SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2024
ORGANIZATION AND MANAGEMENT SERIES NO. 209

PREDICTING THE DEVELOPMENT OF GENERATIVE ARTIFICIAL INTELLIGENCE IN INDUSTRY

Natalia STURGULEWSKA[1*], Katarzyna HALICKA[2]

[1] Bialystok University of Technology; natalia.sturgulewska@pb.edu.pl, ORCID: 0009-0000-5145-6938
[2] Bialystok University of Technology; k.halicka@pb.edu.pl, ORCID: 0000-0001-6370-8995
* Correspondence author

Purpose: The aim of this article is to attempt to predict the development of generative artificial intelligence in industry.
Design/methodology/approach: The study uses a foresight approach with a scenario methodology. It includes literature and industry document analysis to identify key factors influencing GAI development. A survey of academic and industry experts highlighted two main driving forces, and scenario method steps were applied to explore alternative futures.
Findings: The study concluded that the advancement of AI technologies and the establishment of social trust are fundamental to the future of GAI in industry. The scenarios developed illustrate the manner in which distinct combinations of these factors can affect the pace of implementing GAI in industry.
Research limitations/implications: The scenarios, based on expert opinion, limit generalizability. Future research could use quantitative methods, empirical data, or study public trust and ethics in GAI over time.
Practical implications: The results suggest that GAI can improve industrial efficiency, but requires investment in model transparency and data security. Appropriate regulation is also needed to enable the safe and ethical integration of GAI.
Social implications: The development of GAI will affect privacy and the labor market, and a lack of social trust may limit its development. Companies must consider social responsibility to minimize ethical and environmental risks.
Originality/value: The study presents scenarios highlighting the role of social trust and technological progress, offering value to researchers and practitioners planning long-term GAI implementation.
Keywords: generative artificial intelligence, technological foresight, industry, scenarios.
Category of the paper: Research paper.

1. Introduction

Current times are characterized by a significant increase in the impact of technology on people's lives. One of the most exciting technologies is artificial intelligence, which is present in most spheres of our lives – we find it not only in complex computer systems and robots, but also in washing machines and smartphones (Bieroński, 2020). However, many researchers note that the development of AI is challenged by the presence of ethical issues related to, among other things, taking responsibility for the results of AI activities (Stylec-Szromek, 2018) and the surveillance of society (Sroka, 2019). According to the 2019 survey, Poles have many concerns about the performance of AI. More than 60% of respondents indicated that citizens' privacy is their biggest concern related to the spread of AI. The second-biggest concern of respondents was an increase in unemployment, which was indicated by more than 40% of them (Nask, 2019).

In industry, artificial intelligence is used to optimize production processes, among other things. By monitoring real-time data, AI can suggest various types of improvements. Additionally, it is used in the maintenance of a production plant. AI systems support predictive maintenance by anticipating potential failures and detecting all kinds of machine irregularities and suggesting, for example, the replacement of appropriate parts. Furthermore, AI in industry is also used for inventory management, as it helps to avoid shortages and downtime by monitoring stock levels and demand (Korbiel, Czerwiński, Kania, 2023). However, in industry, as in other sectors, it is important to look at technology development from a long-term perspective. For this purpose, Future-Oriented Technology Analysis (*FTA*) is used, which, among other things, enables an organization to prepare for future changes and challenges and to make appropriate decisions related to investing in the most influential technologies. One of the techniques used in FTA is technology foresight, which could be defined as an evaluation and examination of the influence of current technological developments on society (Halicka, 2016).

Despite the growing body of research on artificial intelligence, the specific pathways and development trajectories of Generative Artificial Intelligence within the industrial context remain underexplored. Existing literature often focuses on the technical capabilities of AI systems or their broad societal implications, leaving a gap in understanding how GAI can be effectively integrated into industry while addressing its ethical, environmental, and socioeconomic dimensions. This study seeks to address this gap by adopting a scenario-based approach to predict the development of GAI in industry, identify the factors driving its growth, and provide actionable recommendations for its responsible and effective implementation.

The increasing importance of GAI necessitates a comprehensive understanding of its potential and the challenges it presents. By examining the interplay between technological advancements, public trust, regulatory frameworks, and ethical considerations, this study aims to contribute to the discourse on fostering balanced and sustainable AI development. The findings are intended to serve as a valuable resource for researchers, policymakers, and industry practitioners striving to harness the transformative potential of GAI while mitigating its risks.

2. Literature review

One of the landmark events in the history of artificial intelligence was the Turing Test conducted in 1950. Its author, A. Turing, stated that if a machine is able to carry on a conversation indistinguishable from that of a human, then that machine can be considered intelligent. The Turing Test is considered the first major suggestion in the philosophy of artificial intelligence (Skalfist, Mikelsten, Teigens, 2020). However, its actual beginning is considered to be a conference that took place at Dartmouth in 1956. Its organizers – J. McCarthy, M. Minsky, N. Rochester and C. Shannon – described a project to create artificial intelligence (*AI*). Their main goal was to make a machine behave in a way that could be called intelligent if a human behaved that way (Berente et al., 2021). Although artificial intelligence emerged as early as 1956, it developed slowly due to immature computing technologies (Szpilko et al., 2023). Over the following decades, the term has been defined by various researchers, but still no single, agreed and consistent definition of artificial intelligence has been developed (Holmes, Tuomi, 2022).

One example of AI definition, provided by researchers N. Berente, B. Gu, J. Recker and R. Santhanam, represents AI as a process rather than as a phenomenon in itself. In their definition, artificial intelligence is the frontier of computational progress, which refers to human intelligence in solving increasingly advanced decision-making problems. It thus represents what humans do next in terms of data processing. The researchers also add that artificial intelligence is not a single recognizable thing, a set of tools, a device, a program or an algorithm. Rather, it is an idea, a concept that reflects a constantly evolving phenomenon (Berente et al., 2021).

Artificial intelligence is a multidisciplinary field, which means that many disciplines are related to it and contribute to its development. These include mathematics, biology, psychology, computer science, electronics, computer engineering or linguistics, among others (Arias, 2022; Siuta-Tokarska, 2021). Taking that into consideration, the definition that, according to the authors, best captures the essence of artificial intelligence in the context of considerations related to the topic of the paper is the one describing AI as the ability of a system to accurately

interpret external data, learn from it and use the resulting conclusions to accomplish specific objectives through flexible adaptation (Haenlein, Kaplan, 2019).

The field of AI encompasses a multitude of subfields. It is essential to recognize that AI pertains to the creation of intelligence that is not natural, or the emulation of human intelligence through computer programs. Given the multifaceted nature of intelligent behavior, AI is similarly characterized by a multitude of subfields. The principal subfields include machine learning, natural language processing, expert systems, computer vision, and robotics. It is noteworthy that these subfields are not mutually exclusive, with frequent interconnections between them (Arias, 2022).

One subfield of artificial intelligence is generative artificial intelligence (*GAI*) is focused on developing systems that are capable of generating original and creative outputs, including images, music, text, and other forms of content. By employing deep learning techniques, particularly generative models, these systems are able to produce content that is comparable to that which is created by humans (Ramdurai, Adhithya, 2023).

Generative artificial intelligence models can be divided into two main categories: unimodal and multimodal. Unimodal models are designed to process instructions of a single input type, for instance text-to-text. In contrast, multimodal models are capable of integrating data from multiple sources, enabling the generation of outputs in diverse formats. Multimodal models are applicable to a range of data modalities, including text-to-image, image-to-audio and so on (Feuerriegel et al., 2024).

The GAI models can use a variety of data processing techniques. These include, for example, Generative Adversarial Networks (*GAN*), Generative Pre-trained Transformer (*GPT*), Generative Diffusion Model (*GDM*) (Jovanovic, Campbell, 2022), Variational Autoencoders (*VAE*) and Convolutional Neural Networks (*CNN*) (Yu, Guo, 2023).

Generative adversarial networks are based on the training of a pair of networks. In essence, one network can be conceived of as an art forger, while the other can be regarded as an art expert. In this context, the former is referred to as a generator, which strives to create images that are as realistic as possible. In contrast, the expert network, which is referred to as the discriminator, compares the images created by the generator with authentic images and attempts to distinguish between them. The two networks are trained concurrently, engaging in a competitive process. The generator is unable to access the real images directly, therefore its sole method of learning is through interaction with the discriminator. The expert network receives an error signal indicating whether the image is generated or genuine. When the discriminator's performance is at an satisfactory level, it is possible to halt training of the discriminator, while continuing to develop the generator (Creswell et al., 2018).

Another type of GAI model is GPT, which is one of the deep learning models. This model is pre-trained on large text datasets and uses a self-attention mechanism. Thus, it is able to take into account the context of the entire sentence to generate the next word. This improves the

qualitative capabilities of the model, which can be adapted to specific tasks such as language generation, text classification or machine translation (Yenduri, 2024).

The diffusion model has recently emerged as a technique that has gained considerable popularity. The operation of such models is based on three fundamental steps. At the outset, the user inputs prompts, which may be keywords or a textual description of the desired image. Based on these inputs, the model retrieves images from the Internet or from a previously defined dataset. Next, random noise is added to mask the selected information in the image, thereby creating a variation. Finally, a diffusion process is carried out to produce new images that conform to the user's prompts. Each image created in this way is original, because even if the same prompts are entered, the model will randomly select images from the database, making further changes to them (Zhang, Liu, 2024).

Different types of models are used in many practical GAI solutions, i.e. in systems and applications such as ChatGPT or Midjourney (Hwang, Chen, 2023).

ChatGPT is a widely used generative artificial intelligence chatbot. To interact with this tool, the user poses questions to the model, which responds in a conversational manner. The model's responses are designed to appear realistic, for instance, by acknowledging mistakes or declining to answer inappropriate questions. Additionally, the generated content can assume various forms, including news articles, film scripts, software codes, business plans, and poetry (Budhwar et al., 2023). ChatGPT was created by OpenAI, basing the tool on a deep learning model that was trained on a large data set. As a result, it understands the context of the entire conversation and adapts responses in terms of the use of appropriate language and style (Deng, Lin, 2022). ChatGPT reached the one million user threshold in five days and is now estimated to be used by around one hundred million people, generating one billion visits per month (Baytak, 2024).

Midjourney is a text-to-image generator that employs a diffusion model. The model generates four initial images based on user-entered prompts, such as keywords and specific parameters. Subsequently, it is possible to generate additional images based on the same prompts or adjust them to achieve needed results. The system offers the capacity to generate images in a diverse array of styles, including vintage, or in styles associated with a particular artist. Moreover, Midjourney possesses the capability to manage scenes comprising multiple objects and characters (Zhang, Liu, 2024).

Regardless of the system type, the prompt entered by the user plays a pivotal role in the system's operation. The prompt is the starting point for the model that generates the response and is therefore a key factor in determining the accuracy and value of the result. The process of providing clear, purposeful and effective prompts to GAI models is known as prompt engineering. Its aim is to develop instructions and commands in such a way as to lead to the generation of content that meets the needs of the user (Ekin, 2023).

A correct prompt should contain four key elements: role, task, output and context. The role is one of the most important elements of the prompt. It is intended to provide the model with the perspective in which it should place itself. For example, phrasing the role as ‘recruitment expert’ suggests that the response generated should have professional overtones and be oriented towards the area of human resource management. The second aspect of the prompt is the task, i.e. specifying precisely and clearly what the model is supposed to generate. Then, the prompt should include the context, which is any additional information that may influence the receipt of a more precise answer. The fourth element of the prompt is the output. Its inclusion is optional and depends on the topic being addressed. The output may specify a particular format, language or structure of the answer. Understanding and incorporating these elements into the creation of the prompt is essential to receiving a correct and valuable answer (Ministerstwo Cyfryzacji, 2024).

Many different applications of generative artificial intelligence can be found in the literature. Some industries are using GAI widely, while some are only just identifying areas where performance can be improved by such models. Nevertheless, they are attracting an increasing number of specialists from a variety of backgrounds.

For instance, GAI is used in education, where several applications can be distinguished. The first example is an intelligent learning system that can generate personalized learning plans. It automatically adapts the content of the course and its difficulty by offering tasks that are suitable for a specific user. An intelligent tutoring system can operate on a similar principle, but in addition it suggests learning strategies based on the student's learning habits and needs. Based on its results, the system creates assignments and practice questions. Another example is a homework assessment system that allows not only checking the correctness of the completed assignment, but also generates feedback and suggestions to enable students to understand their mistakes. A final example is an intelligent speech interaction system that, by analysing historical data and continuous learning, creates a knowledge base and algorithm model, thus achieving intelligent speech recognition and synthesis. The learner communicates with the system through voice by asking questions and expressing their needs, and the system recommends resources for learning and practice (Yu, Guo, 2023).

Additionally, GAI is applied in the quality control process, which becomes more accurate and efficient. The tool detects defects, anomalies or deviations from the accepted quality standard and then reports them in real time, reducing the risk of a defective product being delivered to the customer. Furthermore, by analyzing historical data, GAI can predict potential defects before they occur. By having this type of information, manufacturers are able to take proactive action to prevent a problem from occurring (Doanh et al., 2023).

Generative artificial intelligence can also be used in the field of agriculture and environmental protection. Chatbots are not only able to spread information on pest control, effective irrigation methods and other sustainable farming techniques, but are also able to analyze data on soil quality, weather patterns and crop condition. All of these tips are valuable

for increasing yields and reducing wastage. Specialized systems trained in this area, can analyze extensive biological data and identify endangered species and habitats, promoting responsible land use and biodiversity conservation (Rane, 2024).

An interesting example of the use of GAI is the creation of digital twins and avatars, such as Eva Herzigová's 3D avatar. Generative artificial intelligence is able to generate, among other things, photorealistic animation of body movement and texture and motion animation of clothing (Lăzăroiu et al., 2024).

GAI tools are also used in the marketing industry. Specialists use both widely known models such as ChatGPT or Midjourney, but also those created specifically for marketing purposes. Generative artificial intelligence is used, among other things, to personalize content. For example, banks use it to analyze customer data, including their risk profile, and offer personalized investment advice. Retailers, too, use GAI to create recommendations that would influence customers to buy more products (Kshetri, 2024).

GAI is also used in medicine. Singh points out that it significantly improves diagnostic processes, for example in hospitals. This is because the technology is able to transform low-quality scans into highly detailed, high-resolution images. Additionally, models trained on large medical datasets can detect anomalies and identify the early stages of various diseases. Currently, algorithms are successfully diagnosing conditions such as skin cancer, hidden bone fractures and Alzheimer's disease. In addition, the use of GAI provides quick access to answers to medical queries. Instead of searching for information in textbooks, the doctor asks the system a question, which by processing huge amounts of data generates an answer in a short period of time (Singh, 2023). This can be particularly useful for staff who are not fluent in English, as many documents on medical advances are written in that language (Ooi et al., 2023).

The existence of such a large number of models, various systems that are applied in a variety of fields, is testament to the significant advancements made in generative artificial intelligence. Its future development may be influenced by a number of factors. One such factor is the need to build trust in artificial intelligence systems, which researchers say is essential for their wider adoption and integration in a range of fields. This primarily concerns the provision of transparent and comprehensible explanations for decisions, projections or recommendations generated by artificial intelligence (Jangoan et al., 2024).

3. Methodology

The process of building scenarios for the development of generative artificial intelligence in the industry involved the use of a variety of research methods that made it to accomplish the goal set in the work. The research process was divided into four individual phases.

This division, along with an indication of the research methods used in each phase and the outcome of each phase, is shown in Figure 1.

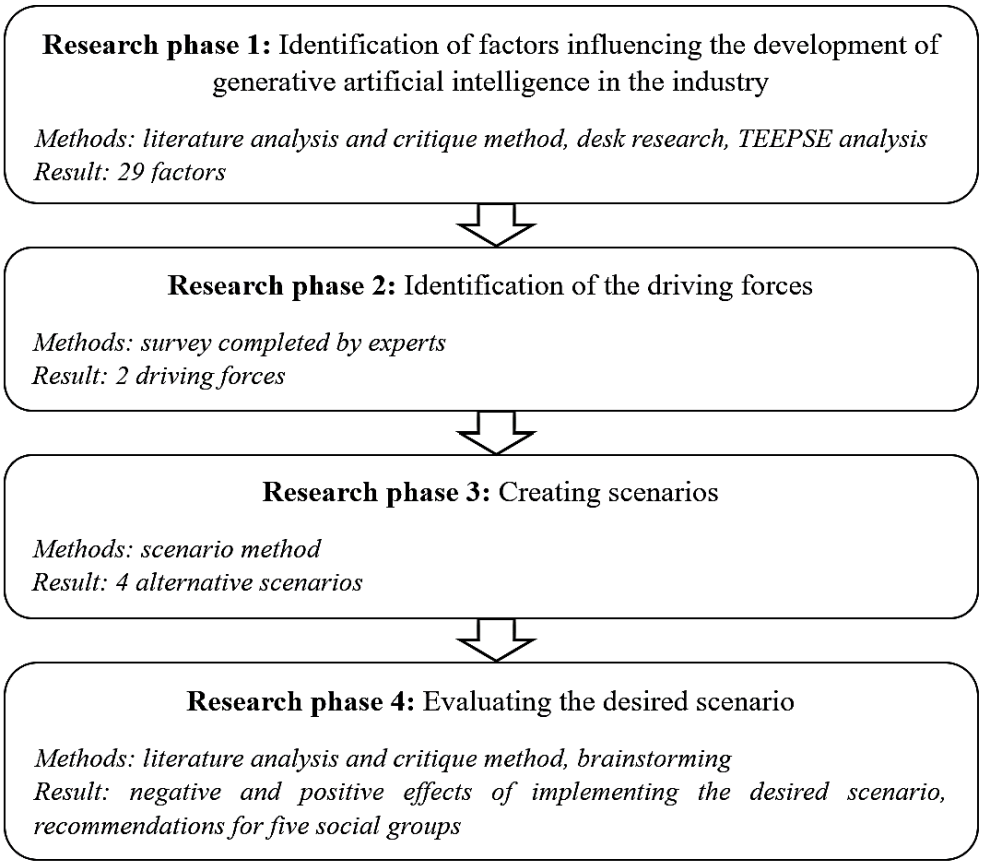

Figure 1. Methodology.

Source: own elaboration.

The research methods used in the study included literature analysis and critique method, desk research, TEEPSE analysis, survey, scenario method and brainstorming. The literature analysis and critique method is based on analysing the data already contained in the literature, which can lead to finding research gaps. This method also enables organizing the available knowledge (Mróz-Jagiełło, Wolanin, 2013). The article also benefits from desk-based research, which involves finding and analysing data available from a variety of sources, such as statistical sources, expert statements, online articles, company databases and other (Bednarowska, 2015).

The TEEPSE analysis was employed to identify the specific factors that drive GAI development within the industry. Its application enabled the factors to be grouped into six categories, the initial letters of which form the name of this analysis: technological, economical, environmental, political, social and ethical factors (Ejdys, Szpilko, 2023). This analysis was selected, due to the inclusion of ethical factors, which are not present in other analyses and represent a significant aspect of GAI technology development. Another research method used was a survey, which allowed identified factors to be assessed by experienced experts.

The scenario method was employed to investigate potential future developments in the growth of GAI within the industry. The scenario method is based on the assumption that the future will evolve in accordance with a pre-established pattern, which is the scenario. It is an outcome of the assumptions that are made regarding the future development and the factors that are influencing the forecast. In light of these considerations, the necessary steps to achieve the desired outcome can be identified (Santarek, 2016).

Finally, a brainstorming method was carried out, which is a method of generating a large number of ideas in a short period of time and selecting the most beneficial ones (Helman, Rosienkiewicz, 2016).

The first phase of the research identified factors influencing the development of generative artificial intelligence in the industry. This was done using desk research, which took into account such sources as academic articles, electronic articles, monographs, expert blogs, European Parliament documents, among others. As a result, twenty-nine factors were obtained, which were then subjected to TEEPSE analysis. This made it possible to assign the factors to six groups based on the area they cover.

Then, in the second phase of the research, a questionnaire was constructed, through which experts evaluated the factors by selecting one of four responses, following a four-point Likert scale: definitely has no impact, rather has no impact, rather has impact, definitely has impact. The survey was completed by twelve experts from both academia and industry. Subsequently, a point scale from 0 to 3 was assigned consecutively for the four response possibilities. Thus, two factors emerged as the driving forces behind GAI's growth in the industry.

The third phase of the study created four alternative scenarios for GAI's development in the industry over a 10-year horizon. The two driving forces identified earlier were used for this. Names for the scenarios were also proposed, with the acronym GAI forming the acronym.

The final phase of the study allowed the identification of the desired scenario and analysis of its effects. Possible negative and positive effects of implementing this scenario were identified for five groups (GAI developers, researchers, the public, government and industry). In addition, the article presents recommendations aimed at the same five groups. The application of the recommendations could result in the realization of the desired scenario and the acceptance of GAI technology by various groups in society.

4. Results

To identify key factors which have a significant impact on the development of GAI in the industry, sources such as academic articles, electronic articles, monographs, expert blogs, company websites, European Parliament documents and the Republic of Poland website were

reviewed. As a result, twenty-nine factors were obtained, which were then divided into six TEEPSE groups:

1) Technological factors:
   - artificial intelligence development (Chan, 2023),
   - the level of productivity enhancement of creative work using generative artificial intelligence (Haase, Hanel, 2023),
   - the amount of data produced and available in companies (European Parliament, 2023),
   - cloud computing development (Keskin, Isik, 2023),
   - ability of the GAI model to provide an explanation of the response generated (Przegalińska, Jemielniak, 2023),
   - computing power (Kwapisz, 2023),
   - the level of reliability of the responses generated (Wang et al., 2023),
   - the level of reduction in the diversity of solutions to specific issues when using the GAI model (Snodgrass, 2024).
2) Economical factors:
   - cost of employing the staff (Gorzkowska, 2022),
   - the productivity level of enterprises (Raj et al., 2023),
   - the level of competition in the GAI market (Rudolph, Tan, Tan, 2023),
   - the value of an index reflecting the readiness of countries to implement artificial intelligence tools (Nzobonimpa, Savard, 2023),
   - number of corporations entering into partnerships with companies offering GAI (e.g. Coca-Cola, Microsoft, Amazon) (Kubera, 2024).
3) Ecological factors:
   - the level of restrictions to reduce greenhouse gas emissions (Biswas, 2023),
   - the environmental cost of using GAI (George, George, Martin, 2023),
   - natural resource consumption and the impact of AI on biodiversity (Ligozat et al., 2022),
   - climate change adaptation and mitigation through GAI models (Vinuesa et al., 2020).
4) Political factors:
   - the level of protection of personal data guaranteed by GAI models (Sebastian, 2023),
   - availability of national funding (Serwis Rzeczypospolitej Polskiej),
   - the level of regulation by the European Parliament (European Parliament, 2020),
   - the level of support for innovation by the European Parliament (European Parliament, 2021).

5) Social factors:
   - availability of qualified staff (Chuang, 2024),
   - the level of public confidence in artificial intelligence (Łapińska et al., 2021),
   - impact of the use of GAI models on social equity (Zajko, 2022),
   - changes in the labor market structure brought about by GAI models (Joamets, Chochia, 2020).
6) Ethical factors:
   - the level of alignment of artificial intelligence with the organization's culture and values, e.g. in the context of employee monitoring (Przegalińska, Jemielniak, 2023),
   - the number of redundancies associated with the replacement of human labour by GAI models (Konstantis et al., 2023),
   - transparency of GAI models and their explanatory power (Haresamudram, Larrson, Heintz, 2023),
   - autonomy and human control over decisions taken by artificial intelligence (Cavalcante Siebert, 2023).

The most numerous group of factors is technological. As many as eight were identified, which may indicate their importance in the context of the problem studied. In second place in terms of numbers are the economic factors, of which five were identified. In the other four groups, the authors identified four factors each.

Based on the identified factors, a questionnaire was prepared in Microsoft Forms. The survey was based on a four-point Likert scale. Participants were able to select one of four responses: definitely has no impact, rather has no impact, rather has an impact and definitely has an impact. The identified factors were then assessed by twelve experts. Seven of them are academics from the Bialystok University of Technology, while five experts come from industry and work in a variety of industries: packaging, FMCG/supply chain, automotive, heating appliance manufacturing and the furniture industry. They also hold diverse positions, such as product development and sales manager, last mile and warehousing procurement manager, product leader SCADA & digital solutions, head of organization and production management and production engineering specialist. These experts evaluated all factors by selecting one of four possible answers.

In addition, point values were assigned to the responses in order to assess which factors were considered by the experts to be key. For this purpose, the following scoring scale was used for individual responses:

- definitely has no impact – 0 points,
- rather has no impact – 1 point,
- rather has an impact – 2 points,
- definitely has an impact – 3 points,

This resulted in the values shown in Table 1.

Table 1.
Assigning points to factors

Group	Factor	Definitely has no impact		Rather has no impact		Rather has an impact		Definitely has an impact		Sum
		no. of responses	points	no. of responses	points	no. of responses	points	no. of responses	points	
TECHNOLOGICAL	Artificial intelligence development	0	0	0	0	4	8	8	24	**32**
	The level of productivity enhancement of creative work using generative artificial intelligence	0	0	1	1	7	14	4	12	27
	The amount of data produced and available in companies	0	0	4	4	5	10	3	9	23
	Cloud computing development	0	0	1	1	8	16	3	9	26
	Ability of the GAI model to provide an explanation of the response generated	0	0	1	1	7	14	4	12	27
	Computing power	0	0	2	2	3	6	7	21	29
	The level of reliability of the responses generated	0	0	0	0	6	12	6	18	30
	The level of reduction in the diversity of solutions to specific issues when using the GAI model	0	0	2	2	9	18	1	3	23
ECONOMICAL	Cost of employing the staff	0	0	2	2	7	14	3	9	25
	The productivity level of enterprises	0	0	4	4	6	12	2	6	22
	The level of competition in the GAI market	0	0	1	1	9	18	2	6	25
	The value of an index reflecting the readiness of countries to implement artificial intelligence tools	0	0	4	4	7	14	1	3	21
	Number of corporations entering into partnerships with companies offering GAI…	0	0	1	1	10	20	1	3	24
ECOLOGICAL	The level of restrictions to reduce greenhouse gas emissions	1	0	6	6	4	8	1	3	17
	The environmental cost of using GAI	0	0	5	5	5	10	2	6	21
	Natural resource consumption and the impact of AI on biodiversity	2	0	4	4	5	10	1	3	17
	Climate change adaptation and mitigation through GAI models	1	0	4	4	7	14	0	0	18

Cont. table 1.

POLITICAL	The level of protection of personal data guaranteed by GAI models	0	0	2	2	8	16	2	6	24
	National funding availability	0	0	4	4	4	8	4	12	24
	The level of regulation by the European Parliament	0	0	1	1	8	16	3	9	26
	The level of support for innovation by the European Parliament	0	0	1	1	9	18	2	6	25
SOCIAL	Qualified staff availability	0	0	2	2	8	16	2	6	24
	The level of public confidence in artificial intelligence	0	0	1	1	5	10	6	18	**29**
	Impact of the use of GAI models on social equity	0	0	7	7	5	10	0	0	17
	Changes in the labor market structure brought about by GAI models	0	0	1	1	11	22	0	0	23
ETHICAL	The level of alignment of artificial intelligence with the organization's culture and values, e.g. in the context of employee monitoring	0	0	4	4	7	14	1	3	21
	Number of dismissals related to the replacement of human labor by GAI models	0	0	0	0	10	20	2	6	26
	Transparency of GAI models and their explanatory power	0	0	2	2	4	8	6	18	28
	Autonomy and human control over decisions taken by artificial intelligence	0	0	1	1	8	16	3	9	26

Source: own elaboration.

By using a point scale and multiplying the number of responses by the number of corresponding points, the two factors that were rated highest by the experts were identified. A criterion of factors from different groups was taken into account in the selection. These factors are highlighted in red in the table. These factors are: artificial intelligence development and the level of public confidence in artificial intelligence.

Identifying these two driving forces enabled the construction of four alternative scenarios for the development of generative AI in industry in a 10-year timeframe:

- Scenario 1 – rapid development of artificial intelligence and high level of public confidence in artificial intelligence.
- Scenario 2 – rapid development of artificial intelligence and low level of public confidence in artificial intelligence.

- Scenario 3 – slow development of artificial intelligence and low level of public confidence in artificial intelligence.
- Scenario 4 – slow development of artificial intelligence and high level of public confidence in artificial intelligence.

The authors named the scenarios with the acronym GAI: Scenario 1 – **G**igantic **A**nd **I**ngenious, Scenario 2 – **G**reat **A**nomaly of **I**nnovation, Scenario 3 – **G**narly **A**ssistant **I**mprovisation, Scenario 4 – **G**radual **A**pproval of **I**ntegrity. The research process carried out made it possible to construct brief descriptions of these scenarios:

- Scenario 1 (**G**igantic **A**nd **I**ngenious) – In the year 2034, generative artificial intelligence (GAI) is a tool used widely across many industries. Its rapid and fast development enables continuous improvement of GAI models. Consequently, these models produce inspiring graphics and provide reliable and credible information that meets the needs of users. This contributes to the high level of public confidence in GAI. In large industrial companies, it is responsible for more than half of the creative work.
- Scenario 2 (**G**reat **A**nomaly of **I**nnovation) – The rapid development of artificial intelligence does not go hand in hand with the generation of trustworthy answers, and focuses mainly on increasing the functionality of systems and improving interfaces. The lack of regulation and safeguards on the part of system developers leads to systems generating false information and low levels of data protection. This, in turn, translates into skeptical users and businesses lacking confidence in the technology. Generative artificial intelligence in 2034 is therefore used sporadically in the industry, mainly to create interesting information graphics. Increasing the reliability of responses and the security level of users could lead to scenario 1, while a lack of progress in this area will result in a move to scenario 3.
- Scenario 3 (**G**narly **A**ssistant **I**mprovisation) – The lack of transparency of systems and their generation of false information results in user reluctance and mistrust. In a 10-year timeframe, industrial companies are reluctant to use technology that is inaccurate and potentially dangerous, for fear of its negative impact on production processes and the leakage of key data. The artificial intelligence market is growing very slowly due to a lack of interested users. GAI also faces a lack of public acceptance and investment difficulties. Only improving the level of reliability of the answers generated and the protection of the data could be a start to gain the trust of investors and businesses, and consequently move towards scenario 2.
- Scenario 4 (**G**radual **A**pproval of **I**ntegrity) – Stricter rules and regulations significantly increase the level of data protection. The reliability of the answers generated is also improving. In the year 2034, industrial companies are more willing to use GAI technologies, as they allow quick access to reliable information, with a high level of security at the same time. On the other hand, strict regulations are significantly slowing

down the development of artificial intelligence, which has also become very expensive. This leads to an insatiable market, as there is a lack of specialized systems tailored to the specific functions required by industry. Subsidies to IT companies could accelerate the development of GAI systems, which will result in a gradual transition to scenario 1.

The scenarios are also presented in the form of a matrix composed of graphical representations of the scenarios generated in the ChatGPT chatbot (Figure 2).

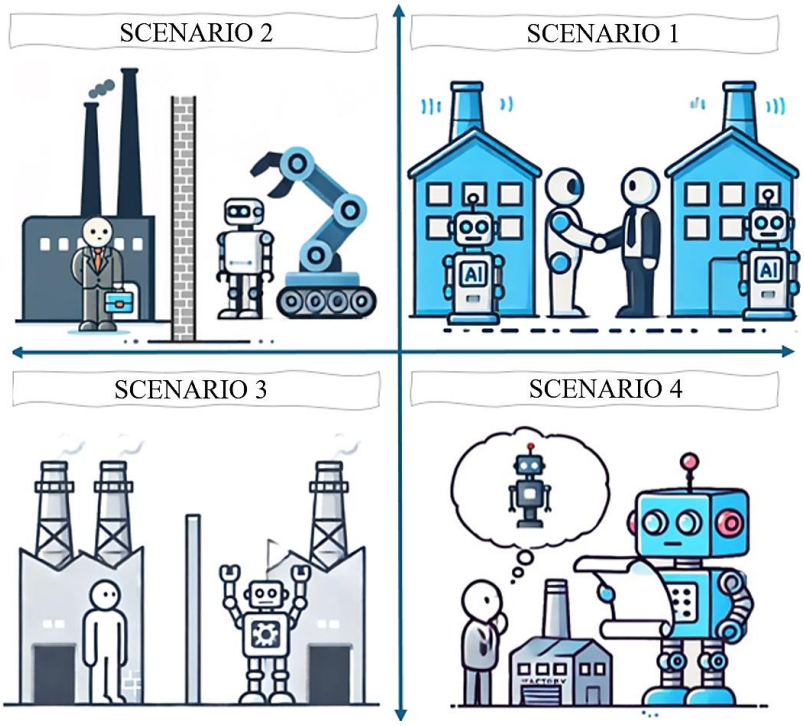

Figure 2. Scenarios for the development of generative artificial intelligence in industry.
Source: pictures generated in ChatGPT chatbot.

The most desirable scenario is Scenario 1. Therefore, its description has been made more specific:

In scenario 1, the rapid development of AI is driven by a high level of public confidence in the technology. Indeed, in a 10-year perspective, the rapid development of AI is driven, among other things, by the high level of interest from manufacturing companies. As a result, increasingly advanced models are being developed that are able to process and analyze huge amounts of data. Nevertheless, the IT companies behind the construction of these models are concerned about respecting copyright and protecting user data. As a result, confidence in generative artificial intelligence is very high and more and more organizations are choosing to use it. Artificial intelligence experts note the emergence of the GAI trend. In line with market requirements, dedicated systems are being built to meet the needs of specific companies and their specificities. Personalization is therefore increasing and the individual preferences of each actor are being taken into account. According to this scenario in 2034, generative artificial intelligence is used in many manufacturing companies, where it is used, for example, to design new products, analyze the market, improve production processes and manage the supply chain.

Additionally, it is commonly used to create marketing content and analytical reports. As a result, in many companies, positions consisting mainly of repetitive and routine tasks have been eliminated as they have been replaced by the GAI system. Some employees were redeployed to positions involving the creation and operation of systems, which required additional training. In addition, GAI has become a decision support tool. It is used for operational decisions by managers and strategic decisions by the boards of directors of the respective organizations. In summary, having a generative artificial intelligence system that not only automates but also streamlines individual processes and introduces new creative and analytical capabilities is a major competitive advantage for a company. Industrial organizations are keen to invest in GAI solutions because the expense has a relatively quick payback.

In order for Scenario 1 to become a reality in 10 years' time, it is necessary to take comprehensive measures to support the development of artificial intelligence and to raise the level of public confidence in GAI technology. Accordingly, the authors has formulated specific recommendations aimed at five groups that have a significant impact on the development of generative artificial intelligence in industry. These groups include: scientists, society, government, GAI developers and industry representatives. Recommendations have been developed based on desk-based research, which has enabled data collection, analysis of current trends and challenges in the area of generative artificial intelligence. The implementation of the identified actions would result in the further development of the studied technology and its acceptance by various social groups.

Recommendations for scientists:

- Exchange of knowledge and experience with industry through, for example, Technology Transfer Centers (Konfederacja Lewiatan, 2024).
- Commercialization of the results of scientific activity (Lampart, 2023).
- Creation of directions related to the creation, handling and interpretation of generative artificial intelligence results (Kotval).

Recommendations for the society:

- Participate in training sessions outlining the benefits and risks of using GAI (Gerbert et al., 2018).
- Openness to re-branding (Aigolab).
- Applying GAI to everyday tasks (European Parliament, 2020).

Recommendations for the government:

- Increasing the stringency of data protection law (General Data Protection Regulation).
- Removal of barriers and creation of legal conditions for the development of AI (Ministerstwo Cyfryzacji, 2023).
- Use of financial incentives such as tax breaks or subsidies for AI development projects (Konfederacja Lewiatan, 2024).

Recommendations for GAI developers:

- Certification of systems to increase protection, differentiation and, consequently, popularity (AI Ethics Certification).
- Turning attention towards ethical risks and opportunities in the development of new models and systems (AI Ethics Lab).
- Creating models who refuse to answer questions that spread hatred (Zewe, 2024).
- Focus on cyber security (Gerbert et al., 2018).

Recommendations for industry representatives:

- Adaptation of staff to new technologies related to GAI by, among other things, improving their competence in this area (Śledziewska).
- Implementation of new structures including increased storage, processing power and bandwidth (Gerbert et al., 2018).
- Building an organizational culture that encourages the implementation of various AI solutions (Szarański).

The recommendations formulated represent a kind of guideline for the respective groups. Their application within 10 years may contribute to the rapid development of artificial intelligence and increase the level of public confidence in generative artificial intelligence, which could consequently lead to the desired scenario. In addition, the recommendations can serve as a reference when creating a plan for GAI development in the industry.

Additionally, the authors highlighted the potential impacts of the indicated scenario, which could be visible in 2034. These were identified by brainstorming with people of different ages and experience in different industries. These impacts were again grouped into five groups, considering scientists, society, government, GAI developers and industry representatives (Table 2).

Table 2.
Potential impacts of the scenario

Negative impact	Positive effects
for the scientists	
• Pressure to achieve rapid technological solutions. • Possible shift in priorities from scientific breakthroughs to commercial projects. • Ethical dilemmas related to social responsibility for discoveries in the artificial intelligence sector. • Potential threat of copyright violation.	• Research funding and grants related to the development of GAI. • Opportunities for cooperation between science and business. • Opening up new areas of research. • Ability to analyze large data sets simultaneously.
for the society	
• Elimination of some jobs, especially those involving routine tasks. • The need to adapt one's skills to new technologies. • High dependence on technology. • Possible discrimination based on gender, color, orientation, language, etc.	• Personalization of products and services. • High demand for people qualified as e.g. prompt engineer, data engineer. • Potentially greater availability of services and products. • Improved quality of life through automation of routine activities.

• Sense of insecurity - significant overemphasis on human competence by GAI. • Widening social inequalities.	• Potential breakthroughs in medicine, renewable energy, etc.
for the government	
• The rapid development of GAI may be outpacing regulatory updates. • Disinformation - spreading false information. • Risk of monopolization of the market. • Problem of establishing responsibility for critical errors made by artificial intelligence systems.	• Economic growth. • Greater transparency of operations and the ability to monitor individual actors. • Improved management of crisis situations. • Automation of public administration tasks, which can increase efficiency and reduce costs. • New tools to fight crime. • Facilitation of decision-making.
for GAI developers	
• Strong competition. • Ethical dilemmas related to the impact of technology on the labor market and user privacy. • High responsibility for correct and continuous operation of systems. • Risk of losing control of technology.	• High demand for GAI systems. • Attracting investors. • Expansion into many markets. • Possibility of extending the systems' functionality to other areas of life.
for industry representatives	
• High dependence on technology. • Accountability of managers for decisions made by the system. • Increasing the advantage of large companies over medium and small companies that do not have sufficient resources to introduce GAI systems. • The need to recruit new staff skilled in artificial intelligence. • Need to invest in protection systems (cyber security).	• Increased efficiency of production processes. • Innovation of products and services. • Facilitated personalization. • Reduced production costs. • Complete automation of many processes. • Acceleration of sales cycles. • Making better business decisions.

When analyzing the identified impacts of the implementation of the desired scenario, it can be seen that the number of potential negative and positive impacts in each group is very similar. In addition, the identification of negative impacts can contribute to a scenario implementation strategy such that the likelihood of their occurrence is as low as possible. Some negative impacts can be avoided altogether – for example, the potential copyright infringement of scientists can be mitigated through the application of appropriate legal regulations relating to GAI models. Positive impacts, on the other hand, can be a motivation for further development of generative artificial intelligence for all groups highlighted.

5. Discussion

The findings of this study offer a comprehensive insight into the factors that shape the development and deployment of generative artificial intelligence (GAI) in industry. The analysis of the views of experts from both the academic and industrial sectors has not only identified the key factors, but also provided an understanding of the complex interplay between

technological, social, economic, environmental, political and ethical factors that will shape the future development of GAI. The scenarios presented illustrate how these factors can either accelerate or slow down the adoption of GAI in industry, with significant implications for stakeholders.

The development of artificial intelligence and public trust have emerged as the two main factors influencing the future of GAI scenarios in the industry. The rapid advancement of artificial intelligence and the growing public trust in its capabilities will enable the widespread adoption of GAI in industry, leading to significant increases in productivity and innovation. On the other hand, slow progress or low levels of trust could result in GAI being used only in a limited number of niche applications. These findings are in line with research indicating that public trust is a key factor in the long-term development of AI technologies (Jangoan et al., 2024).

The generative AI development scenarios outlined in this study reflect concerns identified in the existing literature regarding data security and reliability in AI applications (Sebastian, 2023; Kwapisz, 2024). The anticipated reliance on regulatory and security measures in the GAI trajectory supports the claim that GAI adoption depends not only on technological advances, but also on public mood and ethical alignment (Łapińska et al., 2021; Konstantis et al., 2014).

6. Conclusions

The rise of Generative Artificial Intelligence (GAI) signifies a paradigm shift in industrial operations, offering a spectrum of possibilities for innovation, productivity, and societal transformation. This study underscores the interplay between technological advancements and public trust as critical drivers shaping GAI's development trajectory. The scenarios developed illustrate how these factors can influence the speed and scope of GAI adoption in industry, providing valuable insights for stakeholders navigating this transformative landscape.

GAI's potential is immense: it can revolutionize industrial processes by enabling predictive maintenance, enhancing resource management, and personalizing customer experiences. However, the path to realizing this potential is fraught with challenges. Ethical concerns, such as the transparency of AI systems, accountability for their decisions, and the potential for misuse, must be addressed. Additionally, the socioeconomic implications, including job displacement and skill realignment, necessitate proactive measures to prepare the workforce for an AI-driven future.

The study emphasizes the importance of a collaborative approach involving academia, industry, government, and society to ensure the responsible development and deployment of GAI. Policymakers must establish robust regulatory frameworks that balance innovation with ethical considerations, fostering an environment conducive to trust and safety. Industry leaders

must prioritize investments in secure and transparent AI systems, while embedding AI into their organizational cultures in ways that respect human dignity and creativity. Researchers should continue to explore the multifaceted dimensions of GAI, integrating technological, ethical, and societal perspectives to guide its sustainable development.

Future research could extend this study by employing quantitative forecasting methods, analyzing sector-specific adoption patterns, and conducting longitudinal studies on public trust in AI. Additionally, examining the environmental impact of AI technologies and exploring ways to mitigate their resource intensity will be critical for sustainable development. Stakeholders should also monitor evolving societal attitudes toward AI, ensuring that public engagement and education remain central to GAI's growth.

In 10 years, the realization of the most desirable GAI scenario—characterized by rapid technological development and high public trust—could significantly enhance industrial efficiency, drive innovation, and improve the quality of life. However, achieving this vision requires concerted efforts to address ethical and societal challenges. By fostering transparency, accountability, and inclusivity, stakeholders can ensure that GAI contributes to a future that balances technological advancement with human values.

Ultimately, this study provides a roadmap for navigating the complex and dynamic landscape of GAI development. It highlights the need for cohesive, interdisciplinary approaches that prioritize ethical and sustainable growth. As GAI continues to evolve, its successful integration into industry will depend on the ability of all stakeholders to collaborate, innovate, and address the broader implications of this transformative technology.

References

1. *AI Ethics Lab*. Retreved from: https://aiethicslab.com/, 30.11.2024.
2. Aigolab. *AI w 2030: Wizje przyszłości, które kształtują dzisiejsze decyzje.* Retrieved from: https://www.aigolab.pl/blog/sztuczna-inteligencja-w-biznesie-1/ai-w-2030-wizje-przyszlosci-ktore-ksztaltuja-dzisiejsze-decyzje-23, 30.11.2024.
3. Arias, C.R. (2022). *An introduction to artificial intelligence.* Seattle: SPU Works.
4. Baytak, A. (2024). The Content Analysis of the Lesson Plans Created by ChatGPT and Google Gemini. *Research in Social Sciences and Technology, Vol. 9, Iss. 1,* pp. 329-350, doi: 10.46303/ressat.2024.19
5. Bednarowska, Z. (2015). Desk research–wykorzystanie potencjału danych zastanych w prowadzeniu badań marketingowych i społecznych. *Marketing i rynek, Vol. 7,* pp. 18-26.
6. Berente, N., Gu, B., Recker, J., Santhanam, R. (2021). Managing artificial intelligence. *MIS quarterly, Vol. 45, Iss. 3,* pp. 1433-1450, doi: 10.25300/MISQ/2021/16274

7. Bieroński, M. (2020). Etyczne i moralne wyzwania związane ze stosowaniem Sztucznej Inteligencji. *Kieleckie Studia Teologiczne, Vol. 19*, pp. 7-25.
8. Biswas, S.S. (2023). Potential use of chat gpt in global warming. *Annals of biomedical engineering, Vol. 51, Iss. 6*, pp. 1126-1127, doi: 10.1007/s10439-023-03171-8
9. Budhwar, P., Chowdhury, S., Wood et al. (2023). Human resource management in the age of generative artificial intelligence: Perspectives and research directions on ChatGPT. *Human Resource Management Journal, Vol. 33, Iss. 3,* pp. 606-659, doi: 10.1111/1748-8583.12524
10. Cavalcante Siebert, L., Lupetti, M.L., Aizenberg, E., Beckers, N., Zgonnikov, A., Veluwenkamp, H., ..., Lagendijk, R.L. (2023). Meaningful human control: actionable properties for AI system development. *AI and Ethics, Vol. 3, Iss. 1*, pp. 241-255, doi: 10.1007/s43681-022-00167-3
11. Chan, A. (2023). GPT-3 and InstructGPT: technological dystopianism, utopianism, and "Contextual" perspectives in AI ethics and industry. *AI and Ethics, Vol 3, Iss. 1*, pp. 53-64, doi: 10.1007/s43681-022-00148-6
12. Chuang, S. (2024). Indispensable skills for human employees in the age of robots and AI. *European Journal of Training and Development, Vol. 48, Iss. 1/2,* pp. 179-195, doi: 10.1108/EJTD-06-2022-0062
13. Creswell, A., White, T., Dumoulin, V., Arulkumaran, K., Sengupta, B., Bharath, A.A. (2018). Generative adversarial networks: An overview. *IEEE signal processing magazine, Vol. 35, Iss. 1*, pp. 53-65.
14. Deng, J., Lin, Y. (2022). The benefits and challenges of ChatGPT: An overview. *Frontiers in Computing and Intelligent Systems, Vol. 2, Iss. 2*, pp. 81-83.
15. Doanh, D.C., Dufek, Z., Ejdys, J., Ginevičius, R., Korzynski, P., Mazurek, G., ..., Ziemba, E. (2023). Generative AI in the manufacturing process: theoretical considerations. *Engineering Management in Production and Services, Vol. 15, Iss. 4,* pp. 76-89, doi: 10.2478/emj-2023-0029
16. Ejdys, J., Szpilko, D. (2023). How to ensure the resilience of semiconductor supply chains in the European Union? *Polish Journal of Management Studies, Vol. 28, Iss. 1*, pp. 101-122, doi: 10.17512/pjms.2023.28.1.06
17. European Parliament. *Artificial intelligence: How does it work, why does it matter, and what can we do about it?* Retrieved from: https://www.europarl.europa.eu/stoa/en/document/EPRS_STU(2020)641547, 29.11.2024.
18. European Parliament. *Europejska strategia w zakresie danych: oczekiwania Parlamentu.* Retrieved from: https://www.europarl.europa.eu/topics/pl/article/20210218STO98124/europejska-strategia-w-zakresie-danych-oczekiwania-parlamentu, 30.11.2024.
19. European Parliament. *Regulacje ws. sztucznej inteligencji: oczekiwania Parlamentu.* Retrieved from: https://www.europarl.europa.eu/topics/pl/article/20201015STO89417/regulacje-ws-sztucznej-inteligencji-oczekiwania-parlamentu, 30.11.2024.

20. European Parliament. *Sztuczna inteligencja: szanse i zagrożenia.* Retrieved from: https://www.europarl.europa.eu/topics/pl/article/20200918STO87404/sztuczna-inteligencja-szanse-i-zagrozenia, 29.11.2024.
21. Feuerriegel, S., Hartmann, J., Janiesch, C., Zschech, P. (2024). *Generative ai. Business & Information Systems Engineering, Vol. 66, Iss. 1,* pp. 111-126, doi: 10.1007/s12599-023-00834-7
22. George, A.S., George, A.H., Martin, A.G. (2023). The environmental impact of AI: a case study of water consumption by chat GPT. *Partners Universal International Innovation Journal, Vol. 1, Iss. 2,* pp. 97-104, doi: 10.5281/zenodo.7855594
23. Gerbert, P., Ramachandran, S., Mohr, J.H., Spira, M. *The big leap toward AI at scale.* Retrieved from: https://www.bcg.com/publications/2018/big-leap-toward-ai-scale, 30.11.2024.
24. Gorzkowska, K.M. (2022). Odpowiedzialność za działania sztucznej inteligencji. In: A. Kidyba, A. Olejniczak (Ed.), *Nowoczesne technologie – szansa czy zagrożenie dla funkcjonowania przedsiębiorców w obrocie prawnym i postępowaniach sądowych* (p. 75). Warszawa: Wolters Kluwer.
25. Haase, J., Hanel, P.H. (2023). Artificial muses: Generative artificial intelligence chatbots have risen to human-level creativity. *Journal of Creativity, Vol. 33, Iss. 3,* pp. 1-7, doi: 10.1016/j.yjoc.2023.100066
26. Haresamudram, K., Larsson, S., Heintz, F. (2023). Three levels of AI transparency. *Computer, Vol. 56, Iss. 2,* pp. 93-100, doi: 10.1109/MC.2022.3213181
27. Helman, J., Rosienkiewicz, M. (2016). Design Thinking jako koncepcja pobudzania innowacji. In: R. Knosala (ed.)*, Innowacje w zarządzaniu i inżynierii produkcji* (pp. 62-72). Oficyna Wydawnicza Polskiego Towarzystwa Zarządzania Produkcją.
28. Holmes, W., Tuomi, I. (2022). State of the art and practice in AI in education. *European Journal of Education, Vol. 57, Iss. 4,* pp. 542-570, doi: 10.1111/ejed.12533
29. Hwang, G.J., Chen, N.S. (2023) . Exploring the potential of generative artificial intelligence in education: applications, challenges, and future research directions. *Journal of Educational Technology & Society, Vol 26, Iss. 2,* doi: 10.30191/ETS.202304
30. *IEEE CertifAIEd.* Retrieved from: https://engagestandards.ieee.org/ieeecertifaied.html, 30.11.2024.
31. Jangoan, S., Krishnamoorthy, G., Muthusubramanian, M., Ranjan, R., Sharma, K.K. (2024). Demystifying Explainable AI: Understanding, transparency, and trust. *International Journal For Multidisciplinary Research, Vol. 6, Iss. 2,* pp. 1-13.
32. Joamets, K., Chochia, A. (2020). Artificial intelligence and its impact on labour relations in Estonia. *Slovak Journal of Political Sciences, Vol. 20, Iss. 2,* pp. 255-277, doi: 10.34135/sjps.200204
33. Jovanovic, M., Campbell, M. (2022). Generative artificial intelligence: Trends and prospects. *Computer, Vol. 55, Iss. 10,* pp. 107-112, doi: 10.1109/MC.2022.3192720

34. Keskin, S., Isık, A.H. (2023). Examining the importance of artificial intelligence in the singularization of big data with the development of cloud computing. *International Journal of Engineering and Innovative Research, Vol. 5, Iss. 2,* pp. 170-180, doi: 10.47933/ijeir.1261330
35. Konfederacja Lewiatan. *8 rekomendacji w sprawie sztucznej inteligencji.* Retrieved from: https://lewiatan.org/8-rekomendacji-w-sprawie-sztucznej-inteligencji/, 30.11.2024.
36. Konstantis, K., Georgas, A., Faras, A., Georgas, K., Tympas, A. (2023). Ethical considerations in working with ChatGPT on a questionnaire about the future of work with ChatGPT. *AI and Ethics, Vol. 4*, pp. 1335-1344, doi: 10.1007/s43681-023-00312-6
37. Korbiel, T., Czerwiński, S., Kania, J. (2023). Utrzymanie ruchu oraz eksploatacja maszyn w przemyśle 4.0. *Systemy Wspomagania w Inżynierii Produkcji, Vol. 12, Iss. 1*, pp. 137-151.
38. Kotval, L. *Jak sztuczna intelogencja (AI) wpływa na edukację?* Retrieved from: https://ik.org.pl/2024/04/25/jak-sztuczna-inteligencja-ai-wplywa-na-edukacje/, 30.11.2024.
39. Kshetri, N., Dwivedi, Y.K., Davenport, T.H., Panteli, N. (2024). Generative artificial intelligence in marketing: Applications, opportunities, challenges, and research agenda. *International Journal of Information Management, Vol. 75*, pp. 1-36, doi: 10.1016/j.ijinfomgt.2023.102716
40. Kubera, G. *Rywal ChatGPT twierdzi, że ma coś lepszego. "Rozumienie na poziomie ludzkim"*. Retrieved from: https://businessinsider.com.pl/technologie/nowe-technologie/rywal-chatgpt-twierdzi-ze-ma-cos-lepszego-rozumienie-na-poziomie-ludzkim/k6kvczh, 30.11.2024.
41. Kwapisz, J. *ChatGPT od kuchni. Zaglądamy za kulisy uczenia maszynowego*. Retrieved from: https://android.com.pl/artykuly/570359-chatgpt-od-kuchni-jak-dziala-kulisy-ai/, 25.11.2024.
42. Lampart, M. (2023). *Rozwiązania generatywnej sztucznej inteligencji – zagrożenia i aspekty prawne*. Warszawa: Polska Agencja Rozwoju Przedsiębiorczości, p. 100.
43. Łapińska, J., Kądzielawski, G., Sudolska, A., Górka, J., Escher, I., Brzustewicz, P. (2021). Zaufanie pracowników do sztucznej inteligencji w przedsiębiorstwach przemysłu chemicznego. *Przemysł Chemiczny, Vol. 100, Iss. 2*, pp. 127-131, doi: 10.15199/62.2021.2.1
44. Lăzăroiu, G., Gedeon, T., Szpilko, D., Halicka, K. (2024). Digital twin-based alternate ego modeling and simulation: Eva Herzigová as a 3D MetaHuman avatar. *Engineering Management in Production and Services, Vol. 16, Iss. 3,* pp. 1-14, doi: 10.2478/emj-2024-0020
45. Ligozat, A.L., Lefevre, J., Bugeau, A., Combaz, J. (2022). Unraveling the hidden environmental impacts of AI solutions for environment life cycle assessment of AI solutions. *Sustainability, Vol. 14, Iss. 9,* pp. 1-14, doi: 10.3390/su14095172

46. Mróz-Jagiełło, A., Wolanin, A. (2013). Metoda analizy i krytyki dokumentów w naukach o bezpieczeństwie. *Zeszyty Naukowe Wydziału Zarządzania i Dowodzenia Akademii Obrony Narodowej, Vol. 2, Iss. 6,* p. 115.
47. Nzobonimpa, S., Savard, J.F. (2023). Ready but irresponsible? Analysis of the Government Artificial Intelligence Readiness Index. *Policy & Internet, Vol. 15, Iss. 3,* pp. 397-414, doi: 10.1002/poi3.351
48. Ooi, K.B., Tan, G.W.H., Al-Emran, M. et al. (2023). The potential of generative artificial intelligence across disciplines: Perspectives and future directions. *Journal of Computer Information Systems*, pp. 1-32.
49. Polish Ministry of Digitalization. *Raport: Rekomendacje w zakresie zastosowania sztucznej inteligencji w sądownictwie i prokuraturze.* Retrieved from: https://www.gov.pl/attachment/5e60dcd0-2491-4f83-863c-4f59890a8295, 30.11.2024.
50. Przegalińska, A., Jemielniak, D. (2023). Współpracująca sztuczna inteligencja w zastosowaniach biznesowych. In: M. Ciszewska-Mlinarič (Ed.), *Przyszłość jest dziś. Trendy kształtujące biznes, społeczeństwo i przywództwo* (pp. 31-42). Warszawa: Akademia Leona Koźmińskiego.
51. Raj, R., Singh, A., Kumar, V., Verma, P. (2023). Analyzing the potential benefits and use cases of ChatGPT as a tool for improving the efficiency and effectiveness of business operations. *BenchCouncil Transactions on Benchmarks, Standards and Evaluations, Vol. 3, Iss. 3*, pp. 1-10, doi: 10.1016/j.tbench.2023.100140
52. Ramdurai, B., Adhithya, P. (2023). The impact, advancements and applications of generative AI. *International Journal of Computer Science and Engineering, Vol. 10, Iss. 6,* pp. 1-8, doi: 10.14445/23488387/IJCSE-V10I6P101
53. Rane, N. *Roles and challenges of ChatGPT and similar generative artificial intelligence for achieving the sustainable development goals (SDGs).* Retrieved from: https://ssrn.com/abstract=4603244, 23.11.2024.
54. *Raport: Generatywne AI w biznesie*. Retrieved from: https://www.gov.pl/web/ai/raport-generatywne-ai-w-biznesie, 30.11.2024.
55. Republic of Poland service. *Źródła wsparcia i dofinansowania.* Retrieved from: https://www.gov.pl/web/ai/zrodla-wsparcia-i-dofinansowania, 30.11.2024.
56. Rudolph, J., Tan, S., Tan, S. (2023). War of the chatbots: Bard, Bing Chat, ChatGPT, Ernie and beyond. The new AI gold rush and its impact on higher education. *Journal of Applied Learning and Teaching, Vol. 6, Iss. 1*, pp. 364-389, doi: 10.37074/jalt.2023.6.1.23
57. Santarek, K. (2016). Prognozowanie rozwoju nowych technologii. In: P. Wittbrodt (Ed.), *Innowacyjne technologie w inżynierii produkcji* (pp. 11-38). Lublin: Politechnika Lubelska.
58. Sebastian, G. (2023). Privacy and data protection in ChatGPT and other AI Chatbots: strategies for securing user information. *International Journal of Security and Privacy in Pervasive Computing, Vol. 15, Iss. 1*, pp. 1-14, doi: 10.4018/IJSPPC.325475

59. Singh, J.P. (2023). The Impacts and Challenges of Generative Artificial Intelligence in Medical Education, Clinical Diagnostics, Administrative Efficiency, and Data Generation. *International Journal of Applied Health Care Analytics, Vol. 8, Iss. 5*, pp. 37-46.
60. Siuta-Tokarska, B. (2021). Przemysł 4.0 i sztuczna inteligencja: szansa czy zagrożenie dla realizacji koncepcji zrównoważonego i trwałego rozwoju? *Nierówności Społeczne a Wzrost Gospodarczy, Vol. 65, Iss. 1*, pp. 7-26, doi: 10.15584/nsawg.2021.1.1
61. Skalfist, P., Mikelsten, D., Teigens, V. (2020). *Sztuczna inteligencja: czwarta rewolucja przemysłowa*. Cambridge: Stanford Books.
62. Śledziewska, K. *Sztuczna inteligencja w działaniach organizacji społecznych: wnioski i rekomendacje z pilotażu.* Retrieved from: https://sektor3-0.pl/sztuczna-inteligencja-w-ngo-rekomendacje/, 29.11.2024.
63. Snodgrass, E. *AI w pracy: zwiększa kreatywność, nie rozwiązuje problemów*. Retrieved from: https://businessinsider.com.pl/technologie/nowe-technologie/ai-w-pracy-zwieksza-kreatywnosc-ale-czy-rozwiazuje-problemy/gj0fnd5, 30.11.2024.
64. Sroka, R. (2019). Modele i warunki rozwoju etyki sztucznej inteligencji w biznesie. *Prakseologia, Vol. 161*, pp. 271-290, doi: 10.7206/prak.0079-4872_2015_160_27
65. Stylec-Szromek, P. (2018). Sztuczna inteligencja–prawo, odpowiedzialność, etyka. *Zeszyty Naukowe Politechniki Śląskiej. Organizacja i Zarządzanie, Vol. 123,* pp. 501-509.
66. Szarański, D. *Sektor 3.0.* Retrieved from: https://sektor3-0.pl/sztuczna-inteligencja-w-ngo-rekomendacje/, 29.11.2024.
67. Szpilko, D., Naharro, F. J., Lăzăroiu, G., Nica, E., de la Torre Gallegos, A. (2023). Artificial intelligence in the smart city—a literature review. *Engineering Management in Production and Services, Vol. 15, Iss. 4*, pp. 53-75, doi: 10.2478/emj-2023-0028
68. *Sztuczna inteligencja w oczach Polaków – raport z badań społecznych*. Retrieved from: https://www.nask.pl/pl/raporty/raporty/2594,Sztuczna-inteligencja-w-oczach-Polakow-raport-z-badan-spolecznych.html, 29.11.2024.
69. Vinuesa, R., Azizpour, H., Leite, I., Balaam, M., Dignum, V., Domisch, S., ..., Fuso Nerini, F. (2020). The role of artificial intelligence in achieving the Sustainable Development Goals. *Nature communications, Vol. 11, Iss. 1*, pp. 1-10, doi: 10.1038/s41467-019-14108-y
70. Wang, X., Anwer, N., Dai, Y., Liu, A. (2023). ChatGPT for design, manufacturing, and education. *Procedia CIRP*, *Vol. 119*, pp. 7-14, doi: 10.1016/j.procir.2023.04.001
71. *What is GDPR, the EU's new data protection law?* Retrieved from: https://gdpr.eu/what-is-gdpr/, 30.11.2024.
72. Yenduri, G., Ramalingam, M., Selvi, G.C., Supriya, Y., Srivastava, G., Maddikunta, P.K. R., Raj, G.D., Jhaveri. R.H., Prabadevi, B., Wang, W., Vasilakos, A. V., Gadekallu, T.R. (2024). GPT (Generative Pre-trained Transformer) – A Comprehensive Review on Enabling Technologies, Potential Applications, Emerging Challenges, and Future Directions. *IEEE Access, Vol. 12*, pp. 54608-54649, doi: 10.1109/ACCESS.2024.3389497

73. Yu, H., Guo, Y. (2023). Generative artificial intelligence empowers educational reform: current status, issues, and prospects. *Frontiers in Education, Vol 8,* pp. 1-10, doi: 10.3389/feduc.2023.1183162
74. Zajko, M. (2022). Artificial intelligence, algorithms, and social inequality: Sociological contributions to contemporary debates. *Sociology Compass, Vol. 16, Iss. 3*, pp. 1-16, doi: 10.1111/soc4.12962
75. Zewe, A. *A faster, better way to prevent an AI chatbot from giving toxic responses.* Retrieved from: https://news.mit.edu/2024/faster-better-way-preventing-ai-chatbot-toxic-responses-0410, 29.11.2024.
76. Zhang, Y., Liu, C. (2024). Unlocking the Potential of Artificial Intelligence in Fashion Design and E-Commerce Applications: The Case of Midjourney. *Journal of Theoretical and Applied Electronic Commerce Research, Vol. 19, Iss. 1,* pp. 654-670, doi: 10.3390/jtaer19010035