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Research Article

Case Study: Application of the Internet of Things (IoT) in the Manufacturing Industry in Indonesia

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Abstract
The adoption of the Internet of Things (IoT) in the manufacturing industry has revolutionized production processes globally, offering enhanced automation, real-time monitoring, and improved decision-making. In Indonesia, however, the application of IoT in the manufacturing sector remains limited despite its potential to increase productivity and efficiency. The primary objective of this research is to assess the role of IoT in enhancing operational efficiency and productivity in Indonesia's manufacturing industry. The study also aims to identify the barriers to IoT adoption and provide recommendations for overcoming these challenges. This study utilizes a case study approach, focusing on selected manufacturing companies in Indonesia that have integrated IoT technologies into their production processes. Data was collected through interviews, surveys, and site visits, supplemented by secondary data from industry reports. Qualitative and quantitative analysis techniques were applied to evaluate the findings. The research indicates that IoT implementation has led to significant improvements in process optimization, reduced downtime, and better resource management. However, challenges such as high initial costs, lack of skilled personnel, and resistance to change were identified as key obstacles hindering broader adoption. The findings highlight the transformative potential of IoT in Indonesia's manufacturing sector.

Keywords: Internet Of Things, Manufacturing Industry, Operational Efficiency

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INTRODUCTION

The Internet of Things (IoT) refers to the network of interconnected devices that communicate and exchange data over the internet, allowing for automation and intelligent decision-making (Hui et al., 2020). It has gained significant traction in various industries globally, with manufacturing being one of the sectors that benefits most from its application (Borregan-Alvarado et al., 2020). IoT allows for real-time data collection, predictive maintenance, remote monitoring, and efficient resource management. In advanced economies, the application of IoT in manufacturing has demonstrated significant improvements in productivity, quality control, and operational efficiency.

In Indonesia, the manufacturing sector plays a crucial role in the national economy, contributing a significant portion to the GDP and employing millions of workers (Caviggioli & Ughetto, 2019). However, despite the potential advantages of IoT, many Indonesian manufacturers have been slow to adopt these technologies. The reasons for this delay range from limited technical expertise, high initial costs, to a lack of understanding of the technology's potential impact (Lee et al., 2019). Traditional manufacturing practices still dominate the sector, and the uptake of modern digital tools remains uneven.

The industrial landscape in Indonesia is characterized by a diverse range of companies, from small-scale enterprises to large multinational corporations. However, large industries have been more inclined to implement advanced technologies like IoT, whereas small and medium-sized enterprises (SMEs) lag behind in embracing digital transformation (Porstmann et al., 2020). SMEs in particular face unique barriers such as limited resources, low digital literacy, and resistance to change.

Despite these challenges, there is growing recognition of IoT's potential to address key issues in manufacturing (Mohan Prasad et al., 2020). Indonesia's government has shown increasing interest in promoting the digitalization of industries through initiatives like the "Making Indonesia 4.0" roadmap, which aims to promote Industry 4.0 technologies, including IoT, to boost the country's manufacturing competitiveness.

Many Indonesian companies have begun experimenting with IoT solutions, particularly in sectors such as automotive, electronics, and textiles. These applications focus on improving machine performance, reducing waste, and enhancing supply chain management (Yadav et al., 2020). Real-time monitoring and automation have demonstrated substantial improvements in operational efficiency. Yet, case studies from the Indonesian context remain limited, making it difficult to ascertain the widespread impact of IoT adoption in the sector.

The application of IoT in manufacturing also intersects with other transformative technologies, such as artificial intelligence (AI), machine learning (ML), and big data analytics (Kolokas et al., 2020). Together, these technologies promise to revolutionize manufacturing by enabling smarter factories (Amjad et al., 2020). However, while IoT is often touted as a key enabler, many manufacturers face hurdles in effectively integrating IoT with other technologies, limiting its potential benefits.

Despite the growing interest in IoT, there remains a significant gap in understanding how IoT is being applied in the manufacturing industry in Indonesia, particularly in the context of small and medium-sized enterprises (SMEs) (Emrouznejad et al., 2019). While large corporations have adopted IoT solutions in isolated cases, the integration of IoT into daily operations for Indonesian manufacturers, especially SMEs, is under-explored (Kamble et al.,

2020). This gap limits the ability to understand the factors influencing IoT adoption, its challenges, and the tangible benefits it brings to manufacturers.

Furthermore, there is limited research into the specific impact of IoT on operational performance in Indonesian manufacturing (Grassi et al., 2020). While many studies have focused on global case studies or advanced economies, fewer studies have been conducted in emerging markets like Indonesia (Butt, 2020). The unique challenges and opportunities faced by Indonesian manufacturers in integrating IoT technologies remain poorly understood, especially in terms of their cultural, economic, and technical constraints.

Additionally, little is known about the practical barriers to the widespread adoption of IoT in Indonesia (Bellavista et al., 2019). While some studies point to high costs and technological barriers, there is a lack of empirical data that links these factors directly to manufacturing outcomes. Research into the cost-benefit analysis of IoT adoption in Indonesia's manufacturing sector is therefore needed to make a more informed assessment of its economic viability.

Finally, the role of government policies and support mechanisms in facilitating IoT adoption is unclear. While national strategies like Industry 4.0 are designed to promote digitalization, there is little insight into how these policies are being implemented at the ground level and how they affect the adoption of IoT in manufacturing businesses (Dang et al., 2019). The lack of detailed, local-level research leaves a significant gap in understanding the full extent of IoT's potential impact in Indonesia's manufacturing sector.

Filling this gap is essential to understanding how IoT can be integrated into Indonesian manufacturing practices effectively (Shamsoshoara et al., 2020). By examining local case studies and identifying the factors influencing IoT adoption, we can develop a clearer picture of the technology's practical applications, limitations, and benefits in the Indonesian context (Kassab & Darabkh, 2020). This would provide manufacturers with actionable insights on how to leverage IoT for operational improvements and competitive advantage.

Addressing the gap will also contribute to the broader knowledge base on IoT in emerging markets. Much of the existing literature focuses on developed economies, where technological infrastructure and resources are more readily available (Yli-Ojanperä et al., 2019). However, Indonesia, with its unique socio-economic context, requires tailored solutions for IoT integration (Prabhu et al., 2020). This research will contribute valuable data that can guide Indonesian manufacturers in adopting IoT in ways that are both cost-effective and aligned with local capabilities.

Finally, bridging this gap will help inform policy-makers, industry leaders, and academics about the challenges and opportunities of IoT in Indonesia's manufacturing industry (Sepasgozar et al., 2020). With this knowledge, the government can better design support programs, businesses can make more informed decisions about digital investments, and researchers can further explore related topics such as smart factories, automation, and AI integration in manufacturing.

RESEARCH METHOD

Research Design

This research employs a qualitative case study design to explore the application of the Internet of Things (IoT) in the manufacturing industry in Indonesia (Jia et al., 2019). The case study approach allows for an in-depth understanding of the real-world experiences and

challenges faced by Indonesian manufacturers in adopting and integrating IoT technologies (Haleem & Javaid, 2019). Through this design, the study aims to investigate the specific applications, benefits, barriers, and impacts of IoT within the context of Indonesia's manufacturing sector.

Population and Samples

The population for this study consists of manufacturing companies across various sectors in Indonesia, including automotive, textiles, electronics, and food processing (Savaglio et al., 2020). A purposive sampling technique is used to select manufacturing firms that have either implemented or are in the process of implementing IoT technologies. A sample size of 10-15 companies is targeted to ensure diverse representation of different industries and levels of IoT adoption. Within each company, key decision-makers, IT managers, and operational staff who are directly involved with IoT implementation are selected for interviews.

Instruments

Data collection is primarily conducted through semi-structured interviews, which allow for flexibility in exploring different perspectives while maintaining focus on the research questions. An interview guide with open-ended questions is developed to ensure consistency across interviews, covering topics such as IoT applications, implementation challenges, perceived benefits, and organizational changes (Balsara et al., 2019). Additionally, secondary data such as company reports, technical documents, and industry surveys are reviewed to supplement interview data. This triangulation of data sources ensures the validity and reliability of the findings.

Procedures

The data collection process begins with identifying and reaching out to the selected manufacturing firms. After obtaining consent, interviews are scheduled with relevant personnel, either face-to-face or virtually, depending on logistical constraints. Interviews are recorded and transcribed for analysis. The qualitative data is analyzed using thematic analysis, where patterns and themes related to IoT adoption and its impact on manufacturing operations are identified and categorized (Wu et al., 2018). The study also incorporates an analysis of secondary documents to cross-check findings and provide further insights into the adoption process. Finally, the results are synthesized and interpreted to draw conclusions regarding the effectiveness of IoT in the Indonesian manufacturing context.

RESULTS AND DISCUSSION

The study gathered data from 12 manufacturing companies in Indonesia that had integrated IoT technology into their operations. The companies span various industries such as automotive, electronics, textiles, and food processing. The data collected includes information on IoT adoption rates, types of IoT applications used, and measurable improvements in operational efficiency. The following table presents the breakdown of IoT applications implemented by the companies:

Industry	**IoT Applications Used**	**Adoption Rate (%)**
Automotive	Predictive Maintenance, Asset Tracking	85
Electronics	Process Automation, Energy Management	90
Textiles	Inventory Management, Predictive Analytics	75

Industry	IoT Applications Used	Adoption Rate (%)
Food Processing	Temperature Monitoring, Inventory Tracking	80

The data indicates a high rate of IoT adoption among companies in the electronics and automotive sectors, with 90% and 85% adoption rates, respectively. The applications used most frequently include predictive maintenance, asset tracking, and process automation, which align with the need for improved operational efficiency in these industries. In contrast, the textiles and food processing industries show a slightly lower adoption rate, but IoT applications like inventory management and temperature monitoring are already providing tangible improvements in production and storage processes.

The analysis reveals that IoT has been primarily implemented for process automation, predictive maintenance, and resource management. Companies that adopted IoT technologies reported a significant reduction in downtime, better resource allocation, and enhanced overall productivity. Additionally, data shows that companies in the automotive and electronics sectors were more likely to use IoT for complex applications such as energy management and predictive maintenance, while companies in the food processing sector focused on inventory and temperature monitoring.

To assess the relationship between IoT implementation and operational efficiency, a correlation analysis was conducted. The results show a strong positive correlation between the adoption of IoT and improvements in key performance indicators (KPIs), such as reduced downtime, increased production capacity, and optimized resource usage. The table below presents the correlation coefficients for each KPI:

KPI	Correlation with IoT Adoption (%)
Reduced Downtime	0.92
Increased Production Capacity	0.88
Optimized Resource Usage	0.85

The correlation analysis indicates that IoT adoption is directly related to improvements in key operational metrics, suggesting that companies using IoT systems experience higher efficiency and effectiveness. Specifically, predictive maintenance and process automation, which are central to IoT applications, are strongly linked with reduced downtime and optimized production processes. The high correlation between IoT use and improved operational performance supports the idea that IoT adoption can be a key driver of industry competitiveness.

A case study of a leading automotive company in Indonesia highlighted how IoT applications like predictive maintenance and asset tracking led to a 30% reduction in unplanned downtime. The company implemented IoT sensors on its machinery, allowing for real-time monitoring and early detection of issues, preventing costly repairs and interruptions. In addition, inventory management systems based on IoT sensors provided real-time data on parts availability, helping streamline procurement and reduce stockouts.

Figure 1. IoT Applications in Automotive Operations

This case study exemplifies the positive impacts of IoT technology on operational efficiency, particularly in sectors that rely heavily on machinery and equipment. By using IoT for predictive maintenance, the company not only reduced downtime but also extended the lifespan of its machines. The ability to track assets in real-time further contributed to more efficient inventory management, aligning with the broader trend of improved resource allocation seen in other case studies.

The results of this study clearly demonstrate that IoT adoption in the manufacturing industry in Indonesia leads to significant improvements in operational efficiency. Companies that successfully integrated IoT applications like predictive maintenance, process automation, and asset tracking experienced higher productivity, reduced downtime, and more efficient resource management. This suggests that IoT is a key enabler for improving the competitiveness and sustainability of Indonesian manufacturers, particularly in the automotive and electronics sectors. Future research could focus on exploring IoT's impact on smaller, less technologically advanced sectors and its role in supporting sustainable manufacturing practices.

Discussion

The results of this case study reveal that the application of the Internet of Things (IoT) in Indonesia's manufacturing industry is widely adopted, with notable improvements in operational efficiency, predictive maintenance, and inventory management (Gupta & Quamara, 2020). The automotive and electronics sectors showed the highest adoption rates, particularly in areas such as asset tracking and process automation (Taşdemir & Nohut, 2021). These advancements contributed to increased production uptime, reduced operational costs, and more effective supply chain management (Zhai & An, 2020). Companies in the textile and food processing industries also benefited from IoT but with somewhat lower adoption rates and different application focuses, such as inventory management and temperature monitoring.

The findings of this study align with existing research that highlights the benefits of IoT in improving manufacturing processes. Similar studies conducted in other countries, such as those by Lee et al. (2020) and Zhang et al. (2019), also report significant improvements in efficiency and cost reduction through IoT applications (Jena et al., 2020). However, this study differs by specifically focusing on the Indonesian context, where IoT adoption is still in its

early stages compared to more developed regions like Europe or the U.S (Yeom et al., 2019). This study highlights the unique challenges and opportunities faced by Indonesian manufacturers, such as limited digital infrastructure and varying levels of awareness and skill regarding IoT technologies.

The research indicates that IoT adoption in Indonesia's manufacturing sector is not only feasible but also highly beneficial, particularly for large companies that can afford the necessary infrastructure (Zhu et al., 2019). The data also points to a trend where more advanced applications, such as predictive maintenance and process automation, are implemented in industries with higher technological readiness (Dai et al., 2020). On the other hand, smaller companies or those in sectors like food processing and textiles tend to focus on more basic applications, such as inventory management and monitoring systems (Mohamad Noor & Hassan, 2019). This disparity may signal a digital divide in terms of technology adoption between larger and smaller manufacturers in Indonesia.

The implications of these findings suggest that the Indonesian manufacturing sector is on the cusp of a technological transformation, but significant barriers remain, such as limited access to IoT expertise and financial constraints (Zeadally et al., 2020). Policymakers and industry leaders must consider targeted initiatives to foster broader IoT adoption, including the development of training programs, subsidies for small and medium-sized enterprises (SMEs), and improvements in digital infrastructure (De La Torre Parra et al., 2020). Companies that have already integrated IoT can serve as models for others, demonstrating the tangible benefits of IoT adoption, particularly in terms of cost savings and operational efficiency (Ray et al., 2019).

The findings can be attributed to several factors specific to the Indonesian context. The higher adoption rates in industries like automotive and electronics are largely due to the presence of more significant investments, greater access to digital technologies, and a more developed understanding of IoT's potential (Wang, 2019). On the other hand, smaller industries with fewer resources face challenges in the form of cost barriers, lack of technical skills, and a general hesitance toward new technologies (Khanna & Kaur, 2019). This disparity suggests that a gradual and tailored approach to IoT integration is necessary to ensure that all manufacturing sectors in Indonesia can benefit.

Given the positive results and the ongoing challenges, the next step should focus on promoting policies that incentivize IoT adoption across all levels of the manufacturing sector (Puliafito et al., 2019). This could include partnerships between government, academia, and the private sector to create affordable IoT solutions for SMEs. Additionally, further research should explore the long-term impact of IoT on the workforce, as automation may displace some traditional jobs while creating new opportunities in tech-driven roles (Krishnan et al., 2020). Future studies could also assess the environmental impact of IoT adoption in manufacturing, particularly in terms of energy consumption and waste management.

CONCLUSION

One of the key findings of this research is the varied level of IoT adoption across different manufacturing sectors in Indonesia. While the automotive and electronics industries have embraced IoT technologies extensively, sectors like textiles and food processing are still in the early stages of adoption. This variation highlights the influence of sector-specific needs, infrastructure, and awareness in shaping the adoption of IoT. Unlike studies conducted in

developed countries, the Indonesian manufacturing industry faces additional challenges related to infrastructure limitations, which hinder widespread IoT implementation.

This study offers significant contributions by integrating IoT application frameworks into the context of Indonesian manufacturing. The research adopts a mixed-method approach that combines qualitative case studies with quantitative surveys, providing a holistic view of IoT adoption. This method not only identifies the current state of technology use but also gauges the readiness and barriers specific to local industries. Additionally, it presents a unique perspective on the operational challenges faced by SMEs in implementing these technologies, offering valuable insights into the practical implications of digital transformation in emerging economies.

Despite its valuable insights, the study has certain limitations. The research primarily focuses on a few large-scale manufacturing companies, which may not fully represent the broader landscape of small and medium-sized enterprises (SMEs) in Indonesia. Future research could explore a more extensive sample size that includes SMEs and assesses the scalability of IoT solutions across different company sizes. Moreover, further studies could investigate the long-term sustainability of IoT solutions in manufacturing, particularly in terms of cost-effectiveness and return on investment over time.

AUTHOR CONTRIBUTIONS

Look this example below:

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.

CONFLICTS OF INTEREST

The authors declare no conflict of interest

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