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Enhancing Degree of Internationalization through Digital Transformation: The Role of Product and Process Innovation Performance under Distribution Contexts

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Abstract

Purpose: This study examines the relationship between digital transformation, innovation performance (product and process innovation), and the degree of internationalization in Korean manufacturing firms. The goal is to explore how digital transformation influences innovation performance and contributes to enhancing firms' degree of internationalization. **Research Design, Data, and Methodology:** Using data from the 2022 Korean Innovation Survey (KIS) conducted by the Science and Technology Policy Institute (STEPI), this study investigates the impact of digital transformation on product and process innovation performance. It also examines how these types of innovation affect the degree of internationalization. **Results:** The analysis reveals that digital transformation significantly enhances both product and process innovation performance. Furthermore, these innovation outcomes are positively associated with the degree of internationalization, highlighting their importance in expanding global business activities. **Conclusion:** While this study focuses on product and process innovation performance, it suggests that future research could examine other forms of innovation, such as organizational or marketing innovation. Additionally, exploring internal and external factors affecting digital transformation across various industries would deepen understanding. This research contributes to the growing literature by linking digital transformation to innovation and internationalization, offering theoretical insights and practical guidance for firms seeking global competitiveness.

Keywords : Distribution, Digital Transformation, Product Innovation Performance, Process Innovation Performance, Degree of Internationalization

JEL Classification Code : O33, M15, L60

1. Introduction

The modern business environment is rapidly evolving, and the advancement of digital technology has become a key factor in determining corporate competitiveness (Verhoef et al., 2021). Digital transformation is defined as the process in

which companies move beyond traditional management practices to leverage digital technologies to innovate their business models, operational processes, and organizational structures (Bharadwaj et al., 2013). This transformation plays a crucial role in enhancing firms' innovation capabilities and strengthening their competitiveness in the global market (Verhoef & Bijmolt, 2019).

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However, despite its significance, many small and medium-sized enterprises (SMEs) remain reluctant to adopt digital technologies due to high implementation costs, internal resistance, and uncertainty regarding their effectiveness (Chung, 2021). This reluctance is particularly pronounced in Korea, where prolonged low economic growth and increasing polarization between large corporations and SMEs have intensified competitive pressure among smaller firms (Kim and Hwang, 2016). SMEs often lack sufficient capital and skilled technical personnel, making it difficult to secure competitiveness within a short period. As a result, they are more vulnerable to operational crises such as cash flow shortages, the outflow of key talent, and inefficiencies in logistics, inventory management, and export processes. Moreover, their limited managerial resources (Son et al., 2017) and the high risks associated with innovation failures—where a single unsuccessful attempt can threaten firm survival—further discourage proactive digital investment (Cho, 2010). Accordingly, there is an increasing need for empirical research on the tangible outcomes that companies can achieve through digital transformation.

Digital transformation can have a significant impact on firms' product innovation and process innovation (Ryalat et al., 2023). Product innovation performance refers to a firm's ability to develop new products or enhance existing ones, and the adoption of digital technologies such as data analytics, artificial intelligence (AI), and the Internet of Things (IoT) can accelerate product innovation and improve quality (Henfridsson et al., 2018). Meanwhile, process innovation performance involves improvements in production and operational processes, including the digitalization of supply chains and logistics systems. Digital transformation—through automation, smart manufacturing, and optimized trade operations—can enhance efficiency, improve delivery speed, and reduce costs across both production and distribution activities (Parida et al., 2019). Therefore, this study aims to empirically examine the impact of digital transformation on firms' product innovation and process innovation performance.

Existing studies have emphasized the necessity of innovation but have primarily focused on technological innovation itself (Hansen & Birkinshaw, 2007; Roper et al., 2008). There remains a relative lack of empirical research analyzing the broader impact of digital transformation on corporate performance and global competitiveness. In particular, research on how innovation performance contributes to firms' internationalization remains limited, and there is insufficient empirical evidence on how leveraging digital technologies for innovation translates into international expansion. This study seeks to address these research gaps.

Innovation performance can also influence firms' degree

of internationalization (Ghobakhloo et al., 2021). Higher product innovation performance enables firms to secure a differentiated competitive edge in foreign markets, thereby facilitating global expansion (Zahra & George, 2002). Similarly, process innovation performance can support firms' entry into international markets by reducing production costs and improving operational efficiency (Fernandez-Stark and Gereffi, 2019). Accordingly, this study examines the impact of product innovation performance and process innovation performance on firms' degree of internationalization and aims to clarify how digital transformation ultimately contributes to strengthening corporate competitiveness in the global market.

This study adopts the Diffusion of Innovation Theory (Rogers, 1962) as its theoretical foundation to analyze how firms adopt and diffuse digital technologies and how this influences their product and process innovation performance as well as their internationalization. The Diffusion of Innovation Theory explains how new technologies or ideas are adopted and disseminated within organizations, providing a useful framework for identifying the factors influencing technology adoption and its outcomes (Rogers, 2003). Based on this framework, this study will conduct an empirical analysis of how firms achieve innovation through digital transformation and leverage it as a driving force for global market expansion.

The primary objective of this research is to empirically examine the impact of digital transformation on product innovation performance and process innovation performance and further investigate how these innovation outcomes influence firms' degree of internationalization. Through this analysis, the study seeks to clarify how innovation strategies utilizing digital technologies contribute to strengthening firms' global competitiveness and to provide practical insights for companies in developing effective digital transformation strategies.

2. Research Background

2.1. Digital Transformation

Digital transformation is the process by which firms fundamentally reshape their existing business models, operational processes, and value creation mechanisms by leveraging cutting-edge digital technologies such as big data, the Internet of Things (IoT), and artificial intelligence (Kraus et al., 2021). It goes beyond the mere adoption of technology, encompassing the strategic reorientation of the firm, restructuring of organizational frameworks, and redefining market response strategies. Through this process, firms can enhance managerial efficiency and foster innovation activities (Qi & Xiao, 2020; Vial, 2021).

Moreover, digital transformation strengthens firms' data utilization capabilities, enabling real-time decision-making and enhancing agility in responding to market changes (Westerman et al., 2014). It further facilitates cross-industry integration and dismantles traditional corporate boundaries, supporting the formation of new value creation networks (Kim & Ahn, 2024). These transformations are directly linked to key business outcomes such as increased profitability, expanded market share, and the discovery of new market opportunities (Bughin et al., 2017).

2.2. Diffusion of Innovation Theory

The Diffusion of Innovation Theory explains how new technologies or ideas spread within a society or organization (Rogers, 1962). It is widely used to analyze the factors influencing firms' adoption of new technologies and the elements determining the speed of diffusion (Rogers, 2003). Moore and Benbasat (1991) extended Rogers' framework by identifying eight Perceived Characteristics of Innovation (PCI) that significantly influence the adoption process of technological innovations. The eight characteristics of Relative Advantage, Compatibility, Voluntariness, Image, Ease of Use, Trialability, Result Demonstrability, and Visibility play an important role in explaining the process of companies adopting and internalizing digital technology.

As the adoption and diffusion of digital technologies accelerate in contemporary business environments, the principles of Diffusion of Innovation Theory provide critical insights into the challenges and opportunities firms encounter in their digital transformation journey. For instance, a growing number of Korean SMEs have adopted cloud-based ERP systems to improve operational efficiency and decision-making. This reflects the perceived relative advantage and ease of use of such technologies, which positively influence adoption decisions (Ahn & Ahn, 2020; Christiansen et al., 2022). Similarly, manufacturing firms implementing IoT-enabled smart sensors have reported improvements in production visibility and process control, demonstrating the importance of result demonstrability and compatibility in the diffusion of innovation (Sjödén et al., 2018). These examples show how DOI theory can be practically applied to understand the drivers behind technology adoption in real-world digital transformation efforts.

2.3. Product Innovation Performance

Product Innovation Performance is a crucial indicator for evaluating a firm's long-term innovation capabilities, encompassing not only the launch of new products but also incremental innovation and radical innovation (Burchardt & Maisch, 2019). In other words, product innovation

performance goes beyond merely introducing new products; it is directly linked to continuous R&D investment, technological excellence, market acceptance, and a firm's ability to generate revenue, ultimately serving as a key factor in enhancing corporate competitiveness (Hall & Bagchi-Sen, 2007).

To maintain a sustainable competitive advantage in the market, firms must continuously introduce faster and more advanced new products. Various strategies can be employed to maximize product innovation performance. For instance, increasing R&D investment and actively adopting open innovation strategies enable firms to efficiently incorporate external technologies and accelerate the speed of product innovation through collaboration (Chesbrough, 2003).

From this perspective, digital transformation plays a crucial role in shortening product development and innovation cycles, thereby accelerating product innovation. Additionally, firms with highly innovative products are more likely to lower entry barriers into foreign markets and secure differentiated competitive advantages (Hitt et al., 1997). Firms with high R&D investment and strong product innovation performance often achieve technological superiority in global markets, leading to higher degree of internationalization (López & Roberts, 2002). Companies that integrate digital technologies have successfully enhanced product innovation speed and market adaptability, which are among the key determinants of internationalization success.

Therefore, this study aims to empirically examine how product innovation performance serves as a mediating factor in the relationship between digital transformation and degree of internationalization, by enabling firms to rapidly develop innovative products and respond flexibly to market changes, ultimately expanding their competitiveness in global markets.

2.4. Process Innovation Performance

Process innovation encompasses activities such as production automation, data-driven decision-making, supply chain optimization, and quality management system improvements (Ray et al., 2005). It plays a crucial role in maximizing operational efficiency alongside product innovation (Van Looy, 2021).

In this context, process innovation performance refers to the outcomes achieved by optimizing operational processes, including risk reduction, cost savings, and shorter production cycles. This serves as a key determinant of a firm's sustainable competitive advantage (Bessant & Francis, 2004; Rosemann, 2014). Firms that effectively implement process innovation not only maximize resource utilization efficiency but also enhance productivity and maintain quality standards, thereby strengthening their market

credibility (Frank et al., 2019).

Digital transformation acts as a significant enabler for maximizing process innovation performance by fundamentally reshaping corporate operations and optimizing production processes through the adoption of cutting-edge digital technologies (e.g., AI, IoT, blockchain, cloud computing) (Bharadwaj et al., 2013). This transformation allows firms to optimize operations in a more agile and flexible manner, enhancing their adaptability in global markets (Bogner et al., 2016).

Ultimately, firms that successfully achieve process innovation through digital transformation enhance the flexibility of production processes, enabling them to respond swiftly to global market changes. This, in turn, serves as a crucial competitive advantage for international expansion and export growth (Li et al., 2022). In particular, the adoption of smart factories leveraging digital technologies helps firms overcome geographical constraints in production, facilitates remote operations, and enables the optimization of global production networks, thereby improving internationalization performance.

Therefore, this study aims to empirically examine how process innovation performance mediates the relationship between digital transformation and the degree of internationalization, by maximizing operational efficiency and enhancing production process flexibility, ultimately strengthening firms' competitiveness in global markets.

2.5. Degree of Internationalization

Internationalization is defined as the strategic process by which firms expand various business activities—such as manufacturing, marketing, and R&D—beyond national borders (Welch & Luostarinen, 1988). This process extends beyond mere market entry to include complex strategies aimed at maximizing resource acquisition and utilization, thereby ensuring sustained competitiveness in the global environment (Kaleka & Morgan, 2017; Cuervo-Cazurra et al., 2018). Internationalization is regarded as a key strategic choice that enables firms to overcome domestic market limitations and simultaneously pursue growth opportunities both domestically and internationally (Heo & You, 2024). However, expanding into global markets involves significant uncertainty and substantial investment costs, which can serve as major barriers to internationalization (Ahsan & Musteen, 2011). These challenges often deter firms from expanding their operations internationally (Leonidou, 2004).

In this context, digital transformation has emerged as a crucial enabler of internationalization (Autio et al., 2021). Digital technologies overcome physical distance and resource constraints, allowing firms to enter foreign markets more efficiently, engage with global customers in real time,

and lower market entry barriers through e-commerce platforms and digital marketing (McDermott et al., 2013). Moreover, digitized supply chain systems and operational platforms reduce the complexities of global production and distribution, enhancing the operational efficiency and coordination capabilities of multinational corporations (Bilberg & Malik, 2019). This suggests a mutually reinforcing relationship between digital transformation and internationalization (Archibugi & Iammarino, 2002).

Therefore, this study aims to empirically examine how digital transformation not only enhances operational efficiency but also significantly contributes to internationalization levels through product and process innovation performance. In particular, we focus on how digital transformation strengthens firms' innovation capabilities, thereby improving adaptability, responsiveness, and scalability in global markets. This perspective advances the existing research, which has often analyzed digitalization and internationalization separately, by providing an integrated view of their mediating relationship, offering both theoretical and practical insights.

3. Hypothesis Development

The process by which organizations adopt and utilize previously non-existent digital technologies to respond to environmental changes or explore new opportunities can be understood as a strategic innovation process aimed at enhancing organizational competitiveness (Runge, 1985; Grover & Goslar, 1993). This innovation process encompasses the entire journey from the generation of new ideas to their commercialization (Myers & Marquis, 1969; Daft, 1993), with product innovation performance and process innovation performance being regarded as two key areas that firms focus on to secure sustainable competitive advantage (Christensen & Bower, 1996).

According to Diffusion of Innovation Theory, digital transformation is more likely to be promoted within firms and lead to product innovation performance and process innovation performance when digital technologies possess relative advantage—demonstrating superior performance compared to existing systems—and compatibility—aligning well with the organization's current operations.

Digital transformation enhances flexibility and responsiveness in product development, improving market adaptability and innovation speed (Westerman et al., 2014). By increasing trialability and visibility, as emphasized in Diffusion of Innovation Theory, firms can clearly recognize the benefits of digital transformation, accelerating its adoption and ultimately enhancing the quality of new product development and market acceptance (Burchardt & Maisch, 2019). This diffusion process ultimately reinforces

product innovation performance, helping firms establish differentiated competitiveness in global markets (Hitt et al., 1997; López & Roberts, 2002).

Digital transformation also plays a critical role in process innovation. Technologies such as artificial intelligence (AI), the Internet of Things (IoT), blockchain, and cloud-based systems enable real-time data-driven decision-making, production automation, quality control, and supply chain optimization (Frank et al., 2019; Bharadwaj et al., 2013). These advancements contribute to cost reduction, risk minimization, and productivity enhancement, which are key process innovation outcomes (Reichstein & Salter, 2006; Van Looy, 2021).

From the perspective of Diffusion of Innovation Theory, the ease of use and result demonstrability of these technologies facilitate their rapid adoption within organizations, integrating them into internal processes. Process innovation through digital transformation strengthens global production flexibility and operational efficiency, enabling firms to respond swiftly to market changes and achieve cost competitiveness in international markets (Li et al., 2022). Thus, digital transformation enhances product innovation speed and market adaptability, enabling firms to enter a wider range of international markets, while process innovation improves operational stability and flexibility, increasing the feasibility of internationalization strategies (Li et al., 2022). This underscores that product innovation performance and process innovation performance can significantly influence a firm's degree of internationalization.

In summary, based on the theoretical foundation that digital transformation positively (+) impacts a firm's product innovation performance and process innovation performance—and that these innovation outcomes, in turn, enhance the firm's degree of internationalization—we propose the following research hypotheses:

- H1:** Digital transformation will have a positive (+) effect on product innovation performance.
- H2:** Digital transformation will have a positive (+) effect on process innovation performance.
- H3:** Product innovation performance will have a positive (+) effect on the degree of internationalization.
- H4:** Process innovation performance will have a positive (+) effect on the degree of internationalization.

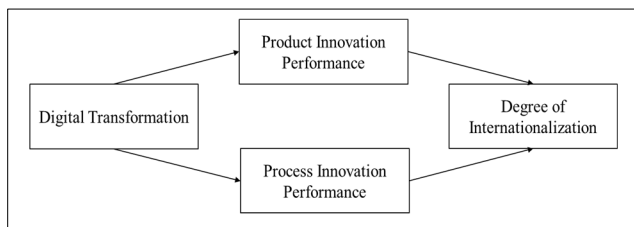


Figure 1: Research Model

4. Methods

4.1. Sample

This study utilized data from the Korean Innovation Survey (KIS) for the manufacturing industry, conducted by the Science and Technology Policy Institute (STePI). KIS 2022 was designed based on the OECD's Oslo Manual, and a comprehensive survey was conducted from 2019 to 2021, targeting 4,000 domestic manufacturing firms. In this study, the most recent manufacturing-related data from the survey is used to analyze the relationships between digital transformation, product innovation performance, process innovation performance, and degree of internationalization. The data used in this study consists of survey responses from a total of 4,000 firms, and the industry-specific sample distribution is presented in Table 1.

Table 1: Industry-Specific Sample Distribution

| Industries | Frequency | Percentage |
|--------------------------------|-------------|------------|
| Chemical | 250 | 6.25% |
| Other Machinery | 527 | 13.17% |
| Automotive | 422 | 10.55% |
| Electronics/Computers | 317 | 7.92% |
| Primary Metals | 210 | 5.25% |
| Electrical Equipment | 275 | 6.87% |
| Metalworking | 383 | 9.57% |
| Food Products | 293 | 7.32% |
| Rubber/Plastics | 306 | 7.65% |
| Nonmetallic Minerals | 149 | 3.72% |
| Paper | 99 | 2.47% |
| Apparel | 79 | 1.97% |
| Medical/Precision | 157 | 3.92% |
| Textiles | 102 | 2.55% |
| Pharmaceuticals | 100 | 2.50% |
| Other Transportation Equipment | 93 | 2.32% |
| Furniture | 42 | 1.05% |
| Petroleum Refining | 17 | 0.42% |
| Leather/Haberdashery | 20 | 0.50% |
| Other Products | 36 | 0.90% |
| Lumber/Timber | 32 | 0.80% |
| Beverages | 24 | 0.60% |
| Printing/Recording Media | 43 | 1.07% |
| Machinery/Equipment Repair | 24 | 0.60% |
| Total | 4000 | 100 |

4.2. Measurement Variables

Dependent variable Degree of internationalization (DOI) is defined as the ratio of a firm's export sales to its total revenue, and it is considered a key indicator of internationalization (Abdi & Aulakh, 2018). This metric is used as a quantitative tool to assess how actively a firm operates in the global market beyond its domestic market

(Khalid, 2020; Radulovich et al., 2018). In this study, based on the 2022 Korean Innovation Survey data, export concentration was calculated using the average values of total revenue and export sales over three years, from 2019 to 2021. Specifically, the export-to-total revenue ratio was calculated to evaluate the firm's export concentration.

Independent variable Digital transformation was measured by whether a firm had already adopted digital transformation. A value of 1 was assigned if digital transformation had been adopted, and a value of 0 was assigned if it had not.

Mediating variables Based on the study by Kim (2014), this research evaluates product innovation performance by considering the introduction of new products that are fundamentally different from existing ones, major improvements to existing products, and the launch of products that are the first to be introduced to the market. This approach is aimed at clearly reflecting the impact of innovative products created by firms on the market. Meanwhile, process innovation performance is measured by the introduction of entirely new production processes, innovative improvements to existing processes, and fundamental changes in logistics and support methods. This comprehensive measurement captures all innovative changes within the firm's operations. This approach aims to assess the firm's innovative capabilities from multiple perspectives and to capture key elements driving change and development.

Control variables Firm type was included to examine how organizational structure and operational methods impact internationalization strategies (Lee, 2006). Firm size is a critical factor influencing a firm's resources, capabilities, and market position (Wu et al., 2007), while firm age serves as a variable representing the accumulated management experience and market position of the firm (Tuppura et al., 2008). Listed Status was also included to explore how being a publicly traded company affects access to capital,

corporate governance, and strategic decision-making, potentially influencing internationalization efforts. The presence in industrial complexes was considered to assess how location conditions and network accessibility impact internationalization activities (Heo & You, 2024). Additionally, the R&D Personnel Ratio was included to investigate how research and development efforts contribute to a firm's innovation capabilities and international competitiveness. Female Employee Ratio and master's degree ratio were also incorporated, as workforce composition and educational background can influence DX and both process and product innovation performance, potentially shaping a firm's innovation-driven internationalization strategies. Lastly, Union Presence was considered to analyze how labor relations and the presence of a union can influence internationalization strategies and firm performance.

4.3. Statistical Analysis

This study utilized data from 4,000 firms, and for the statistical analysis, Structural Equation Modeling (SEM) was employed. SEM is a powerful method for clearly defining relationships between variables and analyzing the interactions between latent and observed variables. Through this approach, the study was able to systematically model the complex causal relationships among variables and evaluate their effects. Furthermore, various fit indices were used to assess the model's adequacy, and the results confirmed that the model fits the data well. Additionally, variance inflation factors (VIFs) were calculated to check for potential multicollinearity issues.

The average VIF value was 1.38, and all VIFs were found to be below 5, well below the commonly accepted threshold of 10 (Neter et al., 1985). Therefore, multicollinearity was not a concern in this analysis.

Table 2: Descriptive Statistics: Means, Standard Deviations, and Correlations

| Variable | Mean | S.D. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|----------------------------------|-------|-------|-------|-------|------|------|-------|-------|-------|-------|-------|-------|-------|------|----|
| 1 Degree of Internationalization | 12.34 | 22.42 | - | | | | | | | | | | | | |
| 2 DX | 0.29 | 0.45 | 0.16 | - | | | | | | | | | | | |
| 3 Product Innovation Performance | 0.37 | 0.61 | 0.28 | 0.30 | - | | | | | | | | | | |
| 4 Process Innovation Performance | 0.36 | 0.68 | 0.23 | 0.25 | 0.62 | - | | | | | | | | | |
| 5 Firm Type | 0.19 | 0.39 | 0.27 | 0.23 | 0.25 | 0.25 | - | | | | | | | | |
| 6 Firm Size | 0.14 | 0.75 | 0.12 | 0.13 | 0.16 | 0.20 | 0.30 | - | | | | | | | |
| 7 Firm Age | 21.57 | 13.48 | 0.21 | 0.14 | 0.23 | 0.19 | 0.30 | 0.13 | - | | | | | | |
| 8 Listed Status | 0.12 | 0.32 | 0.23 | 0.21 | 0.30 | 0.29 | 0.38 | 0.25 | 0.37 | - | | | | | |
| 9 Presence in an Industrial Park | 0.15 | 0.35 | 0.11 | 0.04 | 0.06 | 0.07 | 0.12 | 0.05 | 0.05 | 0.05 | - | | | | |
| 10 R&D Personnel Ratio | 5.93 | 8.82 | 0.22 | 0.22 | 0.38 | 0.25 | 0.08 | 0.04 | 0.06 | 0.16 | 0.04 | - | | | |
| 11 Female Employee Ratio | 22.67 | 18.98 | -0.02 | -0.00 | 0.04 | 0.02 | -0.04 | -0.02 | -0.07 | -0.03 | -0.09 | -0.00 | - | | |
| 12 Master's Degree Ratio | 3.80 | 6.86 | 0.19 | 0.15 | 0.33 | 0.24 | 0.12 | 0.11 | 0.14 | 0.19 | -0.02 | 0.42 | 0.03 | - | |
| 13 Union Presence | 0.21 | 0.40 | 0.27 | 0.24 | 0.31 | 0.32 | 0.46 | 0.26 | 0.36 | 0.39 | 0.08 | 0.09 | -0.05 | 0.18 | - |

a. Two-tailed coefficient test (N=4000)

5. Results

5.1. The Result of SEM

Table 2 displays the means, standard deviations, and correlations for the data. As shown in Table 3, the results further confirm the relative strength of the relationships between these variables, particularly the stronger influence of DX on product innovation performance compared to process innovation performance. The results of this study revealed significant relationships for the key hypotheses. First, H1, which posits that DX positively affects product innovation performance, was supported, with the effect of DX being statistically strong ($B = 0.40, p < 0.001$). Second,

H2, which suggests that DX positively influences process innovation performance, was also supported ($B = 0.37, p < 0.001$). This confirms that the effect of DX on product innovation performance is larger than its effect on process innovation performance. Third, H3, stating that product innovation performance has a strong positive impact on the DOI, was supported, with the effect being significant and strong ($B = 3.59, p < 0.001$). Fourth, H4, which posits that process innovation performance affects the DOI, showed a statistically significant effect, but the influence was relatively weak. Therefore, H4 was partially supported ($B = 1.04, p < 0.1$). This suggests that while process innovation performance does influence DOI, its effect is relatively weak and may not always be statistically significant.

Table 3: The Results of the SEM

| Hypothesis | Path | | B | S.E | t | p | Result |
|------------|--------------------------------|--------------------------------|-------|------|-------|------|-------------------|
| 1 | DX | Product Innovation Performance | 0.40 | 0.02 | 19.81 | 0.00 | Supported |
| 2 | DX | Process Innovation Performance | 0.37 | 0.02 | 16.06 | 0.00 | Supported |
| 3 | Product Innovation Performance | DOI | 3.59 | 0.75 | 4.81 | 0.00 | Supported |
| 4 | Process Innovation Performance | DOI | 1.04 | 0.63 | 1.66 | 0.09 | Partial Supported |
| Control | Firm Type | | 7.47 | 1.00 | 7.47 | 0.00 | |
| | Firm Size | | -0.17 | 0.47 | -0.37 | 0.82 | |
| | Firm Age | | 0.11 | 0.03 | 4.15 | 0.00 | |
| | Listed Status | | 3.34 | 1.20 | 2.79 | 0.01 | |
| | Presence in an Industrial Park | | 4.31 | 0.93 | 4.63 | 0.00 | |
| | R&D Personnel Ratio | | 0.29 | 0.43 | 6.81 | 0.00 | |
| | Female Employee Ratio | | -0.00 | 0.02 | -0.26 | 0.80 | |
| | Master's Degree Ratio | | 0.17 | 0.05 | 3.24 | 0.00 | |
| | Union Presence | | 5.28 | 0.99 | 5.35 | 0.00 | |

5.2. Robustness Check

To ensure the robustness of our main findings, we conducted additional analyses using alternative estimation techniques. Specifically, we re-estimated our models using Logistic Regression and Ordinary Least Squares (OLS) regression, instead of the structural equation modeling (SEM) approach used in the main analysis.

The robustness check involved testing whether our key results hold under different estimation methods. The primary dependent variable, DOI, was re-examined using Logistic Regression and OLS regression. Digital transformation served as the independent variable, whereas product and process innovation performance were used as mediating variables. The remaining factors were included as control variables.

The results indicate that the core relationships remained statistically significant and aligned with the expected directional effects. While minor variations in coefficient magnitudes were observed, the overall patterns were consistent with our primary findings, reinforcing the robustness of our conclusions.

In summary, the alternative regression analyses confirm that our key findings are not sensitive to changes in estimation methods. The positive effect of Digital transformation on DOI and the mediating role of product innovation performance and process innovation performance remains robust across different analytical approaches. These results strengthen the validity and reliability of our theoretical framework.

Table 4: Robustness Check

| Variable | | Main Analysis (SEM) | Robustness Check |
|--------------------------------|--------------------------------|-------------------------|-------------------------|
| DX | Product Innovation Performance | 0.40 ($p < 0.001$) | 0.38 ($p < 0.001$) |
| DX | Process Innovation Performance | 0.37 ($p < 0.001$) | 0.35 ($p < 0.001$) |
| Product Innovation Performance | DOI | 3.59 ($p < 0.001$) | 7.75 ($p < 0.001$) |
| Process Innovation Performance | DOI | 1.04 ($p < 0.1$) | 1.02 ($p < 0.1$) |

6. Conclusion

6.1. Research Summary

This study analyzed the relationships between digital transformation, innovation performance—specifically product and process innovation performance—and their impact on the degree of internationalization. The findings strongly support the key hypotheses proposed.

First, the results confirm that the digital transformation factor positively influences both product and process innovation performance, with a stronger impact on product innovation performance. The effect of digital transformation on product innovation performance was notably higher than its effect on process innovation performance.

Second, the study found that product innovation performance has a significant and strong positive effect on the degree of internationalization, highlighting the critical role of innovation in driving international expansion. However, while process innovation performance also exhibited a statistically significant influence on internationalization, its effect was weaker than that of product innovation performance. This suggests that although process innovation performance contributes to the internationalization process, its impact is less pronounced.

These findings underscore the importance of innovation, particularly product innovation performance, in enhancing the internationalization capabilities of multinational enterprises. The stronger influence of digital transformation on product innovation performance suggests that, for companies seeking to expand into global markets, prioritizing product innovation performance is essential. Developing innovative products is crucial for maintaining competitiveness in the global market.

At the same time, while process innovation performance plays a supporting role in internationalization, firms can enhance its global applicability by adopting smart manufacturing and digital supply chain integration. By leveraging these advanced technologies, firms can optimize production efficiency, improve scalability, and strengthen their ability to operate across diverse international markets. These strategic improvements can help mitigate the relatively weaker impact of process innovation performance on internationalization and enable firms to build a more resilient and competitive global presence.

Therefore, companies should focus on enhancing product innovation performance as a primary driver of internationalization while simultaneously investing in process innovation performance through smart technologies and digital integration to reinforce their global competitiveness.

6.2. Implications

This study provides several practical and policy implications.

First, firms should strategically invest in digital transformation to foster innovation. Leveraging technologies such as artificial intelligence (AI), big data, and the Internet of Things (IoT) can accelerate product development, enable customization, and enhance responsiveness to shifting global demands, thereby strengthening international competitiveness. Additionally, digital tools can enhance logistics management, enabling faster and more efficient distribution processes and reducing operational costs across global supply chains. These advancements can create a significant competitive edge in international markets.

Second, while product innovation performance serves as a key driver of internationalization, process innovation performance ensures long-term sustainability. Companies should actively adopt smart technologies and digital integration to maximize efficiency, streamline global operations, and reduce cross-border complexities.

Third, firms need a balanced innovation strategy. For SMEs and companies entering emerging markets, a phased approach—utilizing product innovation performance for initial market entry and process innovation performance for operational scalability—can be particularly effective.

Finally, this study underscores the importance of policy support. Governments and industry bodies should facilitate digital innovation through R&D incentives, training programs, and international collaboration initiatives. Such measures can help firms digitize their logistics and trade functions, improving supply chain efficiency and market access. Additionally, creating policies that promote the digitalization of cross-border trade, such as simplifying customs procedures and integrating international digital payment systems, will significantly enhance firms' ability to compete in the global marketplace.

6.3. Limitations

While this study offers meaningful insights, it has certain limitations that suggest areas for future research.

First, this study focused on product and process innovation performance, but other forms of innovation—such as service innovation or organizational innovation—may also influence internationalization. Future research could explore these additional dimensions to provide a more comprehensive perspective.

Second, digital transformation was treated as a broad concept without distinguishing between its various components. Further research could analyze how specific digital strategies interact with firm characteristics and

industry dynamics to drive innovation and international expansion.

Third, internationalization was measured using the export ratio, which, while useful, does not fully capture alternative global expansion strategies such as foreign direct investment (FDI) or strategic alliances. Future studies could incorporate multiple indicators to provide a more nuanced analysis of internationalization.

Lastly, while this study examined the relationship between innovation performance and internationalization, additional factors—such as organizational culture and managerial practices—could further enrich our understanding of the drivers of global expansion.

By addressing these limitations, future research can provide deeper insights into the evolving interplay between digital transformation, innovation, and international business success.

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