APTISI Transactions on Management (ATM)
Vol. 8, No. 3, 2024, pp. 259∼265
E-ISSN: 2622-6804 P-ISSN: 2622-6812, DOI:10.33050

Enhancing Organizational Resilience Through Digital Innovation in Manufacturing

Fajriannoor Fanani[1], Jerry Maratis[2], Muhammad Saiful Hadi[3], Lena Magdalena[4], Santiago Ramirez[5*]
[1]Department of Communication Science, Semarang University, Indonesia
[2]Department of Physiotherapy, Esa Unggul University, Indonesia
[3]Department of Business Intelligence, University of Raharja, Indonesia
[4]Department of Information Systems, Catur Insan Cendekia University, Indonesia
[5]Dept. of Business Administration, Ilearning Incorporation, Colombia
[1]fajrian@usm.ac.id, [2]jerry.maratis@esaunggul.ac.id, [3]saiful.hadi@raharja.info, [4]lena.magdalena@cic.ac.id, [5]tiago.ramirez@ilearning.co
***Corresponding Author**

Article Info

Article history:

September 16, 2024
September 27, 2024
September 29, 2024

Keywords:

Digital Innovation
Technology Integration
Manufacturing Sector
Organizational Resilience

ABSTRACT

The manufacturing sector faces increasing challenges in maintaining operational resilience due to market volatility, supply chain disruptions, and technological advancements. This study aims to explore the impact of digital innovation, particularly the integration of advanced technologies such as Artificial Intelligence (AI), Internet of Things (IoT), and automation, on strengthening organizational resilience within the manufacturing sector, while also investigating the complementary role of organizational culture and leadership in supporting these technological advancements. A qualitative approach was employed, involving in-depth interviews with industry leaders from various manufacturing companies, and the data was analyzed to assess both the short-term and long-term effects of digital tools on operational flexibility, risk management, and adaptability. The findings demonstrate that digital innovation significantly enhances organizational resilience in the short term by improving flexibility and risk management, though long-term sustainability requires continuous adaptation to evolving market conditions and internal organizational support. Leadership and culture were found to play a crucial role in fully realizing the benefits of digital transformation. The study concludes that while digital tools offer substantial benefits, they must be complemented by strong leadership and a culture of adaptability to ensure long-term success, with strategic recommendations provided for manufacturing companies to integrate digital tools effectively.

Corresponding Author:

Santiago Ramirez(tiago.ramirez@ilearning.co)
DOI: https://doi.org/10.33050/atm.v8i3.2362

1. INTRODUCTION

In today's fast-evolving digital landscape, the manufacturing sector is facing increasing challenges, including supply chain disruptions, market fluctuations, and global economic uncertainties [1]. To remain competitive, organizations must enhance their operational resilience through technological innovation. Digital

technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and automation offer significant potential for resilience, organizations—particularly small and medium enterprises (SMEs)—face challenges in adopting these innovations [2], [3]. Barriers such as high costs, technical complexity, and limited resources hinder SMEs from fully leveraging these tools [4]. Addressing these challenges would provide a more comprehensive and balanced discussion of digital transformation. However, many manufacturing organizations, particularly small and medium enterprises, struggle to integrate these technologies due to the complexity and costs associated with digital transformation [5], [6]. This research aims to explore how digital innovation can enhance organizational resilience in manufacturing, focusing on its impact on operational flexibility and response to disruptions[7]. The main problem addressed in this study is the lack of effective technology adoption strategies that can improve the resilience of manufacturing operations. By analyzing the integration of digital tools, this research seeks to provide practical insights for manufacturing firms looking to enhance their competitiveness through innovation [8], [9]. The findings of this study will offer strategic recommendations to guide organizations in implementing digital solutions to improve their ability to adapt to rapid changes in the business environment [10]. This study aims to contribute to the literature by offering a framework for how organizations can leverage digital technologies to build resilience, ensuring long-term sustainability in the face of operational risks and market volatility [4], [11].

1.1. Literature Review

Recent research, especially within small and medium enterprises (SMEs), has offered new insights into how digital tools are adopted in resource-constrained environments [12]. Incorporating recent studies, particularly those focusing on SMEs, would enrich the analysis and provide a broader understanding of the role of digital innovation across various organizational contexts [13].

This section explores the major areas where digital transformation is contributing to the improvement of resilience in the manufacturing sector.

1.1.1. Digital Transformation and Resilience in Manufacturing

Digital transformation has become essential in building resilience within manufacturing operations [14], [15]. Emphasized how technologies like IoT and AI help manufacturers improve real-time decision-making and adapt to unexpected disruptions, thereby enhancing resilience [16], [17]. Examined how digital innovations streamline production processes, reducing operational risks and improving overall efficiency in manufacturing environments [18].

1.1.2. IoT Integration for Operational Efficiency

The Internet of Things (IoT) is a critical component in advancing operational efficiency. Lee and Thompson (2021) explored the integration of IoT devices in manufacturing, finding that real-time data from connected systems allows for predictive maintenance [19], minimizing downtime and optimizing resource use. IoT-enabled factories showed a 20% increase in production speed and a significant reduction in costs [20].

1.1.3. Automation in Resilient Manufacturing Systems

Automation technologies play a pivotal role in enhancing manufacturing resilience [21], [15]. Automation and robotics reduce reliance on manual processes, allowing manufacturers to maintain operations even during labor shortages or market fluctuations [22]. The study found that automation not only increased production capacity but also improved the ability of organizations to swiftly adapt to external shocks.

1.1.4. Digital Tools in Supply Chain Management

Supply chain resilience is another area where digital tools, especially AI and blockchain, have shown promise[18]. Use of AI in supply chain optimization, where predictive analytics forecast demand more accurately, reducing the risks associated with stockouts and overproduction [18], [23]. Blockchain's potential in creating more transparent and secure supply chains, which are critical in maintaining resilience during disruptions [24].

Despite the increasing adoption of digital tools in manufacturing, gaps still exist in understanding their strategic implementation, particularly among small and medium enterprises (SMEs) [25], [26]. Many studies focus on large-scale manufacturers, neglecting the challenges that SMEs face in integrating these technologies. Moreover, there is limited research on how digital innovations can be continuously adapted to evolving market and technological trends, which is crucial for long-term organizational resilience [27].

2. METHODY

2.1. Research Design

This study employs a quantitative approach using Structural Equation Modeling (SEM) with SmartPLS to analyze the relationship between digital innovation and organizational resilience. The goal is to explore how digital tools enhance resilience by improving flexibility, risk management, and adaptability in the manufacturing sector.

2.2. Sample and Data

The study involves a larger sample of 150 technology companies of various sizes selected to ensure broader generalizability. However, it is important to acknowledge the limitation of focusing solely on the technology sector. Future studies should include a broader range of industries, such as manufacturing, healthcare, and retail, or explicitly discuss this as a limitation to enhance the relevance of the findings across different sectors.

2.3. Data Collection Techniques

Data were collected using structured questionnaires distributed to key stakeholders such as CTOs, digital transformation managers, and operational leaders. The development and validation of these questionnaires followed a rigorous process, involving pilot testing with a small group of industry professionals to ensure clarity, relevance, and reliability. This validation process ensures the robustness of the data collected and enhances the credibility of the findings. Secondary data from industry reports were also used to complement the primary data.

2.4. Data Analysis

The analysis was conducted using SmartPLS to perform Partial Least Squares-Structural Equation Modeling (PLS-SEM). This method allows for the exploration of complex relationships between variables, enabling the study to assess the direct and indirect effects of digital innovation on organizational resilience. SmartPLS was chosen due to its ability to handle smaller data sets and non-normal data distribution, ensuring robust and reliable results.

3. RESULTS AND DISCUSSION

3.1. Key Findings

The results of the analysis using SmartPLS indicate significant relationships between digital innovation and organizational resilience in the technology sector. Digital tools such as IoT and AI were found to positively impact flexibility, risk management, and adaptability—key elements of resilience. The analysis reveals that companies leveraging digital innovations report significant improvements in their ability to manage risks and respond to operational disruptions.

3.2. Path Coefficients

The path coefficients demonstrate the strength of the relationships between digital innovation and the three key aspects of organizational resilience:

Table 1. Path Coefficients for Digital Innovations Impact on Resilience

Relationships	Path Coefficient
Digital Innovations → Flexibility	0.25
Digital Innovations → Risk Management	0.30
Digital Innovations → Adaptability	0.20

Table 1 presents the path coefficients, which demonstrate the strength of the relationships between digital innovation and three key aspects of organizational resilience: flexibility, risk management, and adaptability. The path coefficient for flexibility is 0.25, indicating a moderate positive relationship between digital innovation and flexibility. For risk management, the path coefficient is 0.30, showing the strongest relationship among the three factors, meaning that digital innovation has a significant impact on improving risk management. The path coefficient for adaptability is 0.20, representing a positive but slightly weaker relationship. Overall, these results suggest that digital innovation positively influences flexibility, risk management, and adaptability, with

the strongest effect on risk management. This supports the hypothesis that the integration of advanced digital tools enhances organizational resilience.

- Digital Innovation → Flexibility: Path Coefficient = 0.25
- Digital Innovation → Risk Management: Path Coefficient = 0.30
- Digital Innovation → Ada ptability: Path Coefficient = 0.20

These results show that digital innovation positively influences flexibility, risk management, and adaptability, supporting the hypothesis that the integration of advanced digital tools can enhance organizational resilience.

3.3. R-squared Values

The R-squared values provide insights into how much of the variance in each resilience factor is explained by digital innovation:

Table 2. R-Squared Values for Resilience Factors

Relationships	R-Square Value
Digital Innovations → Flexibility	0.40
Digital Innovations → Risk Manegement	0.45
Digital Innovations → Adaptability	0.35

Table 2 shows the R-squared (R^2) values, which indicate how much of the variance in each resilience factor is explained by digital innovation. The R^2 value for flexibility is 0.40, meaning that 40% of the variance in flexibility can be attributed to digital innovation. For risk management, the R^2 value is 0.45, indicating that 45% of the variance in risk management is explained by digital innovation, which is the highest among the three factors. Adaptability has an R^2 value of 0.35 showing that 35% of its variance is explained by digital innovation. These values suggest that digital innovation has a significant impact on all three aspects of resilience, with the strongest effect on risk management.

- Flexibility: $R^2 = 0.40$
- Risk Management: $R^2 = 0.45$
- Adaptability: $R^2 = 0.35$

This suggests that digital innovation significantly explains a substantial proportion of the variance in these resilience factors, particularly risk management (45%).

3.4. Effect Sizes

The effect sizes (f^2) measure the impact of digital innovation on each aspect of resilience:

Table 3. Effect Sizes of Digital Innovation on Resilience Factors

Relationship	Effect Size (f^2)
Digital Innovation → Flexibility	0.12
Digital Innovation → Risk Management	0.18
Digital Innovation → Adapatibily	0.10

Table 3 shows the effect sizes (f^2) measuring the impact of digital innovation on three aspects of organizational resilience: flexibility, risk management, and adaptability. The effect size for flexibility is 0.12, indicating a small but noticeable impact, while the effect size for adaptability is 0.10, also categorized as a small effect. The strongest impact is on risk management, with an effect size of 0.18, considered a medium effect. These results suggest that while digital innovation positively affects all three factors, its influence is most pronounced on risk management, followed by flexibility and adaptability.

- Flexibility: Effect Size = 0.12 (small effect)

- Risk Management: Effect Size = 0.18 (medium effect)
- Adaptability: Effect Size = 0.10 (small effect)

These effect sizes indicate that digital innovation has the strongest impact on risk management, followed by flexibility and adaptability.

3.5. Bootstrapping and Statistical Significance

The bootstrapping analysis with 5,000 resamples confirmed the statistical significance of the path coefficients, with all T-values exceeding the threshold of 1.96 at a 95% confidence level:

Table 4. T-Values for Statistical Significance of Digital Innovations Impact on Resilience

Relationships	T-Value
Digital Innovations → Flexibility	5.12
Digital Innovations → Risk Manegement	6.05
Digital Innovations → Adaptability	4.85

Table 4 presents the T-values from a bootstrapping analysis based on 5,000 resamples, which confirm the statistical significance of the relationships between digital innovation and three aspects of organizational resilience: flexibility, risk management, and adaptability. All T-values exceed the threshold of 1.96 at a 95% confidence level, indicating that these relationships are statistically significant. Specifically, the T-value for risk management (6.05) shows the strongest relationship, followed by flexibility (5.12), and adaptability (4.85). These results confirm that digital innovation positively influences all three resilience factors, with risk management being the most significantly affected.

- T-value for Flexibility: 5.12
- T-value for Risk Management: 6.05
- T-value for Adaptability: 4.85

These results confirm that the relationships between digital innovation and organizational resilience are statistically significant.

3.6. Discussion

The findings support the hypothesis that digital innovation enhances organizational resilience by improving flexibility, risk management, and adaptability. Companies that have integrated IoT, AI, and automation into their operations report better preparedness for handling disruptions and a greater ability to adapt to changing market conditions.

The R-squared values suggest that digital innovation plays a particularly important role in improving risk management, with 45% of the variance explained. This aligns with previous research suggesting that digital tools help organizations anticipate and mitigate risks more effectively through real-time monitoring and predictive analytics.

However, while the effect sizes for flexibility and adaptability are smaller, they remain significant. This suggests that while digital tools contribute to improving these areas, other factors (such as organizational culture and leadership) may also play a role in enhancing these aspects of resilience.

4. CONCLUSION

This study has demonstrated the significant impact of digital innovation on enhancing organizational resilience in the technology sector. Key findings show that digital tools such as IoT, AI, and automation positively influence operational flexibility, risk management, and adaptability. The use of SmartPLS analysis provided clear evidence of these relationships, with path coefficients indicating strong connections between digital innovation and resilience factors. The results suggest that companies adopting digital innovations experience improved readiness to handle disruptions, greater flexibility in operations, and enhanced risk management capabilities. The R-squared values show that digital innovation explains a significant proportion of the variance in these resilience factors, particularly in risk management, where the impact is strongest.

Organizations should prioritize the integration of advanced digital technologies, such as AI and IoT, to improve their operational resilience. By doing so, they can enhance their flexibility and adaptability in response to market changes and external disruptions. Additionally, continuous investment in technology should be viewed as an ongoing process rather than a one-time initiative. Future research should expand the sample size and include companies from other sectors to improve the generalizability of the findings. Incorporating more detailed financial metrics, such as ROI and profitability, could also provide a deeper understanding of the long-term financial impact of digital innovation on resilience and sustainability.

REFERENCES

[1] M. M. Galan-Ladero, M. Sarmento, and S. Marques, "Social marketing to achieve the sustainable development goals (sdgs) in 2030 agenda by the united nations," *International Review on Public and Nonprofit Marketing*, vol. 20, no. 3, pp. 521–527, 2023.

[2] A. A. Khan, A. A. Laghari, P. Li, M. A. Dootio, and S. Karim, "The collaborative role of blockchain, artificial intelligence, and industrial internet of things in digitalization of small and medium-size enterprises," *Scientific Reports*, vol. 13, no. 1, p. 1656, 2023.

[3] P. K. Dey, S. Chowdhury, A. Abadie, E. Vann Yaroson, and S. Sarkar, "Artificial intelligence-driven supply chain resilience in vietnamese manufacturing small-and medium-sized enterprises," *International Journal of Production Research*, vol. 62, no. 15, pp. 5417–5456, 2024.

[4] Teslarati. (2024) Tesla supply chain sustainability improvements study. Accessed: 22-September-2024. [Online]. Available: https://www.teslarati.com/tesla-supply-chain-sustainability-improvements-study/

[5] M. D. Jones, S. Hutcheson, and J. D. Camba, "Past, present, and future barriers to digital transformation in manufacturing: A review," *Journal of Manufacturing Systems*, vol. 60, pp. 936–948, 2021.

[6] J. Butt, "A conceptual framework to support digital transformation in manufacturing using an integrated business process management approach," *Designs*, vol. 4, no. 3, p. 17, 2020.

[7] A. V. Wirba, "Corporate social responsibility (csr): The role of government in promoting csr," *Journal of the Knowledge Economy*, vol. 15, no. 2, pp. 7428–7454, 2024.

[8] L. Wu, L. Sun, Q. Chang, D. Zhang, and P. Qi, "How do digitalization capabilities enable open innovation in manufacturing enterprises? a multiple case study based on resource integration perspective," *Technological Forecasting and Social Change*, vol. 184, p. 122019, 2022.

[9] M. Del Giudice, V. Scuotto, A. Papa, S. Y. Tarba, S. Bresciani, and M. Warkentin, "A self-tuning model for smart manufacturing smes: Effects on digital innovation," *Journal of Product Innovation Management*, vol. 38, no. 1, pp. 68–89, 2021.

[10] S. Sagar, "Innovation and sustainability in business: Navigating the future landscape," *IOSR Journal of Business and Management (IOSR-JBM)*, vol. 25, no. 12, pp. 51–60, 2023.

[11] Y. Ye, A. C. Yeung, and B. Huo, "Maintaining stability while boosting growth? the long-term impact of environmental accreditations on firms' financial risk and sales growth," *International Journal of Operations & Production Management*, vol. 40, no. 12, pp. 1829–1856, 2020.

[12] M. Kotkova Striteska and V. Prokop, "Dynamic innovation strategy model in practice of innovation leaders and followers in cee countries—a prerequisite for building innovative ecosystems," *Sustainability*, vol. 12, no. 9, p. 3918, 2020.

[13] Q. Farooq, P. Fu, X. Liu, and Y. Hao, "Basics of macro to microlevel corporate social responsibility and advancement in triple bottom line theory," *Corporate Social Responsibility and Environmental Management*, vol. 28, no. 3, pp. 969–979, 2021.

[14] C. Phonthanukitithaworn, W. A. Srisathan, C. Ketkaew, and P. Naruetharadhol, "Sustainable development towards openness sme innovation: taking advantage of intellectual capital, sustainable initiatives, and open innovation," *Sustainability*, vol. 15, no. 3, p. 2126, 2023.

[15] P. Ralston and J. Blackhurst, "Industry 4.0 and resilience in the supply chain: a driver of capability enhancement or capability loss?" *International Journal of Production Research*, vol. 58, no. 16, pp. 5006–5019, 2020.

[16] M. Andronie, G. Lăzăroiu, M. Iatagan, C. Uță, R. Ștefănescu, and M. Cocoșatu, "Artificial intelligence-based decision-making algorithms, internet of things sensing networks, and deep learning-assisted smart process management in cyber-physical production systems," *Electronics*, vol. 10, no. 20, p. 2497, 2021.

[17] S. Modgil, R. K. Singh, and C. Hannibal, "Artificial intelligence for supply chain resilience: learning

from covid-19," *The International Journal of Logistics Management*, vol. 33, no. 4, pp. 1246–1268, 2022.
[18] A. Baquero, "Optimizing green knowledge acquisition through entrepreneurial orientation and resource orchestration for sustainable business performance," *Marketing Intelligence & Planning*, 2024.
[19] S. Ayvaz and K. Alpay, "Predictive maintenance system for production lines in manufacturing: A machine learning approach using iot data in real-time," *Expert Systems with Applications*, vol. 173, p. 114598, 2021.
[20] O. Chumphong, S. Srimai, and W. Potipiroon, "The resource-based view, dynamic capabilities and sme performance for smes to become smart enterprises," *ABAC ODI Journal Vision. Action. Outcome*, vol. 7, no. 2, p. 129, 2020.
[21] G. Ambrogio, L. Filice, F. Longo, and A. Padovano, "Workforce and supply chain disruption as a digital and technological innovation opportunity for resilient manufacturing systems in the covid-19 pandemic," *Computers & Industrial Engineering*, vol. 169, p. 108158, 2022.
[22] A. S. Gavsi, "The impact of less carbon emission on the brand image of tesla and hyundai in the uk," Master's thesis, İstanbul Gelişim Üniversitesi Lisansüstü Eğitim Enstitüsü, 2023.
[23] T. T. Le, "How do corporate social responsibility and green innovation transform corporate green strategy into sustainable firm performance?" *Journal of Cleaner Production*, vol. 362, p. 132228, 2022.
[24] M. Sharma, S. Joshi, S. Luthra, and A. Kumar, "Managing disruptions and risks amidst covid-19 outbreaks: role of blockchain technology in developing resilient food supply chains," *Operations Management Research*, vol. 15, no. 1, pp. 268–281, 2022.
[25] McKinsey Company. (2024) Responsible product management: The critical tech challenge. Accessed: 22-September-2024. [Online]. Available: https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/responsible-product-management-the-critical-tech-challenge
[26] A. Islam and S. A. Wahab, "The intervention of strategic innovation practices in between regulations and sustainable business growth: a holistic perspective for malaysian smes," *World Journal of Entrepreneurship, Management and Sustainable Development*, vol. 17, no. 3, pp. 396–421, 2021.
[27] A. Neri, E. Cagno, M. Lepri, and A. Trianni, "A triple bottom line balanced set of key performance indicators to measure the sustainability performance of industrial supply chains," *Sustainable Production and Consumption*, vol. 26, pp. 648–691, 2021.