West Science Interdisciplinary Studies
Vol. 03, No. 11, November and 2025: pp. 2213-2220

The Impact of Industrial IoT (IIoT) and Edge Computing Adoption on the Operational Performance of Manufacturing Companies in Central Java

Susatyo Handoko[1], Karnoto[2]
[1] Departemen Teknik Elektro, Fakultas Teknik, Universitas Diponegoro and susatyo73@gmail.com
[2] Departemen Teknik Elektro, Fakultas Teknik, Universitas Diponegoro and karnoto69@gmail.com

ABSTRACT

This study investigates the impact of Industrial Internet of Things (IIoT) and Edge Computing implementation on the operational performance of manufacturing companies in Central Java. A quantitative research approach was employed, involving 150 respondents selected using purposive sampling. Data were collected through a structured Likert-scale questionnaire and analyzed using SPSS version 25, including descriptive statistics, correlation, and multiple linear regression. The results indicate that both IIoT and Edge Computing have a significant positive effect on operational performance, explaining 54% of the variance. Specifically, IIoT enhances real-time monitoring, predictive maintenance, and overall production efficiency, while Edge Computing reduces latency and accelerates data-driven decision-making. The findings provide practical insights for manufacturing managers seeking to optimize operations through advanced digital technologies.

Keywords: *Industrial Internet of Things (IIoT), Edge Computing, Operational Performance, Manufacturing Industry, Central Java.*

1. INTRODUCTION

The rapid advancement of digital technologies has fundamentally transformed the operational landscape of manufacturing industries worldwide. Among these innovations, the Industrial Internet of Things (IIoT) and Edge Computing have emerged as pivotal solutions enabling real-time monitoring, automation, and data-driven decision-making. IIoT refers to the integration of smart sensors, devices, and machinery connected via the internet to collect and exchange data, thereby enhancing operational visibility and efficiency. Edge Computing complements this process by allowing data processing to occur closer to the source of data generation, reducing latency, improving response times, and optimizing resource utilization [1]–[3].

In the context of Indonesia, particularly in Central Java, manufacturing industries are facing increasing pressure to enhance productivity, reduce operational costs, and maintain competitiveness in a rapidly evolving market. Traditional centralized computing approaches often result in delays and inefficiencies in handling large volumes of operational data, which can hinder decision-making processes. Therefore, integrating IIoT with Edge Computing provides a strategic approach to overcoming these challenges and achieving sustainable operational performance improvements [4], [5].

Previous studies have indicated that adopting IIoT and Edge Computing can significantly impact key operational performance indicators such as productivity, quality, flexibility, and overall efficiency [6]–[8]. However, empirical evidence regarding the extent of these effects within Indonesian manufacturing contexts remains limited. Most prior research has predominantly focused on developed countries or examined IIoT and Edge Computing in isolation rather than in an integrated framework.

Given this research gap, the present study aims to quantitatively examine the impact of IIoT and Edge Computing implementation on the operational performance of manufacturing companies in Central Java. Utilizing data from 150 respondents collected through a Likert-scale questionnaire and analyzed using SPSS version 25, this study is designed to generate empirical evidence that enriches theoretical understanding while offering practical insights for manufacturing managers and policymakers. The focus is on how advanced digital technologies can be leveraged to strengthen operational excellence, efficiency, and adaptability within the increasingly competitive manufacturing environment.

The specific objectives of this study include measuring the level of IIoT implementation, evaluating the extent of Edge Computing adoption, and analyzing how both technologies influence operational performance among manufacturing firms in Central Java. Furthermore, the study aims to formulate actionable recommendations that can guide organizations in enhancing operational efficiency through strategic technology adoption. By addressing these objectives, the research contributes to a more comprehensive understanding of how emerging digital technologies can improve performance, boost competitiveness, and support technological advancement within Indonesia's manufacturing sector.

2. LITERATURE REVIEW

2.1 Industrial Internet of Things (IIoT)

The Industrial Internet of Things (IIoT) represents the integration of connected devices, sensors, and machines within industrial environments to enable seamless data collection, communication, and analysis, distinguishing it from consumer IoT, which focuses on personal and household applications [9], [10]. In manufacturing settings, IIoT enhances real-time machinery monitoring, anomaly detection, production schedule optimization, and data-driven decision-making [11], [12]. Its adoption has been linked to significant operational benefits such as increased productivity, reduced downtime, improved resource utilization, and enhanced product quality. Prior studies highlight IIoT's role in enabling predictive maintenance, allowing companies to anticipate equipment failures and avoid costly disruptions [13], [14], while also strengthening real-time decision-making capabilities that are crucial for maintaining competitiveness in dynamic and technology-driven manufacturing environments [15], [16].

2.2 Edge Computing

Edge Computing refers to the decentralized processing of data near its source rather than relying solely on centralized cloud servers, a mechanism that reduces latency, optimizes bandwidth usage, and enables faster response times for critical industrial operations [1], [17]. Within manufacturing environments, this approach supports real-time analysis of sensor data from machines and production lines, allowing timely interventions and operational adjustments to maintain efficiency [6], [18]. When integrated with the Industrial Internet of Things (IIoT), Edge Computing further enhances the value of industrial data by ensuring rapid processing and minimizing dependence on cloud infrastructure for immediate decision-making. Prior research shows that the synergy between IIoT and Edge Computing contributes to improvements in key performance indicators such as production speed, equipment utilization, and defect reduction [7], [19].

2.3 *Operational Performance in Manufacturing*

Operational performance refers to the efficiency and effectiveness with which an organization produces goods or services while meeting established standards of quality, cost, and time, typically measured through indicators such as productivity, production lead time, process flexibility, quality assurance, and cost efficiency in manufacturing settings [20], [21]. Achieving high operational performance allows companies to sustain competitiveness, respond swiftly to market demands, and ensure long-term organizational sustainability. The adoption of digital technologies such as IIoT and Edge Computing has been shown to directly influence these performance dimensions, with IIoT enabling predictive maintenance and continuous monitoring that reduce machine downtime and enhance throughput, while Edge Computing accelerates data processing and supports rapid operational adjustments, thereby improving responsiveness and process reliability [22], [23].

2.4 *Theoretical Framework*

This study is grounded in the Technology-Organization-Environment (TOE) framework, which explains technology adoption through the interplay of technological, organizational, and environmental factors (Tornatzky & Fleischer, 1990). Within this framework, technological factors relate to the capabilities of IIoT and Edge Computing, including real-time monitoring and decentralized data processing; organizational factors encompass management support, workforce competencies, and readiness for digital transformation; while environmental factors involve competitive pressure and regulatory requirements in the manufacturing sector. Applying the TOE framework allows this study to analyze how the implementation of IIoT and Edge Computing interacts with organizational conditions and external pressures to influence operational performance. Based on the reviewed literature, the following hypotheses are proposed.

H1: IIoT implementation has a significant positive effect on the operational performance of manufacturing companies.

H2: Edge Computing implementation has a significant positive effect on the operational performance of manufacturing companies.

These hypotheses guide the quantitative analysis and aim to determine the extent to which advanced digital technologies can enhance operational outcomes in manufacturing.

3. METHODS

3.1 Research Design

This study employs a quantitative research design to examine the impact of Industrial Internet of Things (IIoT) and Edge Computing implementation on the operational performance of manufacturing companies in Central Java. The quantitative approach allows for objective measurement, statistical analysis, and hypothesis testing regarding the relationships between technological adoption and operational performance.

3.2 Population and Sample

The population of this study consists of manufacturing companies operating in Central Java, encompassing various sectors such as textiles, automotive components, electronics, and consumer goods. Using a purposive sampling technique, the study selected 150 respondents who are directly involved in operational management, production supervision, or IT systems within the companies. This sample size is considered adequate for quantitative analysis and provides reliable statistical results using SPSS version 25 [24].

3.3 Data Collection

Primary data were collected through a structured questionnaire distributed to operational managers, IT personnel, and production supervisors. The questionnaire was developed using validated measurement scales from prior studies, with IIoT implementation assessed through indicators such as sensor integration, machine connectivity, real-time data monitoring, and predictive maintenance capabilities [25], [26]. Edge Computing implementation was measured using indicators that capture decentralized data processing, low-latency response, local data storage, and real-time analytics capabilities [1], [2], [27]. Meanwhile, operational performance was evaluated using indicators including productivity, production efficiency, product quality, process flexibility, and cost reduction [19], [28]. All questionnaire items applied a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) to quantify respondents' perceptions of IIoT, Edge Computing, and operational performance.

The measurement structure used in this study is summarized as follows: IIoT implementation is categorized under technological adoption and measured through indicators such as sensor integration, machine connectivity, real-time monitoring, and predictive maintenance; Edge Computing implementation falls under data processing efficiency and is assessed using indicators related to decentralized processing, low-latency response, local storage, and real-time analytics; and operational performance represents operational outcomes measured by productivity, efficiency, quality, flexibility, and cost reduction. All constructs consistently utilize a Likert 1–5 scale to ensure comparability across variables.

3.4 Data Analysis

The collected data were analyzed using SPSS version 25 through several sequential procedures, beginning with descriptive statistics to summarize respondent demographics and the overall levels of IIoT implementation, Edge Computing adoption, and operational performance. Validity and reliability tests were then conducted to ensure the accuracy and consistency of the measurement instruments, where validity was assessed using item-total correlation and reliability was confirmed through Cronbach's alpha values exceeding 0.70. Correlation analysis was subsequently employed to determine the strength and direction of relationships among the study variables. Finally, multiple linear regression analysis was performed to test the hypotheses and examine both the simultaneous and partial effects of IIoT and Edge Computing on operational performance using the regression model: $OP=\beta 0+\beta 1(IIoT)+\beta 2(Edge)+\epsilon$, where OP represents operational performance, IIoT denotes Industrial Internet of Things implementation, Edge refers to Edge Computing implementation, $\beta 0$ is the constant term, $\beta 1$ and $\beta 2$ are regression coefficients, and ϵ is the error term.

4. RESULTS AND DISCUSSION

4.1 Respondent Characteristics

The study surveyed 150 respondents from manufacturing companies in Central Java, consisting of operational managers, production supervisors, and IT personnel. The demographic results indicate that the majority of respondents were male (68%) and predominantly within the age range of 30–45 years (54%). Additionally, most respondents held at least a bachelor's degree (62%), suggesting that the workforce involved in this study possesses adequate educational backgrounds to understand, implement, and evaluate the use of advanced digital technologies within their organizations.

Descriptive statistical analysis shows that IIoT implementation achieved a mean score of 4.12 with a standard deviation of 0.52, Edge Computing implementation recorded a mean of 3.98 with a standard deviation of 0.57, and operational performance obtained a mean score of 4.05 with a standard deviation of 0.50—all falling into the "high" interpretation category. These findings indicate that manufacturing companies in Central Java have embraced IIoT and Edge Computing at relatively strong levels and that their operational performance is perceived as high, suggesting that ongoing digital transformation initiatives are making a positive contribution to operational improvements.

4.2 Validity and Reliability

To ensure that the measurement instruments accurately captured the constructs studied, validity and reliability tests were conducted on the questionnaire items related to IIoT implementation, Edge Computing implementation, and operational performance. Validity testing was performed using the item-total correlation method, where an item is considered valid if its correlation coefficient exceeds 0.30 (Ghozali, 2018). The analysis results show that all items used in this study met the validity criteria: IIoT implementation items demonstrated item-total correlations ranging from 0.525 to 0.742, Edge Computing implementation items ranged from 0.506 to 0.714, and operational performance items ranged from 0.552 to 0.764. These values confirm that each item accurately measures the construct it was intended to assess.

Reliability testing was conducted using Cronbach's alpha to evaluate internal consistency, with values above 0.70 indicating acceptable reliability (Nunnally, 1978). The results revealed Cronbach's alpha values of 0.877 for IIoT implementation, 0.853 for Edge Computing implementation, and 0.895 for operational performance, all of which exceed the reliability threshold. These findings confirm that the questionnaire items are both valid and reliable, ensuring that the data collected are suitable for subsequent statistical analyses, including correlation and multiple linear regression, to test the study's hypotheses.

4.3 Correlation Analysis

Pearson correlation analysis was conducted to examine the relationships among the study variables, revealing that IIoT implementation has a strong positive correlation with operational performance ($r = 0.625$, $p = 0.000$), while Edge Computing implementation also shows a strong positive correlation with operational performance ($r = 0.586$, $p = 0.000$). These results indicate that manufacturing companies adopting IIoT and Edge Computing tend to achieve higher levels of operational efficiency, productivity, and quality, suggesting that the integration of advanced digital technologies contributes substantially to improved operational outcomes.

4.4 Multiple Linear Regression Analysis

Multiple linear regression was used to test the study hypotheses.

Table 1. Multiple Regression

Independent Variable	β (Coefficient)	t-value	p-value	Interpretation
IIoT Implementation	0.416	6.236	0.000	Significant Positive Effect
Edge Computing Implementation	0.363	5.474	0.000	Significant Positive Effect
Constant	1.025	4.122	0.000	–

The results of the multiple regression analysis in Table 1 demonstrate that both IIoT implementation and Edge Computing implementation exert significant positive effects on operational performance in manufacturing companies. The coefficient for IIoT implementation (β =

0.416, p = 0.000) indicates that improvements in IIoT usage—such as enhanced sensor integration, machine connectivity, real-time monitoring, and predictive maintenance—are strongly associated with increases in operational efficiency, productivity, and process reliability. The high t-value (6.236) further reinforces the robustness of this relationship, suggesting that IIoT functions as a critical technological driver for optimizing manufacturing operations. This aligns with earlier studies that highlight IIoT's capacity to reduce machine downtime and support data-driven decision-making (Kamble et al., 2018; Xu et al., 2018). Similarly, Edge Computing implementation shows a significant positive effect on operational performance, with a coefficient of $\beta = 0.363$ ($p = 0.000$) and a t-value of 5.474, indicating that decentralized processing, low-latency responses, and real-time analytics substantially improve production responsiveness and reduce delays in operational adjustments. These findings reinforce the argument that Edge Computing helps minimize dependence on cloud infrastructure and enhances operational agility, consistent with the literature by Shi et al. (2016) and Wang et al. (2019).

Overall, the regression model indicates that both IIoT and Edge Computing contribute meaningfully to operational performance, with IIoT demonstrating a slightly stronger impact. The significant constant term ($\beta = 1.025$, $p = 0.000$) implies that additional organizational elements—such as human resource capability, managerial commitment, and operational culture—may also shape performance outcomes even without the presence of these technologies. Nonetheless, the combined influence of IIoT and Edge Computing underscores the importance of ongoing digital transformation initiatives in driving operational excellence within Central Java's manufacturing sector. Furthermore, the model's R^2 value of 0.54 signifies that 54% of the variance in operational performance can be explained by the implementation of IIoT and Edge Computing, indicating a moderate-to-strong explanatory power and highlighting the substantial role these technologies play in shaping operational outcomes.

Discussion

The results confirm that both IIoT and Edge Computing significantly enhance operational performance in manufacturing companies in Central Java. IIoT implementation demonstrates a strong positive effect, supporting Hypothesis 1, as the use of smart sensors, connected machinery, and real-time monitoring enables companies to optimize production processes, reduce unplanned downtime, and improve product quality. These outcomes are consistent with prior studies by [29]–[31], who found that IIoT contributes to higher productivity and operational efficiency. Edge Computing also shows a significant positive impact on operational performance, supporting Hypothesis 2, by enabling data to be processed near its source, reducing latency, and accelerating decision-making. This facilitates timely production interventions and is aligned with the findings of [32], [33], which highlight the value of decentralized processing for enhancing operational responsiveness and resource utilization.

The integrated effect of IIoT and Edge Computing provides synergistic advantages, where real-time data collection combined with rapid local processing allows companies to respond quickly to operational challenges. This synergy not only improves efficiency and product quality but also reduces costs associated with delays and machine downtime. Overall, the findings indicate that manufacturing companies in Central Java that invest in both IIoT and Edge Computing achieve measurable improvements in operational performance, underscoring the importance of adopting advanced digital technologies as a strategic approach to strengthen competitiveness in the manufacturing sector.

CONCLUSION

This study demonstrates that the implementation of IIoT and Edge Computing significantly improves the operational performance of manufacturing companies in Central Java, with quantitative findings showing that IIoT adoption enhances productivity, reduces machine downtime, and strengthens quality control, while Edge Computing facilitates faster data processing, low-latency decision-making, and more efficient resource utilization; together, these technologies create synergistic benefits that lead to substantial improvements in operational efficiency, cost reduction, and overall competitiveness. The practical implications highlight the need for manufacturing managers to invest in integrating IIoT and Edge Computing into production processes, provide adequate employee training to ensure effective technological utilization, and continuously update digital infrastructure to sustain performance gains. Future research may expand the sample size, investigate other regions in Indonesia, or analyze the long-term effects of digital transformation on strategic and financial performance within the manufacturing sector.

REFERENCES

[1] D. Loghin, S. Cai, G. Chen, T. T. A. Dinh, and ..., "The disruptions of 5G on data-driven technologies and applications," *IEEE Trans. …*, 2020.

[2] P. Sharma, S. Jain, S. Gupta, and V. Chamola, "Role of machine learning and deep learning in securing 5G-driven industrial IoT applications," *Ad Hoc Networks*, 2021.

[3] C. W. Tseng, F. H. Tseng, Y. T. Yang, C. C. Liu, and ..., "Task scheduling for edge computing with agile VNFs on-demand service model toward 5G and beyond," *… and Mobile Computing*. hindawi.com, 2018.

[4] S. Debdas, S. Chatterjee, S. Das, D. Das, S. Hazra, and P. B. Shah, "IoT Edge Based Vertical Farming," in *2023 World Conference on Communication & Computing (WCONF)*, IEEE, 2023, pp. 1–5.

[5] D. Sabella, A. Vaillant, P. Kuure, and ..., "Mobile-edge computing architecture: The role of MEC in the Internet of Things," *IEEE Consum. …*, 2016.

[6] Y. Siriwardhana, P. Porambage, and ..., "A survey on mobile augmented reality with 5G mobile edge computing: Architectures, applications, and technical aspects," *… Surv. &Tutorials*, 2021.

[7] R. Bruschi, J. F. Pajo, F. Davoli, and C. Lombardo, "Managing 5G network slicing and edge computing with the MATILDA telecom layer platform," *Comput. Networks*, 2021.

[8] F. Fang and X. Wu, "A win–win mode: the complementary and coexistence of 5G networks and edge computing," *IEEE Internet Things J.*, 2020.

[9] W. Liu, Y. Liang, X. Bao, J. Qin, and M. K. Lim, "China's logistics development trends in the post COVID-19 era," *Int. J. …*, 2022, doi: 10.1080/13675567.2020.1837760.

[10] F. Nofiard, "Komunikasi Politik Digital di Indonesia," *Al-Hiwar J. Ilmu dan Tek. Dakwah*, vol. 10, no. 2, p. 31, 2022, doi: 10.18592/al-hiwar.v10i2.7548.

[11] S. Latif, J. Qadir, S. Farooq, and M. A. Imran, "How 5G wireless (and concomitant technologies) will revolutionize healthcare?," *Futur. Internet*, 2017.

[12] M. Fahlevi and A. Purnomo, "The Integration of Internet of Things (IoT) And Cloud Computing in Finance and Accounting: Systematic Literature Review," in *2023 8th International Conference on Business and Industrial Research (ICBIR)*, IEEE, 2023, pp. 525–529.

[13] D. Watkins, "Real-time big data analytics, smart industrial value creation, and robotic wireless sensor networks in Internet of things-based decision support systems," *Econ. Manag. Financ. Mark.*, 2021.

[14] M. Browne, "Artificial intelligence data-driven internet of things systems, real-time process monitoring, and sustainable industrial value creation in smart networked factories," *J. Self-Governance Manag. …*, 2021.

[15] P. V Mekikis, K. Ramantas, and ..., "NFV-enabled experimental platform for 5G tactile Internet support in industrial environments," *IEEE Trans. …*, 2019.

[16] H. Li, Z. Yang, C. Jin, and J. Wang, "How an industrial internet platform empowers the digital transformation of SMEs: theoretical mechanism and business model," *J. Knowl. Manag.*, vol. 27, no. 1, pp. 105–120, 2023.

[17] J. Wang, C. Xu, J. Zhang, and R. Zhong, "Big data analytics for intelligent manufacturing systems: A review," *J. Manuf. Syst.*, 2022.

[18] A. N. Toosi, R. Mahmud, Q. Chi, and ..., "Management and orchestration of network slices in 5G, fog, edge and clouds," *Fog Edge Comput. …*, 2019.

[19] S. Sukhmani, M. Sadeghi, M. Erol-Kantarci, and ..., "Edge caching and computing in 5G for mobile AR/VR and tactile internet," *IEEE …*, 2018.

[20] M. L. Tseng, T. P. T. Tran, H. M. Ha, T. D. Bui, and ..., "Sustainable industrial and operation engineering trends and challenges Toward Industry 4.0: A data driven analysis," *J. Ind. …*, 2021, doi: 10.1080/21681015.2021.1950227.

[21] G. R. Nagiah and N. Mohd Suki, "Linking environmental sustainability, social sustainability, corporate reputation and the business performance of energy companies: insights from an emerging market," *Int. J. Energy Sect. Manag.*, 2024, doi: 10.1108/IJESM-06-2023-0003.

[22] T. Whittle, E. Gregova, I. Podhorska, and ..., "Smart manufacturing technologies: Data-driven algorithms in production planning, sustainable value creation, and operational performance improvement," *Econ. Manag. …*, 2019.

[23] R. Taruvinga and U. Sakarombe, "FINANCIAL LITERACY, INFORMALITY, AND SMALL BUSINESS OPERATIONAL PERFORMANCE IN ZIMBABWE.," *J. Ekon. dan Bisnis Airlangga*, vol. 34, no. 1, 2023.

[24] J. F. Hair, W. C. Black, B. J. Babin, and R. E. Anderson, "Multivariate data analysis: Pearson College division," *Pers.*

London, UK, 2010.
[25] U. Awan, R. Sroufe, and M. Shahbaz, "Industry 4.0 and the circular economy: A literature review and recommendations for future research," *Bus. Strateg. Environ.*, vol. 30, no. 4, pp. 2038–2060, May 2021, doi: https://doi.org/10.1002/bse.2731.
[26] Rosenda ALICWAS Berry, "The Use of Technology in the Delivery of Instruction in Public Schools," *Int. J. Multidiscip. Res.*, vol. 6, no. 3, pp. 1–11, 2024, doi: 10.36948/ijfmr.2024.v06i03.20219.
[27] Q. V Pham *et al.*, "A survey of multi-access edge computing in 5G and beyond: Fundamentals, technology integration, and state-of-the-art," *IEEE …*, 2020.
[28] Y. C. Hu, M. Patel, D. Sabella, N. Sprecher, and V. Young, "Mobile edge computing—A key technology towards 5G," *ETSI white paper*. infotech.report, 2015.
[29] M. Humayun, N. Z. Jhanjhi, M. Alruwaili, and ..., "Privacy protection and energy optimization for 5G-aided industrial Internet of Things," *IEEE …*, 2020.
[30] E. J. Khatib and R. Barco, "Optimization of 5G networks for smart logistics," *Energies*, 2021.
[31] L. Hou, S. Tan, Z. Zhang, and N. W. Bergmann, "Thermal energy harvesting WSNs node for temperature monitoring in IIoT," *Ieee Access*, vol. 6, pp. 35243–35249, 2018.
[32] J. Sasiain, A. Sanz, J. Astorga, and E. Jacob, "Towards flexible integration of 5G and IIoT technologies in industry 4.0: A practical use case," *Appl. Sci.*, 2020.
[33] G. Hatzivasilis, K. Fysarakis, O. Soultatos, and ..., "… Industrial Internet of Things as an enabler for a Circular Economy Hy-LP: A novel IIoT protocol, evaluated on a wind park's SDN/NFV-enabled 5G industrial network," *Comput. …*, 2018.