-democracy Handbook* (Council of Europe, 2020), the number of listed e-democracy tools exceeds thirty.

5. Summary

Today's megatrends, as a vehicle for profound civilizational change, are global in scope and affect everyone. Technological developments are increasingly obliterating the borders that have hitherto separated the real and virtual worlds, nature and technology, humans and machines, and the public and private spheres. They also provide a strong impetus for changes in policy-making theory and practice, resulting in the emergence of Policy 4.0 as a new paradigm.

The paper presents arguments supporting the hypothesis that contemporary megatrends of a technological, economic, environmental, social, and political nature are changing the rules of public policy-making to the point where new public policy theories, collectively known as Policy 4.0, are required. As a result, the new detailed public policies will become: (1) more holistic and integrated, (2) more transnational and global, (3) more public-private, (4) more inclusive, (5) more personalised, (6) more oriented towards digitalised, automated, and robotic work, (7) more environment- and resource-oriented, (8) more urban and less territorially balanced, (9) more security oriented, (10) more evidence-based, (11) less inert and more responsive, and regrettably, (12) less democratic.

The emerging Policy 4.0's dilemmas, particularly those concerning the democratic nature of public policy in the digital age, public policy decision-making mechanisms implemented in an increasingly globalised world, and the agency and inclusiveness of actors in an increasingly fragmented public policy arena, appear to be its critical aspects that require further analyses leading to creative solutions.

Promising directions for advancing its conceptualisation also include the development of measurable criteria enabling empirical verification, as well as the construction of theoretical models that explain the causal mechanisms linking specific megatrends to transformations in policy-making processes. Advancing this line of inquiry requires moving beyond descriptive accounts toward more structured classifications and explanatory frameworks that clarify how and why particular megatrends influence institutional change, governance mechanisms, and policy outcomes.

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CYBERATTACKS ON BUSINESSES IN EU COUNTRIES – THE SCALE OF THE PHENOMENON AND ECONOMIC CONSEQUENCES

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Purpose: The aim of this article is to present the differences between EU countries in terms of the scale of cyberattacks on businesses in 2024 compared to 2022, considering various types of cybercrime. The dynamic development of technology and widespread digitisation has meant that companies in many countries are facing increasingly complex challenges in the area of cybersecurity. The consequences of cyber-attacks are multidimensional, including significant financial losses, serious operational disruptions such as downtime or data loss, and broad legal implications, including criminal liability of perpetrators but also civil liability of companies for data leaks.

Methodology: The scale of threats calculated as the change in the percentage of companies attacked by cybercriminals in 2024 compared to 2022. The data was obtained from the Eurostat database for the years 2022 and 2024. In a second step, EU countries were classified by the cyber-attacks on enterprises using a synthetic variable.

Findings: The synthetic variable effectively ranks countries in terms of risk levels, confirming the validity of the aggregation method used. The indicators analysed describe the percentage of companies experiencing specific forms of cyber-attacks (including phishing attacks, ransomware attacks, attacks on system availability and data breaches). Countries such as Denmark, Estonia and Latvia, with more developed cybersecurity policies, achieve better results in reducing the scale of cyber-attacks. In countries with lower synthetic variable values, such as Romania, Portugal and Bulgaria, it seems necessary to strengthen institutional support and intensify educational and investment activities in the area of corporate cybersecurity.

Practical implication: The countries exposed most at risk from cyber-attacks against businesses were identified. Countries where cyber threats have been significantly reduced were also presented. Countries with high synthetic variable values are characterised by significant percentage decreases in most of the analysed indicators, demonstrate high effectiveness of their cybersecurity strategies, and may serve as a benchmark for other countries in terms of protecting the digital infrastructure of enterprises.

Social implication: The article also highlights the costs incurred by companies, including social costs. These are related, among other things, to the disclosure of confidential data, loss of employment or financial resources.

Originality/value: The article deals with a very topical threat that is constantly growing. It lists the countries where companies are most vulnerable to cyberterrorist attacks. It also indicates the costs incurred by companies as a result of cyberattacks.

Keywords: cyber-attacks, financial consequences, operational consequences, legal consequences, hacking, cybercrime.

Category of the paper: research paper.

1. Cyber threats in today's business environment

The growing importance of cyberspace in society has brought about many changes on various levels. Companies have gained new distribution channels; public institutions have simplified numerous procedures for businesses and moved the application process online. We can shop, play the stock market, have psychotherapy sessions and even run a business on the internet. This new space has also opened up new opportunities for dishonest people. On the Internet, we encounter people who spread fake news, gain access to other people's data, and appropriate many goods belonging to others. Cybercrime is becoming more sophisticated every year, aided by the development of new mechanisms such as artificial intelligence and the refinement of old methods such as phishing.

People acting illegally or on the fringes of the law in cyberspace, who are one of the main threats to organizations, are recognized by the general public as hackers. Initially, the term 'hacker' did not have negative connotations, referring to people with high technical skills who pushed the boundaries of technology. As Majewski points out, hackers are a group of intelligent professionals specializing in a specific field, 'experts in programming and solving computer problems (Majewski, 2019). However, in common usage today, the term has an extremely pejorative meaning and is equated with "criminal" or 'computer burglar'.

The number of hackers is constantly growing, and research conducted in 2018 on a group of 169,827 respondents showed that over 90% of hackers are usually people under 35 years of age (over 90%), and 45.3% are between 18 and 24 years old. The main motivations for hackers include the desire to earn money (13.1% of respondents), the desire to learn (14.7%), meeting challenges (14%), fun (14%), the need to prove their skills (3%), career development (12.2%), helping others (8.5%), changing the world for the better (10%) and protection and defense (10.4%) (Fig. 1).

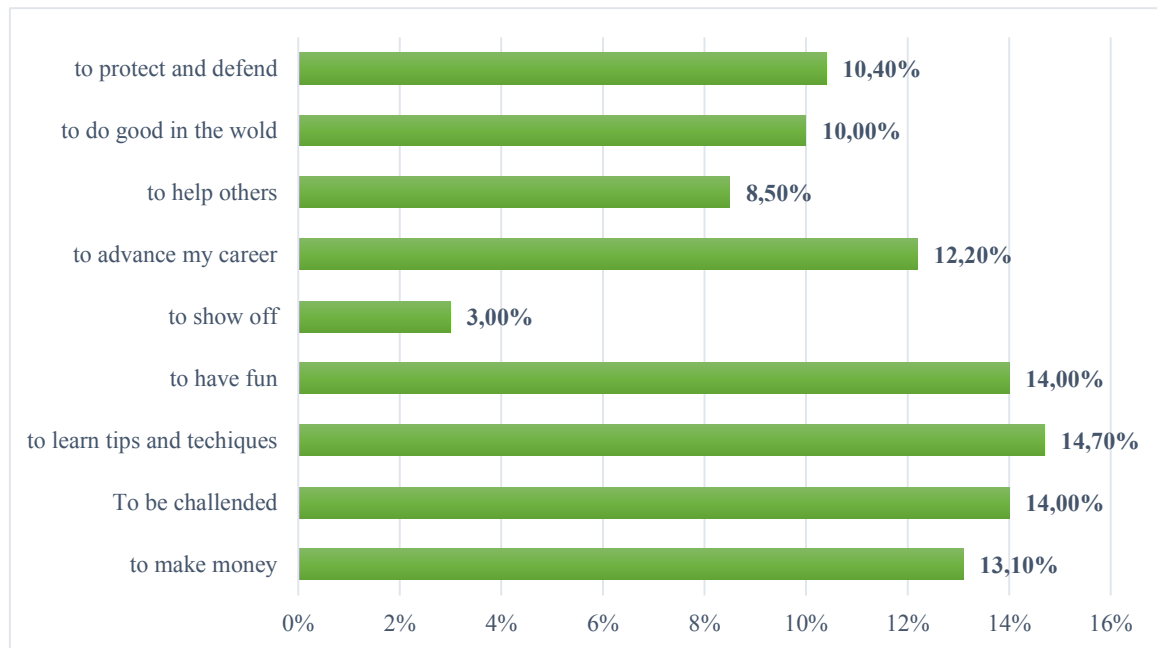


Figure 1. Hackers' main motivation.

Source: Hacker report, 2018, <https://ma.hacker.one/rs/168-NAU-732/images/the-2018-hacker-report.pdf>, 13.08.2025.

Hacker activities are harmful to both individual citizens and enterprises operating in all sectors of the economy. The purpose of the diagram (Fig. 2) is to present the main categories of threats in cyberspace, broken down into technical, organisational and human factors.

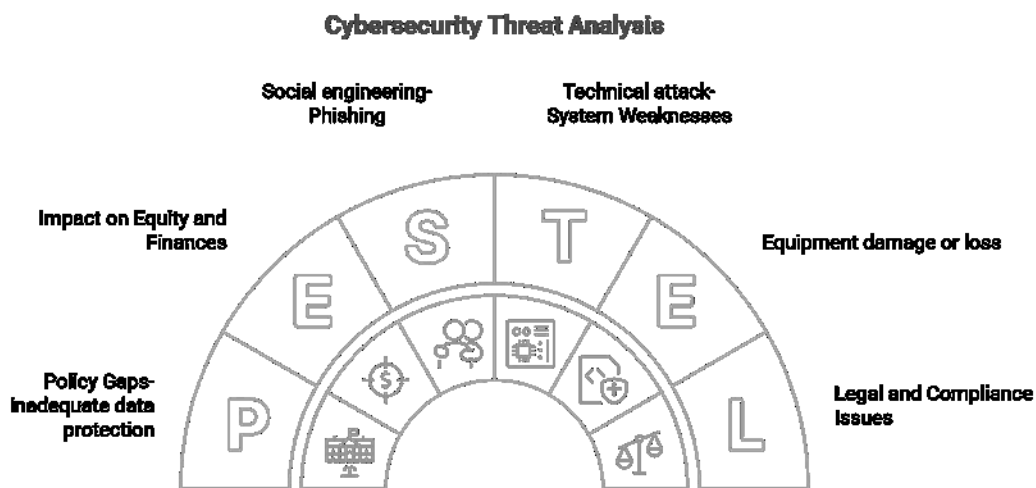


Figure 2. Cybersecurity threat analysis.

Source: Own study.

Among the most common difficulties caused by hackers are disruptions and downtime. Cyberattacks lead to significant disruptions and downtime in the daily operations of businesses. Another significant problem is data theft and sabotage (Fig. 2). Hackers can gain access to internal company information. This also applies to identity theft, installing spyware, sending viruses and destroying computer equipment. Examples include attacks on personal databases. Companies that store personal data of customers are vulnerable to attacks. There have been

cases where hackers have gained access to systems that are an integral part of equipment (e.g. for X-ray examinations) and devices containing personal databases of patients (e.g. for registration purposes). One way to attack a company's software is to infect its systems. Malware (viruses, worms, Trojans, backdoors, exploits, ransomware) can be spread by running an infected program, game, file, email attachment (including spam), and even through Trojan downloaders or botnets.

One of the most popular methods of attack is phishing and social engineering. Cybercriminals impersonate trusted institutions, companies, and even popular applications (e.g., WhatsApp) to steal data, passwords, or persuade users to install malicious software. These activities are often transferred to social media. Therefore, it is important to identify the scale of the phenomenon and monitor changes resulting from actions taken by companies.

2. Materials and Methods

The scale of cyber threats to businesses in EU countries was assessed based on annual data from 2022 and 2024. Four indicators were selected for analysis (Table 1).

Table 1.

Indicators describing the scale of cybercrime against businesses in EU countries

Variable	Full name
W_1	changes in the level of risk due to the loss or damage of confidential data [%]
W_2	changes in the level of risk due to phishing or pharming [%]
W_3	changes in the level of risk due to infection of malicious software [%]
W_4	changes in the level of risk due to ransomware attacks [%]

Source: Own study based on Eurostat. Available online: <https://ec.europa.eu/Eurostat>, 15 December 2025.

Their selection was preceded by a review of the literature, data availability, and statistical analysis (Table 2).

Table 2.

Basic numerical characteristics of indicators describing changes in cyber threats to businesses in EU countries in 2024 compared to 2022

Variable	min	max	mean	SD*	CV**	As
W_1	-26,27	42,51	-1,65	16,48	10,00	0,91
W_2	-53,93	78,13	13,51	37,68	2,79	-0,19
W_3	-53,54	91,67	-8,49	28,10	3,31	1,68
W_4	-29,74	79,47	-1,20	21,54	18,01	1,83

**CV – coefficient of variation, SD* – standard deviation.

Source: Own study based on table 1.

The greatest variation among the EU countries presented in the analysed period was in terms of the changes in the level of risk due to ransomware attacks indicator (Table 2). In 2024, compared to 2022, the coefficient of variation for this feature for EU countries was 180.1%. There are countries where companies have managed to reduce the threat posed by ransomware attacks in 2024 by as much as 30% compared to 2022. There are also countries where the scale of the threat posed by these attacks has increased by almost 90% over the two years analysed.

The most favourable changes in reducing cyber-attacks occurred in the case of infection of malicious software (W_3). In companies from the analysed countries, this represented an average decrease of 8.49%.

The largest increase in risk was caused by the W_2 indicator, changes in the level of risk due to phishing or pharming in the average increase was 13.51%.

The highest asymmetry coefficient was observed for indicator number 4 (1.83), which indicates that the list includes countries where companies observed an above-average increase in risks resulting from ransomware attacks.

In order to present the overall changes in the scale of the analysed threats in 2024 compared to 2022, directed against enterprises in EU countries, a synthetic index has been prepared.

This synthetic indicator for assessing the economic situation of enterprises in EU countries was prepared for each country in each year surveyed, it was determined according to the formula (Hellwig, 1968).

$$Q_i = \sum_{j=1}^n z_{ij} \quad (1)$$

where: Q_i - Synthetic indicator of cyber threat growth in EU countries in 2024 compared to 2022.

Due to the fact that the selected indicators are destimulants for determining the synthetic variable, the normalizing formula proposed in the MUZ method was used.

$$z_{ij} = \frac{\max x - x_i}{\max x - \min x} \quad (2)$$

Normalized value for i – indicator for j country.

The highest value indicates the best object in terms of the phenomenon under study.

The values of the synthetic measure allowed the objects under study to be divided into groups according to the following principle:

group I (very high level): $Q_i \in (\bar{Q} + S_Q; \max_i Q_i]$,

group II (high level): $Q_i \in (\bar{Q}; \bar{Q} + S_Q]$,

group III (medium level): $Q_i \in (\bar{Q} - S_Q; \bar{Q}]$,

group IV (low level): $Q_i \in [\min_i Q_i; \bar{Q} - S_Q]$,

where $\bar{d}$, S_d - the arithmetic mean and standard deviation of the values, respectively

Q_i defined according to the formula (1).

3. Results

Indicators: W_1 ; W_2 ; W_3 ; W_4 are destymulants, hence the rankings of countries by indicator values in 2024 compared to 2022 are presented in descending order in figure 1. High indicator values indicate that countries in 2024, compared to 2022, have reduced the scale of threats caused by cybercrime.

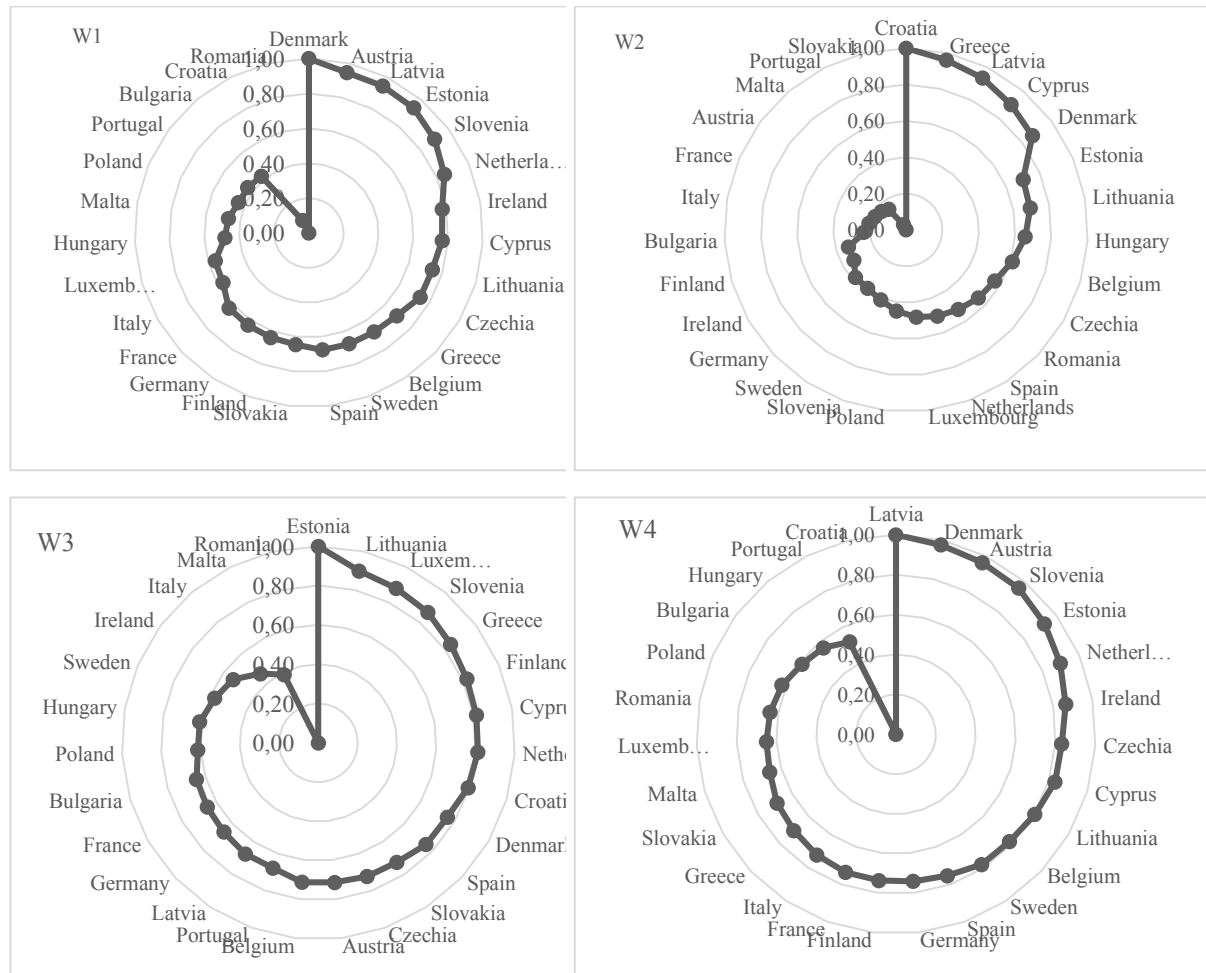


Figure 2. Rankings of EU countries according to standardized indicator values in 2024 compared to 2022.

Source: Own study based on designations as in Table 1.

The first indicator (W_1) describes ICT security incidents leading to: ICT service unavailability, data destruction or damage, and disclosure of confidential data. Changes in this indicator are most unfavorable in Romania, Croatia and Bulgaria (Fig. 2). The scale of this threat in 2024 compared to 2022 increased for companies operating in these countries by 42.51%, 37.01% and 13.31%, respectively. Eighteen countries have managed to reduce the scale of such cyberattacks. The most favourable changes were seen in Denmark (-26.27%), Latvia (-22.43%) and Austria (-22.58%).

The threat posed by pharming, phishing attacks (W_2), and actions by own employees (intentionally or unintentionally) increased in 18 countries. The largest increases were in Slovakia (78.13%), Portugal (73.85%) and Malta (58.50%). The most significant improvements in reducing phishing and pharming attacks were seen in Croatia, where the number of attacks on businesses fell by more than half (53.93%), as well as in Greece (48.72%) and Latvia (45.52%).

Threats due to infection by malicious software or unauthorized intrusion, hardware or software failures (W_3) in 2024 compared to 2022 have been reduced in companies in 20 countries. The scale of this phenomenon has been significantly reduced in Estonia (by 53.54%), Lithuania (38.81%) and Luxembourg (36.13%). Cybercrime has increased significantly in Romania (91.67%), Malta (35.27%) and Italy (25%).

In 16 countries, the scale of threats related to ransomware attacks, hardware or software failures increased (W_4). The largest increase in the number of threatened companies was in Croatia (79.47%), Hungary (17.13%) and Portugal (22.89%). In Denmark, Latvia and Austria, on the other hand, the scale of threats affecting companies decreased by 27%, 29.74% and 25.62%, respectively.

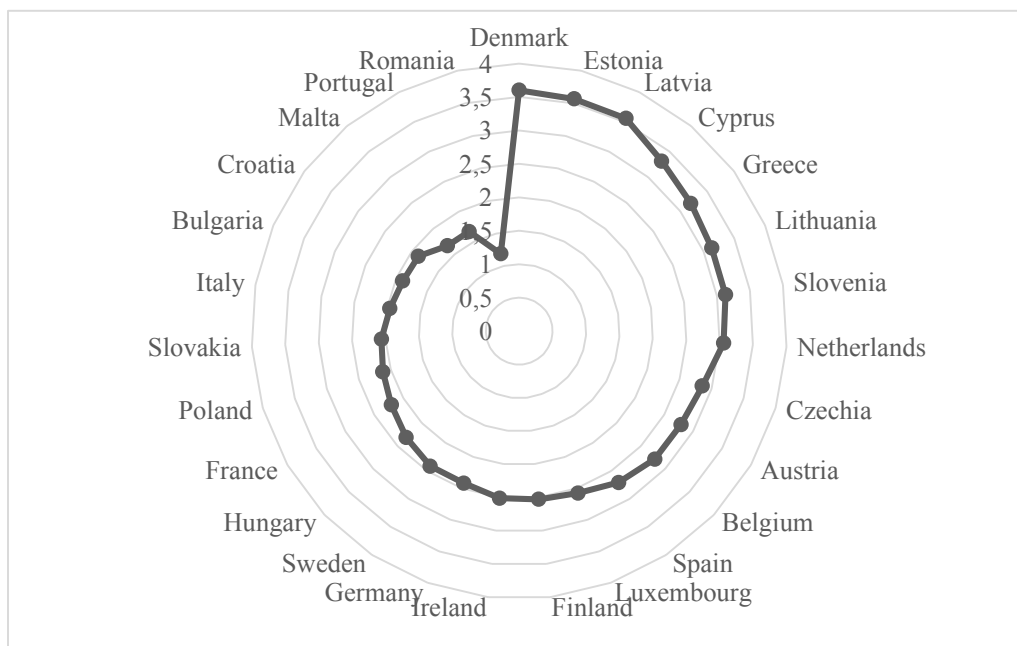


Figure 3. Rankings of EU countries by indicator value Q_i in 2024 compared to 2022.

Source: Own study based on Eurostat.

Countries such as Denmark, Estonia and Latvia are characterised by relatively high synthetic variable values. This means that companies in these countries have effectively reduced the scale of cyber-attacks in 2024 compared to 2022 (Fig. 3). These countries can be considered leaders in improving cybersecurity, which may be due to advanced protection systems, a high level of threat awareness and stable institutional frameworks.

In contrast, Romania, Portugal, Croatia and Bulgaria achieve relatively low synthetic variable values. This indicates the limited effectiveness of measures taken by companies to reduce cyber threats. In these countries, the level of risk has remained high or has only decreased slightly, and in some cases has even increased.

Cyberattacks cause many adverse situations for businesses. Therefore, the costs and losses associated with hacker activity can be divided according to various criteria. Below are some of them that are often cited in the literature on the subject.

4. The financial consequences of cyber-attacks for businesses

In the literature on the subject, the costs associated with cybersecurity and the consequences of data breaches are classified according to several complementary models that allow organizations to analyse risks and plan expenditure more accurately.

The most common division is into three main categories:

- **Direct costs:** These include measurable expenses incurred to ensure protection and repair damage after an attack. They include the purchase and maintenance of protective technologies (antivirus software, firewalls, intrusion detection systems), legal fees, the cost of recovering lost data, and expenditure on audits and certification of compliance with standards (Wygodny, 2021). In the event of a data breach, this group also includes the costs of protecting the identity of affected consumers and financial compensation (Dymek, 2024).
- **Indirect costs:** These relate to preventive and operational activities that are not the result of a specific incident but are necessary for the functioning of the security system (Korszewski, Oreziak, Wielec, 2021). These include employee training, cyber insurance premiums, specialist consulting and the remuneration of personnel responsible for cyber security (Pelc, 2021).
- **Hidden (or opportunity) costs:** These are the most difficult to estimate, but can have the most devastating impact on a company in the long term (Fuksiewicz, 2023). They include loss of reputation and customer trust, disruption to operations, lost contract revenue, brand devaluation, and loss of intellectual property. Nakashima and Robertson, referring to Sony's PlayStation data breach in April 2011, commented that the costs can be significant in terms of damage to a company's reputation (Nakashima, Robertson, 2011). Ash Raghvan (Deloitte, 2016) points out the non-obvious and long-term effects of attacks, which are difficult to estimate. Liu and Kuhn, on the other hand, argue that: 'Depending on the type of data loss that has occurred, an organization may experience different types of consequences, but in almost all cases these include both financial costs and reputational costs' (Liu, Kuhn, 2010).

Deloitte, on the other hand, divides the costs resulting from a cyberattack into ‘above-the-surface’ (better known as the costs of cyber incidents) and ‘below the surface’ costs (hidden or less visible costs) — a total of 14 categories (Deloitte, 2016), as presented in Table 2. Classification according to the ‘Iceberg’ model (Deloitte). The literature also cites a model that divides costs into those that are visible ‘above the surface’ and those that are hidden ‘below the surface’.

- Above-surface costs: Well-known expenses such as technical investigations, notifying customers of the breach, and public relations costs.
- Below-the-surface costs: Long-term effects, including increased external financing costs, loss of customer relationships, and loss of competitive advantage.

Table 1.

Sharing of costs incurred by businesses in connection with cyber attacks

Above-surface costs	Below-the-surface costs
Conducting a technical investigation	increase in insurance premiums
Notifying customers of the breach	increase in debt costs
Protecting customers after the breach	effects of reduced operational activity or destruction
Compliance with regulatory requirements	lost value of customer relationships
Public relations costs	value of lost revenue
Legal advisory fees and court costs	devaluation of the company's reputation
Improving cybersecurity	loss of intellectual value

Source: Study based on Krawczyk-Jezierska, 2016.

The structure of these costs can be compared to an iceberg: expenditure on software or legal assistance is only the tip of the iceberg visible above the water, while beneath the surface lie much more powerful and difficult to measure losses, such as damaged reputation or loss of market advantage, which can ultimately lead to the sinking of the entire organization.

The International Monetary Fund (IMF) and consulting firms propose dividing costs according to the stage of the organization’s activities, distinguishing between costs before and after a cyberattack. This division further distinguishes between the preventive phase and the associated cybersecurity costs:

1. Preventive phase: Costs of ongoing system maintenance and compliance with legal requirements.
2. Reactive (immediate) phase: Expenses for stopping the attack, technical investigation and informing victims.
3. Impact Management: Short-term costs of data recovery and handling legal claims.
4. Business recovery and repair: Long-term investments in new processes and systems and dealing with lower demand for the company's services after the incident. The financial losses resulting from cyber-attacks are enormous and are growing steadily.

In order to prevent cyber-attacks, companies should take a number of measures, including the following.

5. Preventing and managing the risk of cyber-attacks in businesses

Effective prevention of cyber-attacks requires a comprehensive approach, including both preventive and intervention measures. It is necessary to educate people about social values and skills, as well as how to use digital technology, recognize threats and prevent them. Such training should be mandatory. For companies, this also means raising employee awareness about phishing and other social engineering attacks.

In terms of technological security, it is important to install antivirus software and a firewall, and to regularly check the status of antivirus software installations and updates on all devices connected to the network. The operating system, web browsers and other programs should be updated regularly.

Employees and users should use strong and unique passwords. You should set complex passwords yourself, change them regularly and not use the same password for multiple accounts.

Employees should not open suspicious emails, click on links, open attachments from unknown senders, install software from unknown sources, or visit websites with illegal content. It is important to make regular backups of company files.

Employees should also minimize use of open Wi-Fi networks and, when using them, do not share sensitive data or logos.

6. Conclusion

In the face of rapid technological development and widespread digitalization, businesses in countries are facing increasingly complex challenges in the area of cybersecurity. The consequences of cyberattacks are multidimensional, including significant financial losses (amounting to trillions of dollars globally), serious operational disruptions (downtime, data loss) and broad legal implications (criminal liability of perpetrators, civil liability of companies for data leaks).

Available sources emphasize that despite the growing threat, many companies still do not treat cybersecurity as a priority, allocating negligible resources from their IT budgets and lacking adequate response procedures. Low awareness among users (both company employees and the general public) of basic threats such as phishing and malware further facilitates the activities of cybercriminals.

Negative percentage changes indicate a decrease in the percentage of companies affected by cyber-attacks, which should be interpreted as a positive effect of protective measures. Positive values indicate an increase in the scale of attacks and, consequently, a deterioration in

the cybersecurity situation. Significant percentage decreases are observed in many countries, which may indicate the implementation of more advanced protection systems, increased employee awareness, and more effective implementation of EU regulations (e.g. the NIS Directive).

The synthetic variable was constructed as an aggregate of standardised percentage changes in partial indicators (W1-W4). The higher the value of the synthetic variable, the greater the degree to which cyber-attacks have been mitigated by enterprises in a given country. In methodological terms, it serves as a synthetic measure of the effectiveness of companies' preventive and adaptive measures against cyber threats.

Countries with high synthetic variable values are characterised by significant percentage decreases in most of the analysed indicators, demonstrate high effectiveness of their cybersecurity strategies, and may serve as a benchmark for other countries in terms of protecting the digital infrastructure of enterprises.

The results confirm that the level of cyber threats is not uniform across Europe. Countries with a higher level of digital development, such as Denmark, Estonia and Latvia, with more developed cybersecurity policies, achieve better results in reducing the scale of cyber-attacks. At the same time, high exposure to digital technologies means that even in these countries, threats remain a significant challenge. In countries with lower synthetic variable values, such as Romania, Portugal and Bulgaria, it seems necessary to strengthen institutional support and intensify educational and investment activities in the area of corporate cybersecurity.

Effective defense against cyberattacks requires a comprehensive strategy that combines education at all levels (from the youngest users to company management), the implementation of advanced technological security measures, and the development of clear incident response procedures. It is also necessary to increase cooperation between companies, law enforcement agencies and service providers in order to build a more resilient digital environment and minimize the negative effects of cybercrime. Without these measures, the operational, financial and legal risks for businesses will continue to grow.

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