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INNOVATIONS IN THE POLISH OFFSET PRINTING INDUSTRY – A KEY IN BUILDING COMPETITIVE ADVANTAGE IN THE DIGITAL ERA

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Purpose: To examine how innovations implemented by Polish offset printing companies contribute to building competitive advantage in the digital era. The study identifies which innovation types (product, process, marketing, organizational), degrees of novelty, and firm/market characteristics most strongly relate to competitiveness outcomes.
Design/methodology/approach: A nationwide survey of 123 offset printing companies (Poland) was conducted; 85 reported implementing innovations in the past three years. The analysis combines descriptive statistics with non-parametric tests (Mann-Whitney U; Kruskal-Wallis) to assess links between innovation types/novelty and competitiveness benefits across domestic vs. international markets.
Findings: Innovation adoption is shaped by both internal factors (firm size, machine park, print format, age) and external reach (national/international/global markets). Product and marketing innovations show the strongest association with competitiveness—increasing assortment, enabling entry into new markets, and supporting supply-chain optimization—particularly in international markets. Younger firms and those operating at larger scales are more likely to innovate; process and organizational innovations yield operational gains, with competitiveness effects emerging mainly at higher novelty levels.
Research limitations/implications: Results rely on self-reported, cross-sectional data from one country and lack external performance indicators. Future longitudinal and multi-country studies, complemented by qualitative evidence, should validate causality and benchmark objective outcomes. For practitioners, strategic innovation management should prioritize product/market-facing changes while sequencing process/organizational upgrades to amplify competitiveness gains.
Originality/value: This is among the first empirical studies to map the structure, novelty, and effects of innovations in Polish offset printing, disentangling how internal/external conditions and innovation type relate to measurable competitive outcomes in a sector navigating digital transformation.
Keywords: Offset printing, innovation, competitive advantage, digital transformation, Poland, product/marketing innovation, internationalization.
Category of the paper: Research article.

1. Introduction

The Polish printing industry has been experiencing dynamic growth over the past two decades (Cetera, 2015), making Poland an important player on global markets, with the sixth largest global market share, and export revenues exceeding PLN 7 billion, especially in relation to products requiring high-quality printing and post-press - books, children's products (Ministerstwo Rozwoju i Technologii, 2025). These products are largely characteristic of offset printing, guaranteeing very high quality and repeatability of performance.

Given its significant global market share, the development of the printing industry in Poland cannot be achieved without high-volume technologies enabling the fulfilment of very large batches of orders, for which offset printing technology remains relatively well-suited.

The offset printing sector plays a significant role in Poland's industrial structure, providing packaging crucial to key branches such as the food and pharmaceutical industries, which together represent a major share of national industrial output. This is because replacing offset printing with digital printing in packaging production is still an incomplete and slow process, characteristic rather for smaller packaging, such as textile labels (Yilmaz, Cavus, 2018).

Maintaining and developing this industry is also important due to its significance for the automation of trade, transport, and logistics, as it enables the cost-effective production of labels and barcodes read by robots in very large quantities as part of modern sorting, warehousing, and transhipment processes. This applies in particular to RFID tags, which impact the profitability of automation processes because they are much cheaper than chips and transponders (Lopez-Iturri et al., 2023).

The printing industry is undergoing intense technological and organizational transformations. These changes are primarily driven by digital transformation (Merritt, Vilchis-Flores, 2024), which is altering the structure of the industry and leading to the growing popularity of digital printing and 3D printing. At the same time, another driving force behind these changes is regulatory pressure to gradually reduce waste and replace chemicals traditionally used in printing (Reese et al., 2020).

Despite the dynamic changes, scientific knowledge regarding the structure of innovation in the offset printing sector and its impact on business competitiveness remains limited. Academic literature is dominated by technical studies (Tuğrul, 2024; Strižić Jakovljević et al., 2024; Owsiński et al., 2024).

Innovation in the offset printing sector is driven i.a. by the cross-sector competition from the digital printing sector (Burge et al., 2012; Viluksela et al., 2010). Internal sector pressure, on the other hand, is limited by numerous technological and cost-related entry barriers (Burge et al., 2012; Merritt, Vilchis-Flores, 2024).

The offset printing sector is undergoing transformation primarily in two key areas, accompanied by significant structural changes (Merritt, Vilchis-Flores, 2024; Magadán-Diaz and Rivas-Garcia, 2021; Salwin et al., 2020):

1. a shift from a product-focused to a product-service model in supplier relations, with machinery increasingly offered via leasing rather than sale (Salwin et al., 2020),
2. development of hybrid business models that merge traditional offset methods with innovative technologies linked to digital transformation (Magadán-Diaz, Rivas-Garcia, 2021).

The above confirms that the offset printing industry's contemporary development is generally consistent with the diffusion of innovation theory. The spread of digital and hybrid solutions in this industry reflects typical adoption patterns shaped by perceived relative advantage, compatibility with existing practices (e.g. business models), and external pressure (regulation and cross-sector competition). However, there has probably been no study to date that has clearly assessed observations in the offset printing sector in the context of innovation theory.

In particular, there is a need to assess the functioning of this industry in the context of specific models of innovation development. The three-factor model of innovation development accurately reflects the situation of small and medium-sized enterprises in Poland and can serve as the basis for building a theoretical model for research in the Polish offset printing sector. The three-factor model of innovation development assumes that the benefits of innovation lead to the development of the propensity to innovate, while the propensity and ability to innovate determine the development of innovation (Stanisławski, 2020).

The aim of this article is to assess how innovations implemented by Polish offset printing companies contribute to building their competitive advantage in the era of digital transformation in the industry. The article analyses the structure and scale of implemented innovations—including new or significantly modified product, process, marketing, and organizational solutions—and evaluates their impact on operational efficiency, product offering development, and market expansion.

The scientific findings of the paper will be presented in the context of the main theories of innovation and the three-factor model of innovative development.

3. Innovation, Competitiveness, and Digital Transformation in the Offset Printing Industry

3.1. Key Concepts and Definitions

Innovation is the driving force behind effective management and plays a key role in the development of an enterprise. It is a fundamental factor in competitive advantage, technological progress, and sustainable development. Innovation significantly impacts the transformation of companies by optimizing costs and supporting ecological progress. According to definitions that emphasize innovation as a process, novelty and transformation of reality are usually the indicators of whether a given process constitutes an innovation, and based on their outcomes, the scope of the innovation can be determined (Yeremenko, Rudskaya, 2016). According to the Oslo Manual (2018), innovation is a new or significantly improved product or process (or a combination of both) that differs from previous versions and is made available to users or implemented in practice. The manual divides innovation into four types: product innovation, process innovation, organizational innovation, and marketing innovation (OECD/Eurostat, 2018).

A further classification of innovation can be made based on its impact and degree of novelty. Innovations are often described as radical or incremental. Radical innovations result in breakthrough changes that can completely transform existing markets or create entirely new ones, while incremental innovations involve minor improvements or adjustments to existing products or processes (Cabigiosu, Campagnolo, 2016; Garcia, Calantone, 2002).

Innovation is closely linked to a company's competitiveness. Competitiveness is a concept derived from the theory of competitive advantage, which assumes that to survive in a competitive market, companies must offer a unique value proposition and strategy that ultimately allows them to outperform rivals (Lee, Karpova, 2018). There is no single, universally accepted definition of competitiveness (Dzikowska, Gorynia, 2012). Most broadly, competitiveness can be defined as the ability to compete with other market players (Pavliuk, Noda, 2020).

Competitiveness depends on both external and internal factors. External factors include access to technology (Amadasun, Mutezo, 2022), partnerships formed to access such technology (Lahiri, Narayanan, 2013), the overall innovativeness of the its macroeconomic stability (Yu, 2023), appropriate state fiscal policy (Jabłońska-Porzuczek, Smoluk-Sikorska, 2016), and access to infrastructure, trade efficiency and national economic specialization (Lee, Karpova, 2018). Other external factors include the ability of a sector or geographic region to attract people and capital (Čučković et al., 2013).

Internal factors of competitiveness include strategic leadership (Oracha et al., 2021), efficiency in resource management (Purwohandoko, 2018), including knowledge resources (Ma et al., 2019), flexibility in responding to market needs (Games, Roliza, 2019), strategic

planning abilities related to resource provision and use (Davcik, Sharma, 2016), organizational culture (Naidoo, Sutherland, 2016), the ability to adapt to consumer demands (Tumalanov et al., 2017), as well as company image (Zhan-Hui et al., 2011) and effective brand management (Qureshi et al., 2022).

Competitiveness is closely linked to innovation capability, innovation willingness, and the external environment, which together form a three-factor model of innovation development that supports long-term competitive advantage of the enterprise (Stanisławski, 2015). In increasingly competitive markets, innovation gains importance as it enables firms to outperform rivals and adapt to market changes (Distanont, Khongmalai, 2018).

Another important factor influencing the level of competitiveness is digital transformation (Härting et al., 2020), that includes, in particular, the implementation of modern IT tools (artificial intelligence, Internet of Things (IoT), process automation, cloud computing, data analysis, and others), as well as the adaptation of organizations to these technologies (Antczak, Kos, 2022), requiring continuous changes in the mindset of decision-makers and structures (Azieva, 2021). It is not limited to operational improvements; but includes redefining business models, enhancing customer experiences (Cennamo et al., 2020), and adapting organizational culture, regulatory frameworks, and service delivery mechanisms (Manny et al., 2021).

Only the companies that successfully implement digital transformation strategies can increase their operational efficiency and adaptability in fast-changing markets (Yao et al., 2023; Takriti, 2023). The greater their capabilities in implementing information and communication technologies, the better they translate digital transformation into innovation (Zhu, 2024).

Key factors of digital transformation include access to technology (Antczak, Kos, 2022), qualified employees (Xin et al., 2022), cooperation with external entities (Li et al., 2017), and awareness of the cybersecurity (Antczak, Kos, 2022).

The transformation of the printing industry has so far been studied in the context of several theories of innovative development.

Schumpeterian innovation theory posits that economic development is driven by innovations introduced by entrepreneurs, which lead to "creative destruction"— the displacement of old technologies by new ones, which in turn generates increased productivity and profitability (Ülgen, 2013). Neo-Schumpeterian and systems-based approaches, on the other hand, assume that innovations arise from cumulative learning processes as well as the collaboration between companies or other stakeholders (research institutions, states), and that their effectiveness depends on the quality of the innovation system and the organization's ability to absorb the knowledge (Urmetzer et al., 2018). These findings are broadly complemented by E. Rogers's theory of innovation diffusion. According to this theory, the dissemination of specific solutions depends on their advantages over existing solutions, compatibility, complexity, testability, and observability of effects (Mohammadi, 2018).

The printing industry has, in many empirical observations, to some extent eluded older theories of innovation. The first stage of development of the printing industry, associated with the invention of the printing press, challenges Schumpeterian innovation theory because it did not lead to an increase in productivity or per capita income, despite being technologically groundbreaking. The second stage, associated with automation and job reduction, is inconsistent with neo-Schumpeterian and systemic theories of innovation, which assume broad social and organizational benefits resulting from innovation, whereas the observable effect of technological change in this industry is a decline in employment and related business costs (Chungu, 2024).

3.2. Technological and organizational transformations in the offset printing sector

The global printing industry is experiencing significant changes, particularly related to digital transformation, especially the shift from generic offset to digital printing, which is generally faster, more cost-effective, environmentally friendly, and operationally simpler due to minimal machine reconfiguration, lower energy use, and reduced waste (Mirković, 2024).

However, a substantial part of the printing industry continues to rely on offset technology, as it remains profitable for larger production runs and offers excellent detail quality, difficult to maintain in long digital print runs (Vukoje et al., 2021; Spiridonov et al., 2020), which is particularly important for art printing and packaging (Jakovljević, 2024).

Despite the seemingly declining nature of the technology, process innovations in offset printing continue to develop intensively (Hauck, 2015). Despite the lack of transition to digital printing, offset companies are also undergoing a digital transformation that involves supplementing traditional models with online sales and digital distribution, allowing firms to expand their customer base and sustain long-run orders as well as automating the design, production, invoicing, and delivery processes to reduce digital printing's speed advantage (Magadán-Diaz, Rivas-Garcia, 2021).

Digitization in offset printing relies on data (Salwin, 2020), particularly through the implementation of IoT solutions (Meissner, 2021). Moreover, while industrial automation supports the competitiveness of offset printing companies, offset printing itself remains essential to the adoption of automation in other industries by delivering diverse printed solutions, for example, labels read by robots (Perera et al., 2021; Kerndl, Šteffan, 2020).

Against the backdrop of the above review of existing knowledge, many uncertainties and questions remain, creating a cognitive gap.

Although digital transformation, process automation, and business model changes in the offset printing sector are widely seen as factors that enhance competitiveness, there is a lack of systematic, empirical research that definitively quantifies the impact of specific types of innovation (product, process, marketing, organizational) on the competitiveness of these companies. In particular, it is unclear which innovations generate the greatest benefits in both domestic and international markets, or to what extent differences in innovation scale affect

companies' ability to maintain competitive positions in a rapidly changing business environment.

Research further suggests that the implementation of innovations by printing companies depends on both internal and external conditions (Magadán-Diaz, Rivas-Garcia, 2021), yet these factors are not systematically analysed. Relational resources—shaped by structural characteristics and the business environment—are likely to be significant innovation drivers (Salwin et al., 2020), but it remains an open question which specific internal and external factors measurably influence innovation development in this sector. This issue is particularly important for management theory, as some authors believe that the propensity for innovation is directly tied to company size (Codogini et al., 2013). If so, innovation should be most strongly linked to structural factors in sectors where innovation capacity is also likely to depend heavily on market position (Salwin et al., 2020). On the other hand, innovations are also the driving force behind small and medium-sized enterprises, which themselves drive the entire economy (Stanisławski, 2022). Therefore, innovations should be accessible to individual entities regardless of their structural characteristics.

Moreover, while printing companies acknowledge that digital transformation brings performance benefits, little research exists on how these initial gains drive further innovation adoption. In other words, it is unclear whether innovation-based growth models in the offset printing industry are sufficient to ensure lasting competitiveness—or whether these are simply transitional adaptations buying time before a shift to digital printing. It is also uncertain whether offset printing companies are truly innovation-driven, and whether those that successfully implement innovations are more likely to seek additional novel solutions. This represents an important research gap, as management theory strongly suggests that the willingness to innovate is closely linked—if not equivalent—to the perception of innovation benefits (Stanisławski, 2015). The printing sector should not deviate from this paradigm, yet empirical studies on this are lacking.

Identified Research Hypotheses Corresponding to the Cognitive Gap:

H0: Innovations implemented in the past three years have a positive impact on the competitiveness of offset printing companies in Poland.

H1: Innovations implemented by offset printing companies in Poland vary in terms of type (scope) and degree of novelty.

H2: The level of innovation implementation depends on internal conditions of offset printing companies—such as structural characteristics, areas of activity, and experience—as well as external conditions, such as the markets in which they operate.

H3: Implemented innovations directly influence the willingness (benefits) of offset printing companies to adopt further novel solutions.

H4: The benefits generated depend on the type (and degree) of innovation introduced—product and marketing innovations generate the most significant advantages compared to process or organizational innovations.

H5: Improved competitiveness of offset printing companies is the most important benefit achieved in both domestic and international markets.

To better illustrate the impact of innovation in Polish offset printing companies, a model was created for the given hypotheses (see Figure 1).

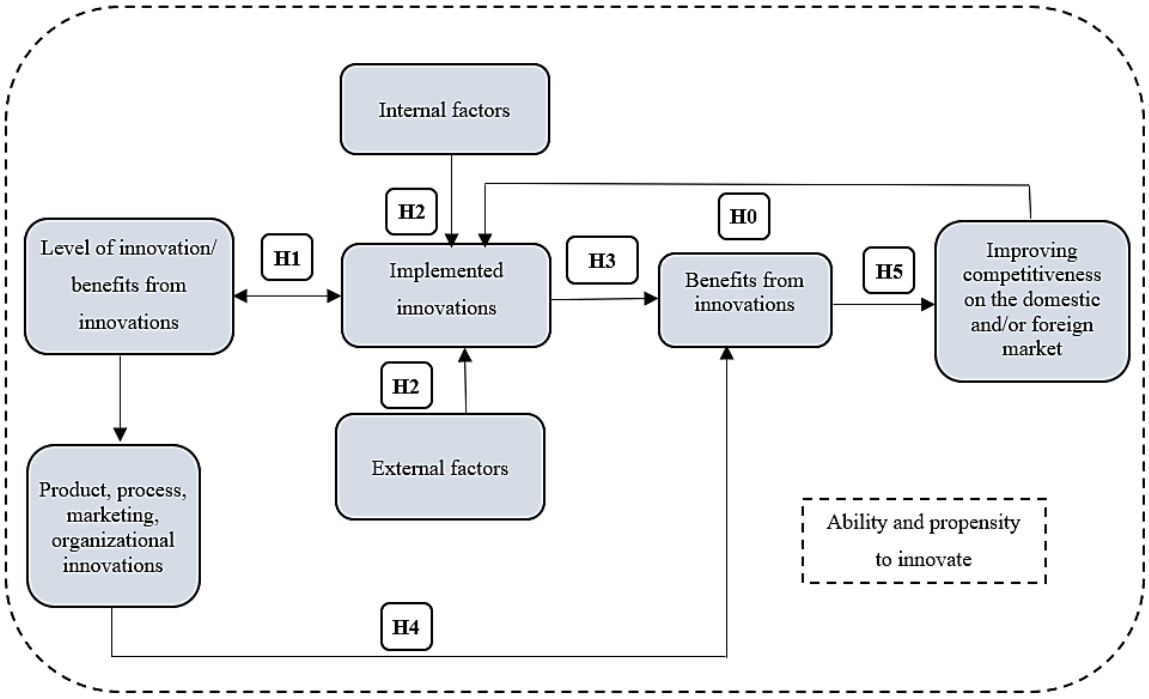

Figure 1. A model to the given hypotheses.

Source: Author's own research.

4. Research methods

4.1. Subject and method of study

The population in this study consists of offset printing companies operating in Poland, equipped with at least one offset printing machine. The data collection was conducted through an online survey from March to May 2023. Responses were obtained from 123 representatives of offset printing companies, which constitutes a representative sample of the studied population (Table 1).

Table 1.
Description of the research group

Distribution of responses	
Factor	All companies (including those that did not introduce innovations)
Company size	
Micro	9 (7.3%)
Small	60 (48.8%)
Medium	49 (39.8%)
Large	5 (4.1%)
Dominant market	
Global	7 (5.7%)
National	42 (34.1%)
International	53 (43.1%)
Regional	20 (16.3%)
Local	1 (0.8%)
Dominant printing profile (focus sector)	
Books / magazines / art	24 (19.5%)
Label (including in mould labeling - IML)	6 (4.9%)
Forms / personalization	4 (3.3%)
Packaging (food and non-food)	32 (26%)
Advertising	56 (45.5%)
Gazette	1 (0.8%)
Number of offset print machines	
1-2	72 (58.5%)
3-4	31 (25.2%)
5-6	81 (4.6%)
7 and more	(1.6%)

Source: Author's own research.

4.2. Statistical Methods

The analysis employed statistical methods to describe the distribution of responses and the structural characteristics of entities. The Mann-Whitney U test (Mann, Whitney, 1947), a semiparametric test, was used to determine intergroup differences. The jamovi project® software (2024) facilitated hypothesis testing using data from 85 enterprises that had implemented innovations.

The criteria for assessing competitiveness improvements included:

1. Expanded range of printing products and services.
2. Entry into new markets or increased market share.
3. Reduced production/labour costs.
4. Improved product quality/reduction in complaints.
5. Time-related process improvements.
6. Enhanced work/production efficiency.

7. Lower unit prices for customers.
8. Increased printing order volumes.
9. Supply chain optimization.
10. Broader range of additional services.
11. Development of online ordering platforms.

Additionally, the impact of innovations on key benefits over the past three years was explored. Cross-group differences were measured using the Mann-Whitney U test for the following industry-specific categories:

1. Employee skill and competence enhancement.
2. Improved financial performance.
3. Reduction in complaints from printing/finishing processes.
4. Establishment of new industry relationships.
5. Compliance with standards and regulations (e.g., FOGRA, FSC, BRC).
6. Reduced environmental impact.
7. Enhanced competitiveness.
8. Improved company image.
9. Increased stability.
10. Faster order fulfilment.
11. Geographical proximity to customers.
12. Digitalization of business processes.
13. E-commerce and online sales development.
14. Increased security of data/graphic files.
15. Other benefits.

5. Results and discussion

5.1. Sample description

123 responses were obtained from Polish companies in the offset printing industry. 85 of them (69.1%) implemented innovations in the last three years, while 38 (30.9%) did not (Table 2). Data came from all seventeen regions of the country and were relatively evenly distributed geographically.

Table 2.
Percentage of companies that have introduced innovations in the last three years

Yes		NO		Together	
Number of replies	%	Number of replies	%	Number of replies	%
85	69.11%	38	30.89%	123	100%

Source: Author's own research.

Most innovative companies in the Polish offset printing sector are medium-sized (54.1%) or small (36.5%) enterprises. Notably, medium-sized firms are disproportionately represented among innovators (54.1%) compared to the general sample (39.8%). In contrast, innovations are less frequently implemented in small enterprises (36.5% vs. 48.8%) and microenterprises (3.5% vs. 7.3%). Innovative firms are predominantly located in metropolitan areas or provincial capitals (40%) and larger cities with populations exceeding 100,000 (22.35%). This urban concentration is more pronounced among innovators (40%) compared to the overall sample (35.8%).

Most innovative companies operate in international (57.65%) or national (30.59%) markets, with minimal focus on regional or local markets.

Innovators are more engaged in packaging printing compared to the general sample (37.7% vs. 26%) but are less involved in print advertising (29.4% vs. 45.5%).

The production infrastructure of printing houses highlights the number and types of machines as key structural features. Companies with 1-2 offset machines represent the largest group among innovators (45.88%), followed by those with 3-4 machines (31.76%). Fewer firms operate with five or more machines, although innovators generally have larger machine parks. For example, 22.4% of innovators operate five or more offset presses, compared to just 6.2% of the general sample.

A significant structural factor in the studied industry is undoubtedly the ability to produce large-format prints. In this regard, it is clear that innovative companies tend to prefer large formats. The B1 format, used by 57.65% of innovators, the B0 format, found in 7.06% of innovators, supports even larger sheet sizes. the B2 format, used by 23.53% of innovators, is the second most popular and is associated with medium-sized productions, such as brochures, catalogues, or books. Smaller formats, including A1 (5.88%), A2 (2.35%), and B3 (3.54%), are used less frequently.

It is also clear that the lack of innovation is related to smaller formats. For instance, 57.7% of innovators use the B1 format compared to 43.9% of the general sample.

Table 3.

Structural characteristics of the study group, including companies that introduced innovations

Distribution of responses	
Factor	Companies that introduced innovations
Company size	
Micro	3 (3.5%)
Small	31 (36.5%)
Medium	46 (54.1%)
Large	5 (5.9%)
Company location	
Rural area	4 (4.7%)
Small town (to 20,000 inhabitants)	9 (10.6%)
Medium town (20,001 to 100,000 inhabitants)	19 (22.4%)
City (above 100.001 inhabitants)	19 (22.4%)
Large city agglomeration/regional capital	34 (40.0%)
Dominant market	
Global	7 (8.2%)
National	26 (30.6%)
International	49 (57.7%)
Regional	3 (3.5%)
Local	-
Dominant printing profile (focus sector)	
Books / magazines / art	20 (23.53%)
Label (including in mould labeling - IML)	6 (7.06%)
Forms / personalization	2 (2.35%)
Packaging (food and non-food)	32 (37.65%)
Advertising	25 (29.41%)
Newspaper	-
Number of offset print machines	
1-2	39 (45.88%)
3-4	27 (31.76%)
5-6	17 (20.00%)
7 and more	2 (2.35%)
Dominant print format	
A1	5 (5.88%)
A2	2 (2.35%)
B0	6 (7.06%)
B1	49 (57.65%)
B2	20 (23.53%)
B3	3 (3.54%)

Source: Author's own research.

5.2. Innovations in the Polish offset print sector

All four main types of innovation are prevalent in the Polish offset printing sector Among innovative enterprises, 62.35% introduced product innovations, 57.65% process innovations, 48.24% organizational innovations, and 29.41% marketing innovations, with product innovations also adopted by over 40% of all surveyed firms (table 4).

Table 4.
Percentage of enterprises that have introduced innovations of types in the last three years

	Yes		NO		Together	
Type of innovation	**Number of replies**	**%**	**Number of replies**	**%**	**Number of replies**	**%**
Product	53	62.35%	32	37.65%	85	100%
Process	49	57.65%	36	42.35%	85	100%
Marketing	25	29.41%	60	70.59%	85	100%
Organizational	41	48.24%	44	51.76%	85	100%

Source: Author's own research.

Product innovations are most often sporadic (45.3%), with a moderate share of evolutionary (30.2%) and radical (24.5%) innovations. They most often reach a national scale (56.6%), while at the company level they constitute 36.9%. However, the surveyed entities also implemented product innovations that were new on a global scale (3.8%).

In most of the surveyed entities, these innovations had a large impact on the innovative development of the company (56.6%), with a medium impact in some cases (30.2%). A very large impact was less frequent (11.3%), and a small impact was almost negligible (1.9%).

Process innovations are most often characterized by a sporadic degree of breakthrough (44.9%), but the share of radical innovations is also significant (36.7%). The evolutionary nature of process innovations is much rarer (18.4%). In terms of the scale of innovations, those on a company scale dominate (53.1%), followed by innovations on a national scale (44.9%), while innovations on a global scale are very rare (1.9%).

The impact of process innovations on company development was most often high (57.1%), with a moderate share of cases with medium impact (26.5%). A very high impact was noted in 14.3% of cases, while a small impact was marginal (1.9%).

Marketing innovations are characterized by a relatively even distribution between evolutionary and sporadic degrees of breakthrough (31-34.5%). In terms of the scale of novelties, company-scale novelties dominate (55.2%), with a relatively large share of national-scale novelties (44.8%). However, no marketing innovations among the surveyed companies were new on a global scale. The impact on the development of the company was most often described as large (48.3%), with a smaller share of cases with medium impact (27.6%). A very large impact was observed in 20.7% of entities, while a small impact was marginal (3.4%).

Organizational innovations are characterized by a dominant share of evolutionary changes (53.7%), followed by innovations (31.7%), with the smallest share recorded for radical innovations (14.6%). In terms of the scale of novelties, organizational innovations most often occur at the company level (70.7%), while fewer are new solutions on a national scale (29.3%). No innovations with a global degree of novelty were declared in this category. Regarding their impact on company development, the largest share falls on cases with a high impact (68.3%), followed by a medium impact (22%). A very high impact accounted for 7.3%, while a small impact remains marginal at 2.4%. This is summarized in Table 5.

Table 5.

Product, process, marketing and organizational innovations by degree of breakthrough, scale of novelty and impact on company development

Factor	Scale	Product	Process	Marketing	Organizational
Degree of breakthrough	Evolutional	16 (30.2%)	9 (18.4%)	10 (34.5%)	22 (53.7%)
	Radical	13 (24.5%)	18 (36.7%)	9 (31%)	6 (14.6%)
	Occasionally	24 (45.3%)	22 (44.9%)	10 (34.5%)	13 (31.7%)
Scale of novelty	Business	21 (36.9%)	26 (53.1%)	16 (55.2%)	29 (70.7%)
	Country	30 (56.6%)	22 (44.9%)	13 (44.8%)	12 (29.3%)
	World	2 (3.8%)	1 (1.9%)	-	-
Impact on the innovative development of the company	Very big	6 (11.3%)	7 (14.3%)	6 (20.7%)	3 (7.3%)
	Big	30 (56.6%)	28 (57.1%)	14 (48.3%)	28 (68.3%)
	Mediocre	16 (30.2%)	13 (26.5%)	8 (27.6%)	9 (22%)
	Small	1 (1.9%)	1 (1.9%)	1 (3.4%)	1 (2.4%)
	Very small	-	-	-	-

Source: Author's own research.

Medium-sized companies (58.57%) are the largest group reporting tangible benefits (table 5), followed by small businesses (31.43%).

Table 6.

Percentage of enterprises that achieved measurable benefits from implemented innovations

Companies that have introduced innovations					
Yes		NO		Together	
Number of replies	%	Number of replies	%	Number of replies	%
70	82.35%	15	17.65%	85	100%

Source: Author's own research.

Companies (table 7) with 1-2 offset presses are the largest group experiencing benefits (38.57%), followed by those with 3-4 presses (34.29%). The B1 format is the most popular among companies experiencing benefits (60%), followed by B2 (20%) and B0 (8.57%).

Table 7.
Enterprises that achieved measurable benefits from implemented innovations

Distribution of responses		
Scale	Number of replies	%
Company size		
Micro	2	2.86%
Small	22	31.43%
Mediocre	41	58.57%
Big	5	7.14%
Number of offset machines		
From 1 to 2	27	38.57%
From 3 to 4	24	34.29%
From 5 to 6	17	24.29%
7 and more	2	2.86%
Dominant print format		
A1	3	4.29%
A2	2	2.86%
B0	6	8.57%
B1	42	60.00%
B2	14	20.00%
B3	3	4.29%

Source: Author's own research.

Companies reported tangible benefits, particularly in the areas of competitiveness, financial performance, and corporate image. Moderate benefits included environmental sustainability, employee development, and digital transformation (Table 8).

Table 8.
Summary of measurable benefits resulting from implemented innovations

Factor	No benefits	Very little benefit	Small	Mediocre	Big	A very big benefit
Raising employee qualifications and competences	3	8	16	16	**20**	7
Improving the company's financial situation	0	6	13	21	**24**	6
Reduction in the number of complaints resulting from the printing or finishing process	0	6	18	18	**21**	7
Establishing new relationships with industry players	3	5	12	19	**25**	6
Compliance with printing regulations, norms and standards (FOGRA, FSC, BRC or equivalent)	6	7	7	**27**	15	8
Reducing environmental impact	2	7	16	17	**20**	8
Improving the company's competitiveness	0	6	5	14	**33**	12
Improving the company's image	1	5	7	11	**32**	14
Increased company stability	0	3	8	16	**31**	12
Speed of order fulfilment	0	2	9	**24**	**24**	11
Location (distance from customer)	17	**19**	12	10	8	4
Digitalization of business processes	3	7	12	20	**22**	6

Cont. table 8.

Development of e-commerce and online sales of printed materials	10	11	3	17	**22**	7
Increased security of data/graphic files	8	6	11	**17**	15	13
Other	**35**	8	9	5	11	2

Source: Author's own research.

The surveyed companies experience an improvement in competitiveness because of the implemented innovative changes in practically every area of their activity. The greatest impact on the improvement in competitiveness is visible around operational efficiency, in the form of streamlining processes related to the time of task completion and increased production efficiency (Table 9).

Table 9.
Improving competitiveness through innovation

Factor	No improvement	Very small	Small	Mediocre	Big	A very big improvement
Increasing the range of printing products and services;	2	7	19	12	**21**	9
Entering new markets or increasing share in existing markets;	1	12	12	13	**23**	9
Reduction of production/labour costs;	3	5	14	16	**26**	6
Improved product quality/fewer complaints	0	3	16	18	**25**	8
Improving time-related processes	0	4	12	15	**32**	7
Increasing work/production efficiency;	0	3	11	16	**33**	7
Reduced unit price for customers	3	10	18	17	**18**	4
Increase in the volume of printing orders	1	5	10	**23**	**23**	8
Supply chain optimization	1	9	15	18	**24**	3
Expanding the range of additional services	2	11	11	15	**25**	6
Development of online ordering platforms	9	7	13	11	**26**	4

Source: Author's own research.

6. Results

6.1. Verification of the hypotheses

The study aimed to determine whether the innovations implemented in the last three years have a positive impact on the competitiveness of companies in the offset printing industry in Poland, which was reflected in the verification of five detailed hypotheses. The formulated hypotheses were largely confirmed.

Companies that introduced innovations (Table 10) differ from those that did not introduce innovations in the Mann-Whitney U test in terms of: market of operation ($p < .001$, $r = 0.693$, large effect size), number of employees ($p < .001$, $r = 0.556$, large effect size), year of establishment ($p = .002$, $r = 0.307$, large effect size), dominant printing sector ($p < .001$, $r = 0.576$, large effect size), number of machines ($p < .001$, $r = 0.425$, large effect size), and dominant printing format ($p < .001$, $r = 0.540$, large effect size). However, the location of the company was not significant ($p = 0.313$, $r = 0.110$).

Table 10.
Factors of innovation of any type (Mann-Whitney U; n = 123)

Factor	p-value	Effect size (r)
Market operation	< .001	0.693
Number of employees	< .001	0.556
Year of establishment	0.002	0.307
Dominant printing sector	< .001	0.576
Number of machines	< .001	0.425
Dominant printing format	< .001	0.540
Company location	0.313	0.110

Source: Author's own research.

H2 is positively verified, as the implementation of innovations is significantly influenced by internal and external conditions of offset printing companies.

Dependence of Innovation Implementation on Internal and External Conditions

All considered structural factors and company environment characteristics, given the reported effect size values, are strong determinants of innovation in the offset printing sector. Further analysis of the directions of influence indicates that, in all cases except for the year of company establishment, there is a negative difference in means. This means that the longer a company has been in business (market experience), the lower the likelihood of innovation. Conversely, the larger the number of employees, the number of offset machines, and the print size, the higher the chance of innovation. Similarly, the broader the market in which a company operates (international, global vs. local, regional), the higher the likelihood of innovation.

Regarding printing types, the likelihood of innovation, ranked from highest to lowest, is as follows:

1. Packaging printing (100%, n = 32).
2. Label printing, including IML (100%, n = 6).
3. Book printing, including books (83.3%, n = 24).
4. Advertising printing (44.6%, n = 56).
5. Forms and personalization materials printing (50%, n = 4).
6. Newspaper printing (0%, n = 1).

None of the structural factors or company environment factors listed so far (Table 11) independently influenced the likelihood of product innovations (no statistically significant differences between groups). The only exception was the dominant printing sector, which independently determines product innovations ($p < 0.001$).

Table 11.
Factors of product innovation (Mann-Whitney U; n = 123)

Factor	p-value	Effect size (r)
Market operation	0.135	0.1722
Number of employees	0.819	0.0271
Year of establishment	0.034	0.2123
Dominant printing sector	< .001	0.4281
Number of machines	0.290	0.1285
Dominant printing format	0.297	0.1215
Company location (population size)	0.283	0.1338

Source: Author's own research.

H2 is further positively verified, with evidence that structural and environmental factors strongly determine the likelihood of innovation implementation.

Regarding the factors influencing process innovation, the only statistically significant factor is the length of the company's operation – the younger the company, the higher the likelihood of process innovation ($p = 0.019$).

Table 12.
Factors of process innovation (Mann-Whitney U; n = 123)

Factor	p-value	Effect size (r)
Market operation	0.490	0.0782
Number of employees	0.217	0.1406
Year of establishment	0.019	0.2296
Dominant printing sector	0.926	0.0119
Number of machines	0.646	0.0550
Dominant printing format	0.067	0.2086
Company location (population size)	0.128	0.1859

Source: Author's own research.

The implementation of marketing innovations (Table 13) statistically significantly differentiates the sample only in relation to the number of printing machines ($p = 0.027$), while all other factors are not individually significant.

Table 13.
Factors of marketing innovation (Mann-Whitney U; n = 123)

Factor	p-value	Effect size (r)
Market operation	0.142	0.1730
Number of employees	0.188	0.1564
Year of establishment	0.530	0.0647
Dominant printing sector	0.930	0.0117
Number of machines	0.027	0.2740
Dominant printing format	0.118	0.1860
Company location (population size)	0.080	0.2229

Source: Author's own research.

None of the considered factors are individually statistically significant in relation to organizational innovations (Table 14).

Table 14.
Factors of organizational innovation (Mann-Whitney U; n = 123)

Factor	p-value	Effect size (r)
Market operation	0.400	0.09424
Number of employees	0.128	0.17129
Year of establishment	0.251	0.11142
Dominant printing sector	0.260	0.13581
Number of machines	0.606	0.06098
Dominant printing format	0.937	0.00942
Company location (population size)	0.131	0.18237

Source: Author's own research.

To examine the impact of both structural and environmental factors on the level of innovation implementation in companies, further analysis was conducted using the Kruskal-Wallis test. This analysis focused on a subgroup of companies that had implemented innovations (n = 85) and considered the degree of novelty (innovation at the company, national, or global level). Within this subgroup, factors such as the number of employees, the company's founding year, market presence, and dominant printing format were not independent determinants of the scale of innovation novelty (no statistical significance). However, the business sector significantly influenced the scale of marketing innovation novelty ($p = 0.024$, $\varepsilon^2 = 0.40$; large effect). Conversely, the number of offset machines was a determinant of the scale of product innovation novelty ($p = 0.003$, $\varepsilon^2 = 0.27$, large effect) and a very strong determinant of process innovation novelty ($p < 0.001$, $\varepsilon^2 = 0.36$).

H3 is positively verified, as the implementation of innovations directly influences the scale of novelty, with factors such as the number of offset machines significantly affecting the novelty of product and process innovations.

Direct Effect of Implemented Innovations on Willingness (Benefits) to Adopt Novel Solutions

Using the Mann-Whitney U test, the benefits derived from innovations were examined within the subgroup of companies that had implemented innovations, using the three-factor model of innovation development (Stanisławski, 2020), which equates to innovation propensity. Statistically significant benefits of product innovations included establishing new relationships with industry entities ($p = 0.010$, $r = 0.381$, medium effect), location (distance from the client) ($p = 0.010$, $r = 0.389$, medium effect), and a reduction in complaints related to printing or post-press finishing ($p = 0.050$, $r = 0.293$, medium effect).

For process innovations, statistically significant benefits were identified in improving employees' qualifications and competencies ($p = 0.023$, $r = 0.31993$, medium effect), location (distance from the client) ($p = 0.035$, $r = 0.29808$, medium effect), and benefits categorized as "other" in the survey ($p = 0.005$, $r = 0.37850$, medium effect).

Marketing innovations were linked to benefits such as establishing new industry relationships ($p = 0.001$, $r = 0.4498$, strong effect), compliance with regulations, norms, or standards related to printing ($p = 0.013$, $r = 0.3410$, medium effect), location (distance from the client) ($p = 0.002$, $r = 0.4345$, strong effect), digitalization of business processes ($p = 0.004$, $r = 0.3954$, medium effect), increased security of data/graphic files ($p = 0.004$, $r = 0.4031$, medium effect), and other benefits ($p = 0.027$, $r = 0.2925$, medium effect).

Statistically significant benefits of organizational innovations included establishing new industry relationships ($p < .001$, $r = 0.51755$, strong effect), compliance with printing-related regulations, norms, or standards ($p < .001$, $r = 0.44408$, strong effect), reducing complaints related to printing or post-press finishing ($p = 0.004$, $r = 0.38612$, medium effect), location (distance from the client) ($p < .001$, $r = 0.47347$, strong effect), supply chain optimization ($p = 0.004$, $r = 0.39102$, medium effect), reduced environmental impact ($p = 0.047$, $r = 0.26939$, medium effect), and other benefits ($p = 0.020$, $r = 0.30122$, medium effect).

H4 is positively verified, as product and marketing innovations are shown to generate the most significant and diverse benefits compared to process and organizational innovations.

Competitiveness Improvement as the Primary Benefit in Domestic and Foreign Markets

Similarly, using the Mann-Whitney U test on data from companies that implemented innovations ($n = 85$), intergroup differences in the development of printing firms' competitiveness were examined. Product innovations were associated with competitive development benefits such as an increase in the range of printed products and services ($p = 0.005$, $r = 0.424$, strong effect), entry into new markets or increased market share ($p = 0.033$, $r = 0.320$, medium effect), supply chain optimization ($p = 0.009$, $r = 0.388$, medium effect), and expansion of additional services ($p = 0.041$, $r = 0.305$, medium effect). Additionally, product innovations had a beneficial impact on the scale of competitiveness improvement for supply chain optimization ($p = 0.029$, $r = 0.302$, medium effect).

Statistically significant benefits for competitiveness improvement from process innovations included streamlining task completion times ($p = 0.003$, $r = 0.40734$, strong effect). However, process innovations did not significantly impact the scale of competitiveness improvement.

Marketing innovations contributed to competitiveness improvement in supply chain optimization ($p = 0.015$, $r = 0.3325$, medium effect), but their impact on the scale of competitiveness improvement was not significant.

Organizational innovations brought significant benefits in terms of supply chain optimization ($p = 0.004$, $r = 0.39102$, medium effect), yet they did not significantly affect the scale of competitiveness improvement.

Variation in Innovation Benefits by Type and Scale, with Product and Marketing Leading

Further exploratory analysis using the Kruskal-Wallis test revealed that none of the listed benefits for innovation development or competitiveness improvement depended on the scale of product innovation novelty. While product innovations were linked to the highest number of statistically significant benefits, the scope of novelty (whether at the company, national, or global level) did not play a determining role.

In contrast, process innovations exhibited fewer benefits overall but showed a strong correlation between the scale of novelty and specific advantages. Benefits dependent on the scale of process innovations included employee qualification and competency improvements ($p = 0.007$), expansion of printed product and service offerings ($p = 0.005$), task completion efficiency ($p = 0.024$), an increase in print order volumes ($p = 0.016$), expansion of additional services ($p = 0.028$), and increased competitiveness due to expanded product offerings ($p = 0.007$) and increased order volume ($p = 0.031$). This suggests that while product innovations bring tangible benefits regardless of novelty scale, process innovations only yield significant advantages when implemented on a national scale.

A similar pattern applies to marketing innovations, where novelty scale was linked to benefits such as improved employee qualifications and competencies ($p = 0.003$), enhanced financial stability ($p = 0.014$), fewer complaints related to printing or post-press finishing ($p = 0.020$), compliance with regulations and standards ($p = 0.031$), increased company stability ($p = 0.044$), faster order fulfilment ($p = 0.014$), expanded product offerings ($p = 0.005$), entry into new markets or increased market share ($p = 0.021$), reduced production costs ($p = 0.010$), and higher productivity ($p = 0.027$). Additionally, the level of marketing innovation novelty appeared to influence firms' perceived adequacy of benefits in relation to their innovation development expectations ($p = 0.036$).

Even more factors were linked to benefits for both innovation development and competitiveness improvement, including higher perceived competitiveness improvement as a benefit of innovation development ($p = 0.016$), expanded product offerings ($p = 0.018$), entry into new markets or increased market share ($p = 0.018$), increased productivity ($p = 0.046$), expanded additional services ($p = 0.004$), and improved competitiveness in the areas of market expansion ($p = 0.003$), task efficiency ($p = 0.032$), productivity ($p = 0.029$), and increased print order volumes ($p = 0.027$).

To assess the markets where competitiveness improvement occurred, the Mann-Whitney U test was conducted ($n = 85$). The results suggest that competitiveness improvements were visible in both domestic and international markets, with stronger effects in international markets. Market conditions influenced the frequency of competitiveness improvement in several areas, including:

Expansion of printed product and service offerings ($p = 0.013$, $\varepsilon^2 = 0.15731$, medium effect), as well as the scale of competitiveness improvement in this area ($p = 0.010$, $\varepsilon^2 = 0.16334$, strong effect).

Entry into new markets or increased market share ($p = 0.050$, $\varepsilon^2 = 0.11357$, medium effect), with the scale of competitiveness improvement in this area being statistically significant ($p = 0.007$, $\varepsilon^2 = 0.17602$, strong effect).

Supply chain optimization ($p = 0.024$, $\varepsilon^2 = 0.13707$, medium effect).

Expansion of additional services ($p = 0.007$, $\varepsilon^2 = 0.17615$, strong effect).

Increased print order volumes ($p = 0.032$, $\varepsilon^2 = 0.12740$, medium effect).

Pairwise comparisons using the DSCF method revealed that significant statistical differences in competitiveness improvement occurred between companies operating in domestic vs. global markets, particularly for expanded product offerings ($p = 0.028$) and increased print order volumes ($p = 0.039$).

H5 is positively verified, as improved competitiveness emerges as the most significant benefit of innovation, observed across both domestic and international markets, with stronger effects internationally.

7. Discussion

Our results are consistent with previous academic publications on innovation in the printing industry as we confirmed that the innovation it this sector encompasses not only technological but also business model (organizational, marketing) innovations (Magadán-Diaz, Rivas-Garcia, 2021; Salwin et al., 2020).

The results confirm Schumpeter's theory assumption that innovation is strongly related to firm-level structural advantage (scale, equipment intensity, market orientation—all enablers of "creative destruction"). However, this theory is partly contradicted by the finding that older companies show lower levels of innovation, even though it assumes that big, well-established firms are the main drivers of innovation.

Scientific interpretations diverged to the time being as to whether innovation capacity stems primarily from company size (Codogini et al., 2013) or whether it is an inherent feature of small and medium-sized enterprises that serve as the engine of the economy (Stanisławski, 2022). Some scholars argued that younger firms are more open to innovation-related risk as part of a resource accumulation strategy rather than for short-term financial return (Coad et al., 2016), and that innovation receptivity may be lower in firms with longer-tenured employees (Verworn, Hipp, 2009). This supports perspectives emphasizing the role of firm age in shaping innovation dynamics (Kalbuana et al., 2022; Xu et al., 2020; Coad et al., 2016; Verworn, Hipp, 2009).

There are no discrepancies with the general interpretation of neo-Schumpeterian models. Their assumptions regarding cumulative learning and organizational capabilities are reflected in the role of internal factors and in the differentiation of innovation outcomes by type. Since the level of novelty correlates with benefits in process and marketing innovations (but not product innovations), this confirms the theoretical assumption that innovation outcomes depend on a firm's absorptive capacity and the integration of technological and organizational procedures (Sancho‑Zamora et al., 2022), not solely on the objective novelty of the innovation.

The strategic role of marketing innovation in facilitating digital market access is highlighted in the literature (Magadán-Diaz, Rivas-Garcia, 2021). Innovation benefits are interpreted differently depending on their orientation—those associated with product and marketing innovation are seen as mechanisms of market expansion, while process and organizational innovations relate more closely to internal efficiency. Such differences correspond with broader theoretical models distinguishing between exploration and exploitation, and between externally- versus internally-facing innovation effects (Magadán-Diaz, Rivas-Garcia, 2021).

While the historical development of the printing industry has not been consistent with classical theories of innovation, as the uptake of the printing press had limited macroeconomic effects, contemporary innovations related to digital technologies in this industry have translated primarily into reduced labor costs rather than increased productivity (Chungu, 2024). It is worth noting that the diffusion of innovation theory seems to explain these uncertainties. In light of this theory, it can be argued that despite the ground-breaking nature of the printing press, its adoption may have been limited by the low observability of macroeconomic effects and the slow pace of technology diffusion. In turn, contemporary innovations in printing—though quickly adopted due to their clear cost advantages and ease of testing—are characterized by low compatibility with earlier work models.

Based on our findings, the spectrum of benefits from innovation is much broader in the offset printing industry than in the printing industry as a whole. However, the results are consistent with Rogers's innovation diffusion theory (Rogers, 2003), as innovations are more readily adopted by firms with higher observable performance, suggesting that perceived relative advantage, trialability, and observability also play a significant role in the offset printing industry. It can be added that since young firms were more prone to innovation, this may reflect early adopter profiles, while the differential diffusion of product, process, and marketing innovations—depending on dominant print format, sector, and market scope—corresponds to the assumption of compatibility and complexity as factors in new product adoption (Shaker, George, 2002). Furthermore, the lack of an observed location effect further suggests that diffusion is currently less geographically constrained due to the advances of digital transformation in the sector studied and the favourable models offered by press manufacturers (Salwin et al., 2020).

In light of the three-factor model of innovation development (Stanisławski, 2020), the presented findings confirm that the ability to generate and absorb innovation depends on the company's resources (number of employees, machinery, market reach) as well as its development stage. At the same time, the relatively low correlation between the scale of benefits and the level of novelty of product innovations suggests that the decisive factor in gaining competitive advantage is not the originality of the solution itself, but the ability to commercialize it.

Integrating the presented findings with broader theoretical models reveals that innovation potential in the offset printing sector reflects key tenets of the resource-based approach, which form the basis of sustainable competitive advantage, as innovations enable firms to leverage competitive advantages and—in line with the three-factor model of innovation development—motivate firms to pursue further innovation implementation. The relationship we observed between marketing and product innovations and external performance is consistent with the dynamic capabilities model (Teece et al., 1997). According to these models, firms' ability to detect, utilize, and reconfigure resources in response to a changing environment ultimately determines the scope and impact of innovation outcomes.

Since product and marketing innovations have been shown to deliver broader competitive advantages, while process and organizational innovations tend to promote internal performance, interpretation within the context of exploration and exploitation models is also necessary (March, 1991). The competitive advantage of offset printing companies stemmed from balancing radical, market-oriented innovations with incremental, efficiency-oriented improvements, particularly those promoted by machine suppliers. The variable impact of the scale of novelty, particularly in process and marketing innovations, further reflects the importance of absorptive capacity theory (Zahra, George, 2002).

8. Conclusion

8.1. Empirical Implications

Our study confirms that the vast majority of offset printing companies in Poland implemented at least one innovation in the last three years and observed a measurable impact on competitiveness and innovation development. These innovations varied in terms of type and scale of innovation, with structural and market factors (number of machines, company age, markets served – international orientation) strongly associated with innovation diffusion. Product and marketing innovations generated the widest range of benefits, including market expansion and supply chain optimization, while process and organizational innovations were more closely linked to operational improvements. The scale of innovation did not always correlate with greater benefits, particularly in the case of product innovations.

8.2. Recommendations for Management

Managers in the offset printing industry should recognize that internal potential is a key factor in fostering innovation, but international market presence plays an equally important motivating role. Product and marketing innovations should be emphasized, as they deliver the fastest strategic benefits in terms of competitiveness. Decision-makers should not assume that only breakthrough innovations matter – incremental innovations, especially those targeted at new markets or customer groups, can deliver significant benefits. Sustainable innovation potential requires conscious investment in research and process improvement, especially in the case of process and organizational innovations. Companies should also consider implementing structured mechanisms for tracking and assessing the scale and results of innovation. This is particularly important given the transformation of business models and new forms of collaboration with machinery suppliers. Changing these models involves implementing innovations, such as marketing and organizational ones, but also requires searching for optimal solutions and making choices. Therefore, systematic evaluation of decisions in the context of developing a competitive advantage is essential, as well as the flexible implementation of further changes if the expected results are not achieved.

8.3. Policy applications

The offset printing sector is generic compared to digital printing, but it is still important for the national economy and provides a space for widespread innovation. Our results indicate the significant value of supporting innovation not only through financing high-tech transformation, but also through programs that encourage the development of marketing, service models, and the internationalization of traditional industries, even if the solutions being developed are already used globally. Disruptive innovation is not the only requirement for realizing the benefits of innovative development. Policy should particularly focus on younger and smaller companies with high potential, especially where their development has a real impact on other industries, particularly packaging and labeling. Given that location did not significantly impact innovation levels, regionally neutral digital infrastructure and knowledge dissemination tools—rather than local subsidies—may be more effective in driving the diffusion of innovation throughout the sector.

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