

From Technology Use to Firm Competitiveness: An Innovation-Based Perspective from an Emerging Economy- Evidence from Algerian Industrial Firms

Djamel Bensaadi¹, Ouerdia Bougaba², Mohamed Abadi³

¹Email: Djamel.bensaadi@univ-bba.dz

²Email: Ouerdia.bougaba@univ-bba.dz

³Email: Mohamed.abadi@univ-bba.dz

Abstract

Technology has become an important strategic resource for industrial firms seeking to strengthen their competitiveness. However, having access to and using technology does not necessarily translate into better competitive performance. The way in which technological resources create competitive advantage, particularly in emerging economies, is still not fully understood. This study addresses this issue by examining the process through which technology use contributes to competitive advantage, with particular attention to the roles of process innovation, product innovation, product quality, and customer satisfaction. The study adopts a Partial Least Squares Structural Equation Modelling (PLS-SEM) approach and draws on data collected from leading Algerian industrial firms in the electronics and household appliances sector. The data were analysed using SmartPLS 4. The results show that technology use does not have a direct effect on competitive advantage. Instead, its contribution becomes evident through a sequence of related effects. Technology use first stimulates process innovation, which supports product innovation and subsequently contributes to higher product quality. Improved product quality then enhances customer satisfaction and, ultimately, contributes to competitive outcomes. The findings highlight product quality as a particularly important link in this process, acting as the main mechanism through which innovation is transformed into tangible competitive benefits. Customer satisfaction, in contrast, has a more specific contribution: it improves market share but does not directly influence profitability or cost reduction. The mediation analysis further shows that a substantial part of the relationship between technology use and competitive advantage is explained by this sequential pathway. By focusing on the mechanisms rather than simply the direct relationship between technology and competitiveness, this study provides a more comprehensive understanding of how technological investments generate value for industrial firms. The findings also have practical implications for firms seeking to obtain greater returns from technology. Rather than treating technology investment as an end in itself, firms should focus on using technology to support innovation, strengthen product quality, and ultimately deliver greater value to customers.

Keywords: Technology use; Process innovation; Product innovation; Product quality; Customer satisfaction; Competitive advantage; PLS-SEM.

Introduction

The industrial sector is undergoing rapid transformation as a result of technological and digital advancements, making technology one of the most influential factors affecting firms' capacity to innovate and maintain their competitiveness in increasingly dynamic business environments (Nambisan et al., 2017). However, technological investments do not always lead to better performance or stronger competitiveness. In practice, while some firms gain significant competitive benefits from adopting advanced technologies, others, despite having similar technological resources, struggle to turn these investments into tangible competitive outcomes. This apparent paradox raises a fundamental question: how and under what conditions can technological resources be transformed into economic value and, ultimately, competitive advantage within firms?

Received: July 03, 2026; Accepted: August 24, 2026; Published: September 08, 2026

© 2026 The Author. Published by IMCRA. This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY 4.0), which permits unrestricted use, distribution, adaptation, and reproduction in any medium, provided that the original author and source are properly credited.

<https://creativecommons.org/licenses/by/4.0/>



The literature helps explain this disparity by arguing that technology is not, in itself, a source of competitive advantage; rather, its value depends on how effectively it is integrated into organisational processes and used to build innovation capabilities. From the perspective of the Resource-Based View (RBV), technology constitutes a strategic resource that can contribute to competitive advantage when it is valuable, rare, difficult to imitate, and effectively organised (Barney, 1991). Similarly, Dynamic Capabilities Theory suggests that sustaining competitive advantage depends on a firm's ability to continuously adapt, reconfigure, and deploy its resources in response to changing environmental conditions (Teece et al., 1997). Taken together, these perspectives suggest that the strategic value of technology lies not simply in possessing technological resources, but in the ability to transform them into organisational capabilities that support innovation and create value.

Within this context, process innovation represents an initial step in converting technological capabilities into operational improvements, particularly by redesigning production processes, improving efficiency, and increasing organisational flexibility. These operational improvements can, in turn, provide a foundation for product innovation, enabling firms to develop new products and improve existing ones. As product innovation develops, it can contribute to higher product quality, which increases the value perceived by customers and, consequently, strengthens customer satisfaction. Accordingly, the competitive benefits of technology are unlikely to emerge from technological investment alone. Instead, they become more visible when technology is translated into process and product innovation, improved product quality, and greater customer value, which can ultimately contribute to stronger customer satisfaction and competitive outcomes such as market share, profitability, and cost reduction.

Although considerable research has examined the relationships among technology use, innovation, and organisational performance, previous studies have varied considerably in terms of the variables examined and the relationships explored. Most have focused on specific or isolated relationships rather than bringing these constructs together within a broader framework that explains how technological resources can be transformed into competitive outcomes. As a result, there is still a need for models that explain the sequence of mechanisms through which technology use contributes to firm competitiveness, particularly in emerging economies where firms operate under different technological, institutional, and market conditions.

This research gap is especially relevant in Algeria, where industrial firms are under growing pressure to accelerate digital transformation, modernise production systems, improve productivity, and remain competitive in both domestic and international markets. Understanding how technological investments translate into actual competitive benefits is therefore important not only from a theoretical perspective but also for industrial policymakers and managers seeking to build sustainable competitive capabilities.

Building on this perspective, this study develops and empirically tests a structural model that examines how technology use contributes to firm competitiveness through a sequential pathway involving process innovation, product innovation, product quality, and customer satisfaction. To achieve this objective, the study employs Partial Least Squares Structural Equation Modelling (PLS-SEM) to examine the direct and indirect relationships between the constructs and, more importantly, to determine whether and how these variables mediate the relationship between technology use and firm competitiveness.

The main contribution of this study lies in developing and empirically validating an integrated model that explains how technological resources are transformed into competitive outcomes. By moving beyond the conventional focus on direct relationships between technology and performance, the study provides a clearer picture of the organisational mechanisms through which technology creates competitive value. The study also adds empirical evidence from Algerian industrial firms, contributing to the growing literature on technology use, innovation, and competitiveness in emerging economies and offering further insight into how firms can turn technological resources into meaningful competitive benefits.

The remainder of this article is organised as follows. Section 2 presents the theoretical background, reviews the relevant literature, and develops the research hypotheses. Section 3 outlines the research methodology, while Section 4 presents the empirical findings. Section 5 discusses these findings in relation to the existing literature. Finally, the article summarises the main conclusions, discusses the study's limitations, and suggests directions for future research.

2. Theoretical Background

2.1. Technology Use as a Driver of Innovation

Rapid technological advances and the widespread diffusion of digital technologies over the past two decades have fundamentally transformed the business environment, reshaping production systems, competitive dynamics, and the ways in which firms create and capture value. Technology is no longer viewed merely as a means of improving operational efficiency; rather, it has become a strategic resource that allows firms to access knowledge, support organisational learning, and build innovation capabilities, thereby strengthening their ability to respond to rapidly changing market conditions (Vial, 2019; Zhang et al., 2025).

The concept of technology use has also changed considerably over time. Earlier studies primarily focused on technological intensity, typically measured by research and development (R&D) expenditure (Schmoch et al., 2003; OECD, 2007). More recent research, however, places greater emphasis on how firms use technology to access knowledge, develop organisational capabilities, support learning, and transform technological resources into innovative outcomes (Schot & Steinmueller, 2018; OECD/Eurostat, 2018). Consequently, the ability to make effective use of technology has become increasingly important, rather than simply having access to it.

This perspective is consistent with the Resource-Based View (RBV), which argues that resources can provide sustainable competitive advantage when they are valuable, rare, difficult to imitate, and non-substitutable (Barney, 1991). Complementing this view, Dynamic Capabilities Theory explains how firms can turn these resources into improved organisational performance by sensing emerging opportunities, seizing them, and continuously reconfiguring their resource base (Teece et al., 1997). Within the context of digital transformation, dynamic capabilities play an important role in helping firms integrate digital technologies into their operations, improve organisational agility, and continually adapt their resources to maintain competitive advantage (Warner & Wäger, 2019; Verhoef et al., 2021; Pitelis et al., 2023; Teece, 2025).

2.2. Process Innovation.

Process innovation represents one of the key mechanisms through which firms can turn technological resources into operational improvements. It focuses on improving production methods and organisational processes to increase efficiency, enhance quality, reduce costs, and improve operational flexibility. According to the Oslo Manual, process innovation refers to the implementation of new or significantly improved production methods, service delivery processes, or supporting business activities that improve operational performance and contribute to value creation (OECD/Eurostat, 2018).

Contemporary literature increasingly views process innovation as an organisational capability rather than simply a technological upgrade. It involves the continuous improvement and redesign of organisational processes, together with the integration of knowledge and technology into day-to-day operations. These activities can foster organisational learning and strengthen firms' capacity to adapt to changing business environments (Crossan & Apaydin, 2010). From this perspective, process innovation provides an important link between technological investment and tangible improvements in firm operations.

Digital technologies have an increasingly important role in enabling this process. Artificial intelligence (AI), the Internet of Things (IoT), big data analytics, and other digital technologies can improve information flows, optimise resource utilisation, reduce operational waste, and increase production flexibility and responsiveness to changing customer needs. As a result, the effective use of technology can provide firms with new opportunities to redesign and improve their processes, making

technology an important driver of process innovation (Chirumalla, 2021; Shah *et al.*, 2024).

The benefits of process innovation are not limited to internal operational improvements. By improving processes and strengthening organisational capabilities, firms can create a stronger foundation for product innovation, allowing them to transform technological knowledge into products that offer greater value to customers. Firms that continuously improve their production processes may therefore be better able to develop innovative products and, in turn, strengthen their competitive performance (Domnich, 2022; Iherobiem & Sanusi, 2023).

2.3. Product Innovation.

Product innovation represents one of the key outcomes of firms' innovation activities, allowing them to turn technological and organisational capabilities into new or significantly improved products that provide greater value to customers and strengthen their competitive position. According to the Oslo Manual, product innovation involves introducing new products to the market or significantly improving existing products in ways that enhance their functional characteristics and market appeal (OECD/Eurostat, 2018).

However, product innovation depends on more than access to technology. It also requires a combination of organisational capabilities, including knowledge management, cross-functional collaboration, continuous learning, and the ability to respond quickly to changing market needs. Accordingly, successful product development depends largely on how effectively firms combine and use these complementary resources rather than simply on the amount of research and development (R&D) expenditure (Kozludzhova, 2023).

Product innovation is also closely connected to process innovation. Efficient and flexible production processes provide firms with the conditions needed to turn innovative ideas into commercially viable products while maintaining quality and reducing development time. In this sense, process and product innovation can be viewed as complementary dimensions of organisational innovation, with improvements in production processes supporting firms' ability to develop and deliver new products effectively (Domnich, 2022).

Furthermore, contemporary digital technologies give firms new ways to understand customer needs, speed up product design and development, and improve the quality and market performance of their products (Blichfeldt & Faullant, 2021). As product innovation leads to products that better meet customer expectations, it can increase perceived value, strengthen customer satisfaction and loyalty, and ultimately contribute to higher market share and stronger firm competitiveness (Amoasi *et al.*, 2024).

2.4. Product Quality as a Value Creation Mechanism.

According to Service-Dominant Logic (SDL), value does not reside in the product itself but emerges through customers' use of the product and their evaluation of the benefits it provides. From this perspective, technology and innovation do not generate customer value on their own; rather, they serve as strategic resources that enable firms to develop products that better meet customer needs and expectations. Product quality therefore plays a central role in translating these resources into value for customers and, ultimately, into greater customer satisfaction (Vargo & Lusch, 2017).

Product quality is widely recognised as a key concept in the quality management and innovation literature. It reflects the value customers derive from a product's performance, reliability, and ability to meet or exceed their expectations through its functional and technical characteristics (Garvin, 1987; ISO 9000:2015; OECD, 2018).

Contemporary research suggests that product quality results from the interaction of technological, organisational, and innovation capabilities within the firm. The adoption of advanced digital technologies, together with process and product innovation, can improve product design, increase precision and reliability, and shorten development cycles, allowing firms to offer products of higher quality and greater value to customers (Blichfeldt & Faullant, 2021; Kozludzhova, 2023). In this context, process innovation can improve production efficiency and reduce operational errors, while product innovation can introduce new features and functional improvements. When these two forms

of innovation work together, they can lead to higher product quality, making quality an important and tangible outcome of the innovation process.

Empirical evidence also supports this relationship. Restrepo-Morales et al. (2024) found that innovation, product quality, and customer satisfaction form an interconnected system that influences firms' competitive performance, suggesting that the economic value of innovation becomes more visible when innovative efforts result in products of superior quality. Similarly, recent studies have consistently identified product quality as an important determinant of customer satisfaction, showing that improvements in product attributes can increase perceived value and, in turn, strengthen customer satisfaction, loyalty, and repurchase intentions (Bhowmick & Seetharaman, 2023; Daffa & Simanjuntak, 2024; Utama Nst et al., 2024; Sihombing et al., 2025).

2.5. Customer Satisfaction.

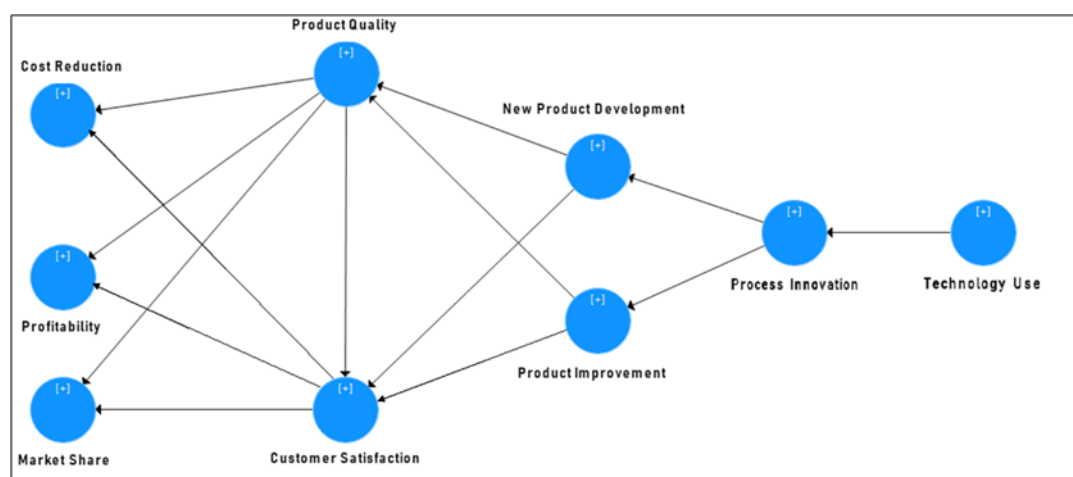
Customer satisfaction is widely recognised as a key indicator of a firm's ability to create value and maintain competitiveness. It reflects customers' evaluation of a product's performance in relation to their prior expectations and actual experience with the product (Oliver, 1997; Kotler & Keller, 2016). From the perspective of Service-Dominant Logic (SDL), value is not determined simply by the production of goods but emerges from customers' perceptions of the benefits they obtain through their use. Customer satisfaction can therefore be understood as an important outcome of the value perceived by customers (Vargo & Lusch, 2017).

The literature further suggests that customer satisfaction does not result directly from technology or innovation. Instead, it develops when these capabilities are translated into products that provide higher quality and greater value to customers. Technology can strengthen firms' innovation capabilities, while process and product innovation can improve operational performance and product functionality, ultimately contributing to better product quality and higher perceived value (Blichfeldt & Faullant, 2021; Kozludzhova, 2023; Restrepo-Morales et al., 2024).

Furthermore, empirical research consistently points to product quality as a major determinant of customer satisfaction. Products characterised by superior performance, reliability, and ease of use are more likely to meet or exceed customer expectations, thereby increasing satisfaction (Bhowmick & Seetharaman, 2023). This relationship has also been supported by several recent studies, including Daffa and Simanjuntak (2024), Utama Nst et al. (2024), and Sihombing et al. (2025). These studies report a significant positive relationship between product quality and customer satisfaction and further suggest that satisfaction can transmit the effects of product quality to outcomes such as customer loyalty and repurchase intentions.

3. Research Model and Hypotheses Development

The conceptual model proposed in this study is based on the idea that firm competitiveness does not result simply from possessing technology, but from how effectively firms use technological resources across a connected process of innovation and value creation. Drawing on the Resource-Based View (RBV), Dynamic Capabilities Theory, and Service-Dominant Logic (SDL), the model proposes that technology use provides the foundation for process innovation, which in turn supports product innovation. These innovation activities are expected to contribute to higher product quality, which can enhance customer satisfaction and ultimately strengthen firm competitiveness. The hypothesised relationships among the study constructs are presented in Figure 1.

Figure 1. Conceptual Research Model

Source: Developed by the authors.

3.1. Technology Use, Process Innovation, and Product Innovation.

In the present study, technology use is conceptualised as a strategic resource that helps firms build and strengthen their innovation capabilities by facilitating knowledge acquisition, supporting organisational learning, and improving coordination across different activities. Its contribution, however, goes beyond improving day-to-day operations. More efficient and flexible production processes give firms greater capacity to turn technological knowledge and resources into new products and to improve existing ones more effectively.

Accordingly, the following hypotheses are proposed:

H1. *Technology use has a positive effect on process innovation.*

H2. *Process innovation has a positive effect on new product development.*

H3. *Process innovation has a positive effect on product improvement.*

3.2. Product Innovation and Product Quality.

The market value of innovation does not come simply from introducing new products; it also depends on how effectively innovation improves product attributes and overall quality. While new product development gives customers access to new choices and alternatives, improving existing products can enhance their performance, reliability, and perceived value. Therefore, both developing new products and improving existing ones are expected to have a positive effect on product quality.

Accordingly, the following hypotheses are proposed:

H4. *New product development has a positive effect on product quality.*

H5. *Product improvement has a positive effect on product quality.*

3.3. Product Quality and Customer Satisfaction.

Product quality is the dimension most directly connected to the customer experience and therefore represents a key mechanism through which the benefits of innovation can translate into customer satisfaction. As product quality improves in terms of performance, reliability, and functional attributes, customers are likely to perceive greater value, resulting in higher levels of satisfaction. Furthermore, new products and significant improvements to existing products may also directly influence customer satisfaction when they better address customers' needs and expectations.

Accordingly, the following hypotheses are proposed:

H6. *Product quality has a positive effect on customer satisfaction.*

H13. *New product development has a positive effect on customer satisfaction.*

H14. *Product improvement has a positive effect on customer satisfaction.*

3.4. Product Quality, Customer Satisfaction, and Firm Competitiveness.

The effects of product quality can extend beyond the customer experience to influence firms' overall competitive performance, particularly through greater operational efficiency, lower costs, higher profitability, and increased market share. Customer satisfaction can further help firms translate this customer value into tangible market and economic outcomes. Higher levels of customer satisfaction are associated with greater repurchase behaviour, a stronger corporate reputation, and a broader customer base, which can contribute to higher profitability and market share while supporting more efficient use of organisational resources.

Accordingly, the following hypotheses are proposed:

H7. *Product quality has a positive effect on cost reduction.*

H8. *Product quality has a positive effect on profitability.*

H9. *Product quality has a positive effect on market share.*

H10. *Customer satisfaction has a positive effect on market share.*

H11. *Customer satisfaction has a positive effect on profitability.*

H12. *Customer satisfaction has a positive effect on cost reduction.*

4. Methodology.

4.1. Research Design and Conceptual Framework.

This study adopts a quantitative explanatory research design to investigate how technology use contributes to firm competitiveness in Algerian industrial firms. Drawing on the Resource-Based View (RBV), Dynamic Capabilities Theory, and Service-Dominant Logic (SDL), the study develops a structural model to explain how technological resources can be transformed into competitive outcomes. Specifically, the proposed framework brings together technology use, process innovation, product innovation, product quality, customer satisfaction, and the different dimensions of firm competitiveness, allowing the study to examine both direct and indirect relationships among these constructs.

The empirical analysis uses cross-sectional data and applies Partial Least Squares Structural Equation Modelling (PLS-SEM). This approach is particularly suitable for examining complex relationships among latent constructs and assessing multiple mediation effects within a single structural model.

The proposed model assumes that technology use supports process innovation, which in turn contributes to product innovation. These innovation activities are expected to improve product quality and strengthen customer satisfaction, ultimately contributing to firm competitiveness. Accordingly, the model also examines the sequential mediating roles of process innovation, product innovation, product quality, and customer satisfaction, providing a more detailed explanation of how the effects of technology use are translated into competitive outcomes.

4.2. Population and Sample.

The study population consists of Algerian industrial firms operating in the electronics and household appliances sector within the industrial zone of Bordj Bou Arréridj, one of Algeria's prominent emerging industrial clusters. The respondents included chief executive officers, unit managers, and senior managers responsible for production, technical, and administrative activities. These individuals were selected because they have direct knowledge of their firms' technology use, innovation activities, and operational practices.

A purposive sampling strategy was adopted to identify respondents who could provide relevant and reliable information in line with the objectives of the study. Data were collected between 2025 and 2026 through 55 structured face-to-face interviews using a standardised questionnaire based on a five-point Likert scale.

Although the sample size is relatively modest, it is considered adequate for the PLS-SEM analysis

conducted in this study and exceeds the minimum requirement suggested by the ten-times rule (Hair et al., 2022). In addition, PLS-SEM is widely recognised as a suitable approach for studies with relatively small samples and models focused on prediction and the examination of complex relationships. The demographic and professional characteristics of the respondents are presented in Table 2.

Table 2. Demographic and Professional Characteristics of the Respondents.

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	44	80.0
	Female	11	20.0
Age	Less than 35 years	19	34.5
	35 years and above	36	65.5
Educational Level	Bachelor's degree	20	36.36
	Master's degree	35	63.64
Position	Chief Executive Officer (CEO)	4	7.27
	Unit Manager	37	67.27
	Senior Staff	14	25.45
Work Experience	Less than 5 years	7	12.7
	5–10 years	19	34.6
	More than 10 years	29	52.7

Source: Developed by the authors.

4.3. Data Collection Procedure and Instrument Development.

The study relied on primary data collected between 2025 and 2026 through structured face-to-face interviews with chief executive officers, unit managers, and senior staff from the participating industrial firms. A standardised questionnaire was used throughout the interviews to maintain consistency across respondents. The questions were presented in the same sequence, and responses were recorded using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), providing quantitative data suitable for Partial Least Squares Structural Equation Modelling (PLS-SEM).

Before the fieldwork began, the researchers contacted the management of the participating firms to obtain the necessary permissions and arrange the interviews. To promote consistency in the data collection process and reduce the potential for interviewer-related bias, both authors conducted all interviews personally and followed the same standardised interview protocol.

To establish content validity, the questionnaire was reviewed by experts in management, statistics, and research methodology, who assessed the clarity, relevance, and suitability of the measurement items. Based on their feedback, minor linguistic and organisational changes were made to the questionnaire. A pilot study was also conducted with a small group of respondents from the target population to assess the clarity of the questions and the practicality of the data collection procedure. The pilot results indicated that the questionnaire was clear and suitable for the main data collection, and no major changes were considered necessary.

4.4. Measurement of Constructs.

The study employed multi-item scales to measure the latent constructs included in the conceptual model. The measurement items were adapted from established scales in the existing literature on

technology use, process innovation, product innovation, product quality, customer satisfaction, and firm competitiveness. Where necessary, minor linguistic adjustments were made to reflect the Algerian industrial context while maintaining the original meaning of the measurement items.

Consistent with the conceptual framework, the indicators relating to the design of new production processes and the improvement of existing production processes were combined to measure the latent construct of process innovation. This approach reflects the way process innovation is practised within the industrial firms examined in this study.

All constructs were measured using a five-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The conceptual model includes nine latent constructs, measured through a total of 44 observed indicators, as presented in Table 3.

Table 3. Measurement of the Study Constructs.

Construct	Dimension	Number of Items	Source
Technology Use	Technology Use	5	Zhu & Kraemer (2005); Venkatesh et al. (2003)
Process Innovation	Process Innovation	7	Prajogo & Sohal (2006)
Product Innovation	New Product Development	4	Prajogo & Sohal (2006)
	Product Improvement	5	Prajogo & Sohal (2006)
Product Quality	Product Quality	4	Flynn et al. (1994); Kaynak (2003)
Customer Satisfaction	Customer Satisfaction	5	Oliver (1997); Fornell et al. (1996)
Firm Competitiveness	Cost Reduction	6	Li et al. (2006)
	Profitability	3	Li et al. (2006)
	Market Share	5	Li et al. (2006)

Source: Developed by the authors based on the relevant literature.

5. Results.

5.1. Descriptive Statistics.

Descriptive statistics were first calculated to provide an overview of the study constructs and respondents' perceptions before assessing the measurement and structural models. Specifically, the mean and standard deviation were calculated for each latent construct, with the results presented in Table 4.

Table 4. Descriptive Statistics of the Study Constructs

Construct	Mean	Standard Deviation
Technology Use	3.545	0.755
Process Innovation	3.168	1.122
New Product Development	4.186	0.626
Product Improvement	4.051	0.666
Product Quality	4.364	0.645
Customer Satisfaction	4.342	0.425
Cost Reduction	4.103	0.612

Market Share	3.626	0.910
Profitability	3.491	0.717

Source: Authors' calculations based on the SmartPLS 4.1.1 output.

The descriptive statistics show that the mean scores ranged from 3.168 to 4.364, indicating a generally positive level of agreement with the questionnaire items across the study constructs. Product Quality recorded the highest mean score ($M = 4.364$), followed by Customer Satisfaction ($M = 4.342$) and New Product Development ($M = 4.186$), suggesting that respondents generally viewed these aspects as relatively well established within their firms. In contrast, Process Innovation had the lowest mean score ($M = 3.168$), indicating greater variation in the extent to which process innovation practices were adopted across the surveyed firms.

The standard deviations ranged from 0.425 to 1.122, reflecting a moderate degree of variation in respondents' perceptions. Overall, the level of dispersion suggests that respondents' views were sufficiently varied while remaining within a reasonable range, with no indication of excessive response inconsistency that would raise concerns for the subsequent analyses.

5.2. Assessment of the Measurement Model

Before evaluating the structural model, the measurement model was assessed to determine the reliability and validity of the scales used to measure the latent constructs. In line with established guidelines for Partial Least Squares Structural Equation Modelling (PLS-SEM), the assessment examined indicator reliability, internal consistency reliability, and convergent validity (Hair et al., 2022).

As shown in Table 5, the assessment was conducted after removing a small number of indicators that showed low or negative factor loadings, following established recommendations for PLS-SEM. The final measurement model was then evaluated using Cronbach's alpha, Composite Reliability (CR), and Average Variance Extracted (AVE) to assess the internal consistency and convergent validity of the constructs.

Table 5. Assessment of Indicator Reliability, Internal Consistency, and Convergent Validity.

Construct	Final Number of Items	Factor Loadings	Cronbach's Alpha	Composite Reliability	AVE
Technology Use	4	0.671–0.928	0.877	0.917	0.737
Process Innovation	4	0.917–0.970	0.968	0.976	0.912
New Product Development	4	0.846–0.909	0.892	0.925	0.755
Product Improvement	5	0.605–0.905	0.884	0.915	0.687
Product Quality	5	0.589–0.870	0.929	0.950	0.825
Customer Satisfaction	5	0.831–0.870	0.857	0.899	0.645
Cost Reduction	3	0.725–0.915	0.808	0.886	0.724
Profitability	1	0.932*	1.000	1.000	1.000
Market Share	5	0.844–0.903	0.923	0.941	0.762

*Note: Profitability was measured using a single indicator after the removal of the remaining items.

Source: Authors' calculations based on the SmartPLS 4.1.1 output.

The results indicate that the measurement model demonstrates strong reliability and internal consistency. Cronbach's alpha values ranged from 0.808 to 1.000, while Composite Reliability (CR) values ranged from 0.886 to 1.000, all exceeding the recommended threshold of 0.70 (Hair et al., 2022). These findings indicate that the constructs have satisfactory levels of internal consistency.

Regarding indicator reliability, a small number of measurement items with low or negative factor loadings were removed before the model was re-estimated. The remaining indicators showed acceptable factor loadings. A few items with loadings close to the recommended minimum threshold were retained because their inclusion did not compromise the overall quality of the measurement model, as reflected in the Composite Reliability and AVE results. This approach is consistent with the recommendations of Hair et al. (2022).

For convergent validity, the Average Variance Extracted (AVE) values ranged from 0.645 to 1.000, with all values exceeding the recommended minimum of 0.50. This indicates that each latent construct accounts for a substantial proportion of the variance in its associated indicators, providing evidence of adequate convergent validity across all measurement scales.

Overall, the findings support the reliability and validity of the measurement model, indicating that it has adequate psychometric properties for examining the structural relationships proposed in the conceptual model.

5.3. Assessment of the Structural Model.

5.3.1. Collinearity Assessment.

Before evaluating the structural relationships, collinearity among the predictor constructs was assessed using the Variance Inflation Factor (VIF). As recommended by Hair et al. (2022), VIF values below 5.0 indicate that multicollinearity is not a concern. The results are presented in Table 9.

Table 9. Collinearity Assessment (VIF Results).

Structural Relationship	VIF
Technology Use → Process Innovation	1.000
Process Innovation → New Product Development	1.000
Process Innovation → Product Improvement	1.000
New Product Development → Product Quality	1.760
Product Improvement → Product Quality	1.760
New Product Development → Customer Satisfaction	2.419
Product Improvement → Customer Satisfaction	2.419
Product Quality → Customer Satisfaction	3.926
Product Quality → Cost Reduction	3.989
Product Quality → Profitability	3.989
Product Quality → Market Share	3.989
Customer Satisfaction → Market Share	3.958
Customer Satisfaction → Profitability	3.958
Customer Satisfaction → Cost Reduction	3.958

Source: Authors' calculations based on the SmartPLS 4.1.1 output.

The results presented in Table 9 show that all VIF values ranged from 1.000 to 3.989, well below the recommended threshold of 5.0 (Hair et al., 2022). This indicates that multicollinearity does not pose a concern in the structural model, as the predictor constructs do not show problematic levels of collinearity. The path coefficients can therefore be interpreted with greater confidence, as their estimates are unlikely to be substantially affected by multicollinearity.

5.3.2. Coefficient of Determination (R²)

The explanatory power of the structural model was assessed using the coefficient of determination (R²) and the adjusted coefficient of determination (Adjusted R²) for each endogenous construct.

Following Hair et al. (2022), R^2 values of 0.75, 0.50, and 0.25 are generally interpreted as indicating substantial, moderate, and weak explanatory power, respectively. The results are reported in Table 10.

Table 10. Coefficient of Determination (R^2) Results.

Endogenous Construct	R^2	Adjusted R^2
Process Innovation	0.699	0.694
New Product Development	0.438	0.427
Product Improvement	0.437	0.427
Product Quality	0.745	0.735
Customer Satisfaction	0.788	0.780
Cost Reduction	0.602	0.595
Market Share	0.642	0.629
Profitability	0.300	0.287

Source: Authors' calculations based on the SmartPLS 4.1.1 output.

The results presented in Table 10 indicate that the structural model has moderate to substantial explanatory power across the endogenous constructs. Customer Satisfaction recorded the highest R^2 value ($R^2 = 0.788$), indicating that approximately 78.8% of its variance is explained by the predictor constructs included in the model. Product Quality ($R^2 = 0.745$) and Process Innovation ($R^2 = 0.699$) also showed relatively high explanatory power, suggesting that the model accounts for a substantial proportion of the variance in these constructs.

Market Share ($R^2 = 0.642$) and Cost Reduction ($R^2 = 0.602$) also demonstrated moderate to substantial explanatory power. New Product Development ($R^2 = 0.438$) and Product Improvement ($R^2 = 0.437$) showed moderate explanatory power, with the model explaining approximately 44% of the variance in each construct. Although Profitability had the lowest R^2 value ($R^2 = 0.300$), the model still explains 30.0% of its variance, which represents a meaningful level of explanatory power in behavioural and management research, where organisational outcomes are typically influenced by a range of factors beyond those captured in a single model.

Overall, the findings suggest that the proposed structural model provides satisfactory explanatory power, particularly for the key mediating constructs of Process Innovation, Product Quality, and Customer Satisfaction. This supports the model's ability to explain the mechanisms through which technology use is translated into different dimensions of firm competitiveness.

5.3.3. Assessment of Predictive Relevance (Q^2)

The predictive relevance of the structural model was assessed using Stone–Geisser's Q^2 statistic, obtained through the blindfolding procedure. According to Hair et al. (2022), a Q^2 value greater than zero indicates that the model has predictive relevance for the corresponding endogenous construct. As a general guideline, Q^2 values of 0.02, 0.15, and 0.35 represent small, medium, and large levels of predictive relevance, respectively. The results are reported in Table 11.

Table 11. Assessment of Predictive Relevance (Q^2).

Endogenous Construct	Q^2
Process Innovation	0.511
New Product Development	0.247
Product Improvement	0.239
Product Quality	0.563
Customer Satisfaction	0.592

Cost Reduction	0.381
Market Share	0.428
Profitability	0.184

Source: Authors' calculations based on the SmartPLS 4.1.1 output.

As shown in Table 11, all endogenous constructs produced positive Q^2 values, indicating that the structural model has predictive relevance for each endogenous variable included in the analysis. Customer Satisfaction ($Q^2 = 0.592$), Product Quality ($Q^2 = 0.563$), and Process Innovation ($Q^2 = 0.511$) showed particularly strong predictive relevance, with all three values well above the 0.35 threshold for large predictive relevance.

Similarly, Market Share ($Q^2 = 0.428$) and Cost Reduction ($Q^2 = 0.381$) also demonstrated large predictive relevance, highlighting the model's strong predictive capability for these dimensions of firm competitiveness. In contrast, New Product Development ($Q^2 = 0.247$), Product Improvement ($Q^2 = 0.239$), and Profitability ($Q^2 = 0.184$) showed moderate predictive relevance, with their values falling between 0.15 and 0.35.

Overall, the findings indicate that the proposed structural model has strong predictive relevance across the endogenous constructs, particularly for the key mediating variables—Process Innovation, Product Quality, and Customer Satisfaction—and the main competitiveness outcomes of Market Share and Cost Reduction. Taken together with the R^2 results, these findings provide support for the model's ability to both explain and predict the endogenous constructs, strengthening its suitability for testing the proposed theoretical relationships.

5.3.4. Assessment of Effect Size (f^2).

The effect size (f^2) was assessed to determine the contribution of each exogenous construct to the explained variance of its corresponding endogenous construct. Following Hair et al. (2022), f^2 values of 0.02, 0.15, and 0.35 are generally interpreted as indicating small, medium, and large effects, respectively. The results are reported in Table 12.

Table 12. Assessment of Effect Size (f^2).

Structural Relationship	f^2
Technology Use → Process Innovation	0.872
Process Innovation → New Product Development	0.776
Process Innovation → Product Improvement	0.772
New Product Development → Product Quality	0.482
Product Improvement → Product Quality	0.351
Product Quality → Customer Satisfaction	0.541
Product Quality → Cost Reduction	0.814
Product Quality → Profitability	0.386
Product Quality → Market Share	0.118
New Product Development → Customer Satisfaction	0.184
Product Improvement → Customer Satisfaction	0.167
Customer Satisfaction → Market Share	0.241
Customer Satisfaction → Profitability	0.006
Customer Satisfaction → Cost Reduction	0.015

Source: Authors' calculations based on the SmartPLS 4.1.1 output.

The results presented in Table 12 show substantial variation in the size of the effects across the proposed relationships. Technology Use had a large effect on Process Innovation ($f^2 = 0.872$), while Process Innovation also showed large effects on New Product Development ($f^2 = 0.776$) and Product Improvement ($f^2 = 0.772$). These results underline the important role of technology use in supporting process innovation and, in turn, strengthening product innovation.

Similarly, Product Quality had large effects on Cost Reduction ($f^2 = 0.814$), Customer Satisfaction ($f^2 = 0.541$), and Profitability ($f^2 = 0.386$), while its effect on Market Share ($f^2 = 0.118$) was relatively small. New Product Development ($f^2 = 0.184$) and Product Improvement ($f^2 = 0.167$) had medium effects on Customer Satisfaction, while Customer Satisfaction had a medium effect on Market Share ($f^2 = 0.241$).

By contrast, the effects of Customer Satisfaction on Profitability ($f^2 = 0.006$) and Cost Reduction ($f^2 = 0.015$) were negligible. This suggests that customer satisfaction adds very little explanatory value for these two competitiveness dimensions once the effects of the other predictor constructs are taken into account.

Overall, the effect size analysis highlights Technology Use, Process Innovation, and Product Quality as the most influential constructs in the model. These findings reinforce the idea that the contribution of technology to firm competitiveness is largely realised through innovation and value-creation processes rather than through direct effects alone.

5.3.5. Structural Path Analysis and Hypothesis Testing.

The proposed hypotheses were tested using the bootstrapping procedure with 5,000 resamples. Statistical significance was assessed based on the path coefficients (β), t-values, and p-values, following the methodological guidelines of Hair et al. (2022). A 5% significance level ($p < 0.05$) was used to determine whether the proposed hypotheses were supported. The results of the structural path analysis are reported in Table 13.

Table 13. Structural Path Coefficients and Hypothesis Testing.

Hypothesis	Structural Path	β	t-value	p-value	Decision
H1	Technology Use $\rightarrow$ Process Innovation	0.836	12.845	<0.001	Supported
H2	Process Innovation $\rightarrow$ New Product Development	0.662	7.944	<0.001	Supported
H3	Process Innovation $\rightarrow$ Product Improvement	0.662	7.921	<0.001	Supported
H4	New Product Development $\rightarrow$ Product Quality	0.532	5.814	<0.001	Supported
H5	Product Improvement $\rightarrow$ Product Quality	0.414	4.328	<0.001	Supported
H6	Product Quality $\rightarrow$ Customer Satisfaction	0.651	6.742	<0.001	Supported
H7	Product Quality $\rightarrow$ Cost Reduction	0.914	18.926	<0.001	Supported
H8	Product Quality $\rightarrow$ Profitability	0.503	2.215	0.027	Supported
H9	Product Quality $\rightarrow$ Market Share	0.345	2.987	0.003	Supported
H10	Customer Satisfaction $\rightarrow$ Market Share	0.482	4.756	<0.001	Supported

H11	Customer Satisfaction → Profitability	0.052	0.233	0.816	Not Supported
H12	Customer Satisfaction → Cost Reduction	-0.160	0.903	0.369	Not Supported
H13	New Product Development → Customer Satisfaction	0.344	2.816	0.005	Supported
H14	Product Improvement → Customer Satisfaction	-0.082	0.754	0.452	Not Supported

Source: Authors' calculations based on the SmartPLS 4.1.1 output.

The structural model provides strong empirical support for the proposed framework, with 11 of the 14 direct hypotheses receiving statistical support. The findings show that Technology Use has a strong positive effect on Process Innovation ($\beta = 0.836$), which in turn significantly contributes to both New Product Development ($\beta = 0.662$) and Product Improvement ($\beta = 0.662$). These results suggest that the contribution of technological resources to innovation is largely realised through firms' ability to improve their processes, rather than through technology alone.

The analysis further shows that both dimensions of Product Innovation have a significant positive effect on Product Quality, with New Product Development ($\beta = 0.532$) having a stronger effect than Product Improvement ($\beta = 0.414$). Product Quality then emerges as a central mechanism in the value-creation process, with significant positive effects on Customer Satisfaction, Cost Reduction, Profitability, and Market Share. Among these relationships, the strongest effect is observed for Cost Reduction ($\beta = 0.914$), highlighting the important operational benefits associated with higher product quality.

At the final stage of the proposed framework, Customer Satisfaction has a significant positive effect on Market Share ($\beta = 0.482$), but does not have a statistically significant effect on Profitability or Cost Reduction. Furthermore, while New Product Development has a significant direct effect on Customer Satisfaction, the direct effect of Product Improvement is not statistically significant. This may suggest that incremental improvements to existing products do not necessarily translate into higher customer satisfaction unless customers perceive these improvements as meaningful or as resulting in better product quality.

Overall, the findings provide empirical support for the proposed sequential value-creation mechanism, in which the benefits of technology are realised through a series of interconnected capabilities. Specifically, Technology Use strengthens Process Innovation, which supports Product Innovation and contributes to higher Product Quality, which in turn enhances Customer Satisfaction and selected dimensions of firm competitiveness. These results reinforce the central argument of the study: technology creates competitive value primarily through the organisational and innovation capabilities it enables, rather than through direct effects alone.

5.3.6. Mediation Analysis.

The significance of the indirect effects was assessed using the bootstrapping procedure, in line with the recommendations of Hair et al. (2022). Where both direct and indirect effects were observed, the type of mediation was determined by examining the significance and direction of the direct and indirect paths. The results of the mediation analysis are presented in Table 14.

Table 14. Results of the Mediation Analysis.

Hypothesis	Indirect Effect	Mediator	β	t-value	p-value	Type of Mediation	Decision
H15	Technology Use → New Product Development	Process Innovation	0.553	6.94	<0.001	Indirect-only mediation	Supported

		n					
H1 6	Technology Use → Product Improvement	Process Innovation	0.553	6.88	<0.001	Indirect-only mediation	Supported
H1 7	New Product Development → Customer Satisfaction	Product Quality	0.346	3.92	<0.001	Partial mediation	Supported
H1 8	Product Improvement → Customer Satisfaction	Product Quality	0.270	3.15	0.002	Full mediation	Supported
H1 9	New Product Development → Cost Reduction	Product Quality	0.486	4.97	<0.001	Indirect-only mediation	Supported
H2 0	Product Improvement → Cost Reduction	Product Quality	0.379	4.18	<0.001	Indirect-only mediation	Supported
H2 1	New Product Development → Profitability	Product Quality	0.268	2.37	0.018	Indirect-only mediation	Supported
H2 2	Product Improvement → Profitability	Product Quality	0.208	2.11	0.035	Indirect-only mediation	Supported
H2 3	New Product Development → Market Share	Product Quality	0.184	2.81	0.005	Partial mediation	Supported
H2 4	New Product Development → Market Share	Customer Satisfaction	0.166	2.74	0.006	Partial mediation	Supported
H2 5	Product Improvement → Market Share	Product Quality	0.143	2.28	0.023	Indirect-only mediation	Supported

Source: Authors' calculations based on the SmartPLS 4.1.1 output.

The mediation analysis shows that all the indirect effects are statistically significant, providing strong support for the mediating mechanisms proposed in the conceptual framework. In particular, Process Innovation fully mediates the relationship between Technology Use and both dimensions of Product Innovation, suggesting that the contribution of technological resources to product innovation is largely realised through improvements in firms' operational processes rather than through direct effects.

The findings also identify Product Quality as the main value-creation mechanism in the model. It mediates the effects of New Product Development and Product Improvement on Customer Satisfaction, Cost Reduction, Profitability, and Market Share. Notably, Product Quality fully mediates the relationship between Product Improvement and Customer Satisfaction, whereas its mediating effect between New Product Development and Customer Satisfaction is partial. This suggests that new product development can influence customer satisfaction both directly and indirectly through improvements in product quality.

In addition, Customer Satisfaction partially mediates the relationship between New Product Development and Market Share, highlighting its role in converting the value created through new products into improved market performance.

Overall, the mediation results provide strong empirical support for the proposed sequential value-creation mechanism, showing that the competitive benefits of technology emerge through a series of interconnected organisational capabilities. Specifically, Technology Use strengthens Process Innovation, which supports Product Innovation and contributes to higher Product Quality, which then enhances Customer Satisfaction and, ultimately, selected dimensions of competitive performance. These findings reinforce the central theoretical proposition of the study that technology contributes to competitive advantage primarily through indirect organisational and value-creation mechanisms

rather than through direct effects alone.

6. Discussion.

This study examined how technology use contributes to competitive performance by focusing on the organisational mechanisms through which technological resources are turned into tangible business outcomes in manufacturing firms. Drawing on the Resource-Based View (RBV), Dynamic Capabilities Theory, and Service-Dominant Logic, the study goes beyond the assumption that technology automatically creates competitive advantage. Instead, it proposes that the value of technological resources develops through a sequential process in which technology supports process innovation, process innovation facilitates product innovation, product innovation improves product quality, and higher quality strengthens customer satisfaction and, ultimately, competitive outcomes.

The empirical findings provide strong support for this perspective. Technology use does not appear to influence competitiveness as a stand-alone strategic resource; rather, its value depends on the organisational capabilities that firms build around it. In particular, Process Innovation emerges as a key mechanism for converting technological resources into innovation capabilities and, subsequently, into improved competitive outcomes. This suggests that technological investment alone is unlikely to generate sustainable competitive advantage unless firms also develop the organisational routines, knowledge-integration mechanisms, and innovation capabilities needed to make effective use of technological opportunities.

The study therefore provides a more integrated understanding of how technology can contribute to competitiveness in manufacturing environments. While previous research has often focused on direct relationships between technology adoption, innovation, and performance, the present findings highlight the organisational mechanisms that connect these elements and explain how technology creates value. By identifying the sequential pathway from technological resources to competitive outcomes, the study offers a clearer account of how firms can turn technological potential into meaningful and sustainable competitive benefits.

The following sections discuss the main findings in relation to the theoretical foundations and existing empirical evidence.

6.1 Technology as the Foundation of Organisational Innovation.

The empirical evidence indicates that technology use provides an important foundation for developing firms' innovation capabilities. Rather than creating value simply through the adoption of digital technologies or advanced production systems, technology strengthens firms' ability to redesign production processes, facilitate knowledge sharing, improve operational flexibility, and support continuous improvement.

This finding supports the central argument of the Resource-Based View (RBV) that resources create competitive value when they are combined with firm-specific capabilities that are difficult to imitate. From this perspective, technology is not necessarily a strategic asset on its own; its value depends largely on how effectively firms integrate it into their organisational routines and innovation processes.

The findings also extend the logic of Dynamic Capabilities Theory by showing that the contribution of technological resources to competitiveness is largely realised through capability development rather than direct performance effects. In particular, Process Innovation emerges as an important organisational mechanism through which firms respond to technological opportunities, adapt their operational practices, and turn technological investments into stronger innovation capabilities.

This represents an important theoretical contribution. While previous studies have identified technology as an antecedent of innovation (Prajogo & Sohal, 2006; Nambisan et al., 2017; Blichfeldt & Faullant, 2021; Restrepo-Morales et al., 2024), the present study goes a step further by explaining how technology contributes to value creation and identifying the organisational mechanism through which this occurs. By positioning Process Innovation as a key link between technological resources and value creation, the study offers a more nuanced understanding of how technology can ultimately contribute to competitive advantage.

6.2 From Process Innovation to Product Innovation.

The results further demonstrate that Process Innovation plays a key role in supporting Product Innovation. Improvements in production processes create better conditions for developing new products and improving existing ones by increasing operational flexibility, reducing production constraints, and helping firms apply technological knowledge to market-oriented solutions.

This relationship suggests that Product Innovation does not develop independently of a firm's internal operational capabilities. Instead, successful product development depends on efficient, flexible, and innovation-oriented production systems. Process Innovation therefore provides an important internal foundation for turning technological knowledge into products with commercial value.

These findings are consistent with previous studies that identify Process Innovation as an important antecedent of Product Innovation (Prajogo & Sohal, 2006; Atalay *et al.*, 2013; Domnich, 2022). However, the present study adds to this literature by highlighting the sequential nature of the innovation process. Rather than treating process and product innovation as separate dimensions, the findings suggest that improvements in production processes create the organisational conditions that enable firms to develop and improve their products.

Moreover, this relationship illustrates the complementary nature of exploratory and exploitative innovation activities. Process capabilities can support exploratory activities, such as developing new products, while also facilitating exploitative activities, such as improving existing product lines. This perspective is particularly relevant to manufacturing firms in emerging economies, where strengthening internal operational capabilities can provide an important foundation for sustained innovation performance.

6.3 Product Innovation as a Driver of Product Quality and Customer Value.

The findings show that Product Innovation contributes to competitive performance mainly through its effects on Product Quality and the value perceived by customers. Both New Product Development and improvements to existing products were found to enhance perceived product quality and customer satisfaction, suggesting that the competitive value of innovation comes not simply from offering a wider range of products, but from improving the characteristics that matter to customers.

One possible explanation is that innovation becomes strategically valuable when technological improvements are reflected in tangible product attributes, such as greater reliability, better functionality, and more consistent performance. Product Quality therefore serves as an important link between firms' internal innovation capabilities and the value they deliver to customers.

This interpretation is consistent with Service-Dominant Logic, which argues that value is not simply embedded in products but emerges through customers' experiences and evaluations of their use. From this perspective, Product Innovation creates meaningful value when customers recognise improvements in product performance, functionality, and usefulness.

The findings also support previous empirical research identifying Product Quality as an important determinant of Customer Satisfaction (Bhowmick & Seetharaman, 2023; Daffa & Simanjuntak, 2024; Utama Nst *et al.*, 2024). However, the present study extends this perspective by showing that Product Quality is an important mediating link through which firms' innovation capabilities are translated into customer value and, ultimately, competitive outcomes.

6.4 Product Quality and Customer Satisfaction as Complementary Drivers of Competitive Performance.

The results further demonstrate that Product Quality has a direct contribution to several dimensions of competitive performance, including cost efficiency, profitability, and market share. This finding highlights the strategic importance of quality as both an operational capability and a market-oriented resource.

Higher product quality enables firms to reduce inefficiencies related to defects, rework, and after-sales problems while also strengthening customer trust and market position. Quality improvements can therefore generate both internal efficiency gains and external competitive benefits.

In contrast, Customer Satisfaction has a more specific role in the model, showing a positive effect on Market Share but no significant direct effect on Profitability or Cost Reduction. Rather than indicating a contradiction, this finding suggests that customer-related outcomes may influence different dimensions of competitiveness through different mechanisms.

Customer satisfaction primarily reflects market-oriented benefits, including customer retention, loyalty, repeat purchases, and positive effects on corporate reputation. Profitability, however, depends on a broader range of factors, including pricing strategies, production costs, resource utilisation, and financial management. The financial benefits associated with customer satisfaction may therefore emerge indirectly and over a longer period rather than through an immediate effect on profitability.

This finding provides an important theoretical implication by suggesting that customer satisfaction should not necessarily be viewed as an immediate indicator of financial performance, but rather as a strategic market capability that can contribute to longer-term value creation. This interpretation is consistent with previous research showing that customer satisfaction is more closely associated with market-related outcomes than with short-term financial performance (Anderson & Sullivan, 1993; Oliver, 1999). It also supports recent evidence suggesting that customer satisfaction strengthens customer loyalty and contributes to improved market performance (Sihombing et al., 2025).

6.5 The Mediating Mechanisms of Value Creation.

The mediation analysis provides further insight into how technology contributes to competitive performance. All indirect effects were statistically significant, indicating that the relationship between Technology Use and competitive performance is largely transmitted through a sequence of interconnected organisational capabilities rather than occurring directly. Specifically, Technology Use strengthens Process Innovation, which supports Product Innovation, contributes to higher Product Quality, and can enhance Customer Satisfaction, ultimately affecting different dimensions of firm competitiveness.

These findings suggest that the competitive value of technology does not come simply from acquiring or using technological resources. Instead, competitive advantage depends on firms' ability to combine these resources with complementary organisational capabilities and use them effectively throughout the innovation process. In this sense, Process Innovation, Product Innovation, Product Quality, and Customer Satisfaction represent successive stages through which technological resources can be transformed into market and economic value.

From a theoretical perspective, the findings highlight the complementary contribution of the Resource-Based View, Dynamic Capabilities Theory, and Service-Dominant Logic. The Resource-Based View explains why technological resources can have strategic value, while Dynamic Capabilities Theory helps explain how firms adapt, reconfigure, and use these resources through innovation capabilities. Service-Dominant Logic further emphasises that the value generated through these activities is ultimately reflected in the quality of products and the value perceived by customers.

Accordingly, the main theoretical contribution of this study lies in showing that the relationship between Technology Use and competitive performance is better understood as a capability-driven process of value creation than as a simple technology–performance relationship. By identifying the sequential roles of Process Innovation, Product Innovation, Product Quality, and Customer Satisfaction, the study provides a more integrated explanation of how firms can turn technological resources into meaningful and sustainable competitive benefits.

7. Conclusion.

This study sought to explain how technological resources are transformed into competitive advantage within manufacturing firms by developing and testing a model that links Technology Use with Process Innovation, Product Innovation, Product Quality, Customer Satisfaction, and competitive performance. The findings show that technology does not create competitive advantage through a direct effect. Instead, its contribution is realised through a sequence of organisational and innovation capabilities that enables firms to turn technological resources into market and economic value.

The main contribution of the study lies in developing and empirically validating an integrated model

of technology-driven value creation. The findings indicate that technology acts as an enabling strategic resource, while Process Innovation, Product Innovation, Product Quality, and Customer Satisfaction provide complementary mechanisms through which this resource can be converted into competitive benefits. In doing so, the study brings together the Resource-Based View, Dynamic Capabilities Theory, and Service-Dominant Logic to provide a more integrated explanation of how firms create and capture value from technology.

From a managerial perspective, the findings suggest that technology investments are unlikely to deliver their full competitive potential unless they are supported by efforts to improve production processes, strengthen innovation capabilities, enhance product quality, and develop human capital. Managers should therefore view technology not as an isolated investment, but as part of a broader capability-building strategy focused on creating sustainable competitive value.

Although the study provides important theoretical and practical insights, its findings should be interpreted in light of several limitations. The research focused on manufacturing firms within a single industrial and geographical context and used a cross-sectional research design, which limits the ability to capture how capabilities develop and evolve over time. Future research could test the proposed model across different industries and institutional contexts, use longitudinal designs to examine the development of capabilities over time, and extend the framework by incorporating additional organisational and technological factors, such as digital transformation, organisational resilience, knowledge management, and artificial intelligence.

References

- Anderson, E. W., & Sullivan, M. W. (1993). The antecedents and consequences of customer satisfaction for firms. *Marketing Science*, 12(2), 125–143. <https://doi.org/10.1287/mksc.12.2.125>
- Atalay, M., Anafarta, N., & Sarvan, F. (2013). The relationship between innovation and firm performance: An empirical evidence from Turkish automotive supplier industry. *Procedia - Social and Behavioral Sciences*, 75, 226–235. <https://doi.org/10.1016/j.sbspro.2013.04.026>
- Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, 17(1), 99–120. <https://doi.org/10.1177/014920639101700108>
- Bhowmick, A., & Seetharaman, A. (2023). *Impact of product quality on customer satisfaction: A systematic literature review*. In *Proceedings of the 2023 7th International Conference on Virtual and Augmented Reality Simulations (ICVARS '23)* (pp. 93–99). ACM. <https://doi.org/10.1145/3603421.3603434>
- Blichfeldt, H., & Faullant, R. (2021). Performance effects of digital technology adoption and product & service innovation: A process-industry perspective. *Technovation*, 102, 102275. <https://doi.org/10.1016/j.technovation.2021.102275>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.
- Crossan, M. M., & Apaydin, M. (2010). A multi-dimensional framework of organizational innovation: A systematic review of the literature. *Journal of Management Studies*, 47(6), 1154–1191. <https://doi.org/10.1111/j.1467-6486.2010.00920.x>
- Daffa, M., & Simanjuntak, M. (2024). Perceived product quality and price on local brand fashion consumer satisfaction. *Jurnal Doktor Manajemen*, 7(1), 93–103. <https://doi.org/10.22441/jdm.v7i1.25128>
- Domnich, Y. (2022). The impact of product and process innovations on productivity: A review of empirical studies. *Foresight and STI Governance*, 16(3), 68–82. <https://doi.org/10.17323/2500-2597.2022.3.68.82>
- Flynn, B. B., Schroeder, R. G., & Sakakibara, S. (1994). A framework for quality management

research and an associated measurement instrument. *Journal of Operations Management*, 11(4), 339–366. [https://doi.org/10.1016/S0272-6963\(97\)90004-8](https://doi.org/10.1016/S0272-6963(97)90004-8)

- Fornell, C., Johnson, M. D., Anderson, E. W., Cha, J., & Bryant, B. E. (1996). The American Customer Satisfaction Index: Nature, purpose, and findings. *Journal of Marketing*, 60(4), 7–18. <https://doi.org/10.2307/1251898>
- Geisser, S. (1974). A predictive approach to the random effect model. *Biometrika*, 61(1), 101–107.
- Hair, J. F., Hult, G. T. M., Ringle, C. M., Sarstedt, M., Danks, N. P., & Ray, S. (2022). *Partial least squares structural equation modeling (PLS-SEM) using R: A workbook*. Springer. <https://doi.org/10.1007/978-3-030-80519-7>
- Iherobiem, A. C., & Sanusi, A. O. (2023). Process innovation as a strategic tool in enhancing the performance of organizations: A study of manufacturing firms in Nigeria. *Entrepreneurship and Innovation Exchange*, 13(1). <https://doi.org/10.5195/emaj.2023.306>
- Kaynak, H. (2003). The relationship between total quality management practices and their effects on firm performance. *Journal of Operations Management*, 21(4), 405–435. [https://doi.org/10.1016/S0272-6963\(03\)00004-4](https://doi.org/10.1016/S0272-6963(03)00004-4)
- Kozludzhova, K. (2023). Key aspects of product innovations: Theoretical knowledge and research study. *Journal of Law and Sustainable Development*, 11(5), e1130. <https://doi.org/10.55908/sdgs.v11i5.1130>
- Li, S., Ragu-Nathan, B., Ragu-Nathan, T. S., & Rao, S. S. (2006). The impact of supply chain management practices on competitive advantage and organizational performance. *Omega*, 34(2), 107–124. <https://doi.org/10.1016/j.omega.2004.08.002>
- Nambisan, S., Lyytinen, K., Majchrzak, A., & Song, M. (2017). Digital innovation management: Reinventing innovation management research in a digital world. *MIS Quarterly*, 41(1), 223–238.
- OECD. (2007). *OECD science, technology and industry scoreboard 2007: Innovation and performance in the global economy*. OECD Publishing.
- OECD/Eurostat. (2018). *Oslo manual 2018: Guidelines for collecting, reporting and using data on innovation* (4th ed.). OECD Publishing. <https://doi.org/10.1787/9789264304604-en>
- Oliver, R. L. (1997). *Satisfaction: A behavioral perspective on the consumer*. McGraw-Hill.
- Oliver, R. L. (1999). Whence consumer loyalty? *Journal of Marketing*, 63(Special Issue), 33–44. <https://doi.org/10.2307/1252099>
- Pitelis, C. N., Teece, D. J., & Yang, H. (2023). Dynamic capabilities and MNE global strategy: A systematic literature review-based novel conceptual framework. *Journal of Management Studies*. <https://doi.org/10.1111/joms.13021>
- Prajogo, D. I., & Sohal, A. S. (2006). The integration of TQM and technology/R&D management in determining quality and innovation performance. *Omega*, 34(3), 296–312. <https://doi.org/10.1016/j.omega.2004.11.004>
- Restrepo-Morales, J. A., Valencia-Cárdenas, M., & López Cadavid, D. A. (2024). Interplay of customer satisfaction, innovation, and product quality: Key determinants of company performance. *Journal of Technology Management & Innovation*, 19(2). <https://doi.org/10.4067/S0718-27242024000200028>
- Schmoch, U., et al. (2003). *Linking technology areas to industrial sectors*. Final Report to the European Commission, DG Research.
- Schot, J., & Steinmueller, W. E. (2018). Three frames for innovation policy: R&D, systems of

-
- innovation and transformative change. *Research Policy*, 47(9), 1554–1567. <https://doi.org/10.1016/j.respol.2018.08.011>
- Sihombing, R. E., Vitaharsa, L. I., & Pramadanti, R. (2025). Determinants of product quality on customer loyalty through repurchase intention and customer satisfaction at Kopi Kenangan. *Ilomata International Journal of Management*, 6(4), 1602–1620. <https://doi.org/10.61194/ijjm.v6i4.1876>
 - Stone, M. (1974). Cross-validated choice and assessment of statistical predictions. *Journal of the Royal Statistical Society: Series B (Methodological)*, 36(2), 111–147.
 - Sui, X., Jiao, S., Wang, Y., & Wang, H. (2024). Digital transformation and manufacturing company competitiveness. *Finance Research Letters*, 59, 104683. <https://doi.org/10.1016/j.frl.2023.104683>
 - Teece, D. J. (2025). *Dynamic capabilities: Foundational concepts*. Cambridge University Press. <https://doi.org/10.1017/9781009688910>
 - Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, 18(7), 509–533. [https://doi.org/10.1002/\(SICI\)1097-0266\(199708\)18:7<509::AID-SMJ882>3.0.CO;2-Z](https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z)
 - Utama Nst, A. M., Mamuaya, N. C., Sultan, T., Kusuma, Y. B., Dewi, G. C., & Nugroho, A. P. (2024). Unraveling the antecedents of customer loyalty in the restaurant industry: The impact of perceived price fairness, product quality, and service quality through the lens of customer satisfaction. *Journal of Logistics, Informatics and Service Science*, 11(9), 237–251. <https://doi.org/10.33168/JLISS.2024.0915>
 - Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3), 425–478. <https://doi.org/10.2307/30036540>
 - Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Dong, J. Q., Fabian, N., & Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research*, 122, 889–901. <https://doi.org/10.1016/j.jbusres.2020.09.022>
 - Vial, G. (2019). Understanding digital transformation: A review and a research agenda. *The Journal of Strategic Information Systems*, 28(2), 118–144. <https://doi.org/10.1016/j.jsis.2019.01.003>
 - Warner, K. S. R., & Wäger, M. (2019). Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal. *Long Range Planning*, 52(3), 326–349. <https://doi.org/10.1016/j.lrp.2018.12.001>
 - Zhang, S., et al. (2025). Digital transformation and strategic innovation capabilities: Enhancing the sustainability of high-tech SMEs in China. *International Journal of Academic Research in Business and Social Sciences*. <https://doi.org/10.6007/IJARBS/v15-i8/26253>
 - Zhu, K., & Kraemer, K. L. (2005). Post-adoption variations in usage and value of e-business by organizations: Cross-country evidence from the retail industry. *Information Systems Research*, 16(1), 61–84. <https://doi.org/10.1287/isre.1050.0045>
-