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A Review of IoT Smart Decision-Making Processes to Enhance Organizational Performance in the Manufacturing Industry

Siti Nur Maisarah Isnin[1], Nurul Farhaini Razali[2*], Nor Azah Abdul Aziz[3] Sitinor Wardatulaina Mohd Yusof[4] Nur Syakirah Ahmad[5] Kohila Malar Kalesamy[6]

[1,2*,3,4]Fakulti Pengurusan Teknologi dan Teknousahawanan, Universiti Teknikal Malaysia Melaka

[5]Fakulti Keusahawanan dan Perniagaan, Universiti Malaysia Kelantan

[6]School of Technology, Asia Pacific University of Technology and Innovation

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ABSTRACT

In the era of Industry 4.0, the Internet of Things (IoT) has emerged as a transformative technology with the potential to enhance organizational performance in the manufacturing sector significantly. The primary aim of this paper is to review previous studies on how the manufacturing industry can improve its organizational performance by implementing IoT Smart Decision-Making Processes. Despite the numerous benefits associated with IoT, including real-time monitoring, predictive maintenance, and process automation, many firms face significant challenges such as high implementation costs, limited technical expertise, cybersecurity risks, and uncertain returns on investment. The paper addresses critical questions regarding which IoT Smart Decision-Making processes are instrumental in enhancing organizational performance, how these processes drive improvements in manufacturing outcomes, and what essential elements constitute an effective IoT Smart Decision-Making process in the manufacturing industry. By bridging the gap between the theoretical potential of IoT and its practical application in developing economies such as Malaysia, this paper proposes an IoT smart decision-making process for industry practitioners, informs policy formulation, and contributes to the academic discourse on smart manufacturing and Industry 4.0.

Keywords: Industry 4.0, Internet of Things (IoT), Manufacturing Industry, Organizational Performance, Smart Decision-Making, Malaysia.

INTRODUCTION

The incorporation of digital technology like the IoT Smart Decision-Making Process has transformed the industrial sector in the Fourth Industrial Revolution (Industry 4.0). According to Atzori, Iera, and Morabito (2010), the Internet of Things is a network of physically linked devices that gather, share, and act upon data in real-time, facilitating more informed decision-making and improved operational visibility. Predictive maintenance, real-time inventory management, process automation, and improved product customisation are all made possible in manufacturing. In addition to increasing operational effectiveness, these competencies are turning into vital facilitators of technological innovation performance, which refers to businesses' ability to launch new or vastly enhanced goods, procedures, and systems (Choi, Wallace, & Wang, 2016).

Even though IoT Smart Decision-Making Processes have shown great promise, successful implementation remains a challenge, with issues like high initial investment, lack of skilled personnel, data security concerns, and unclear return on investment (ROI) slowing its widespread integration. Despite these obstacles, companies that successfully implement IoT frequently report notable improvements in their innovation capabilities, responsiveness to market demands, and production efficiency. To stay competitive in an increasingly globalized and technology-driven economy, many manufacturing firms have turned to IoT as a strategic tool for innovation (Ghobakhloo & Fathi, 2021).

In keeping with the growing digitization of manufacturing, new data indicates that over 70% of manufacturers worldwide have either implemented or are in the process of implementing IoT solutions. Businesses that successfully integrate IoT report productivity increases of up to 25% and equipment downtime reductions of 20–30% (Statista, 2023; McKinsey & Company, 2021). These figures demonstrate how crucial it is to comprehend how to use IoT Smart Decision-Making Processes in ways that provide quantifiable improvement results. As a result, this research is both pertinent and topical, offering useful perspectives to academic researchers and industry professionals who are interested in the nexus between innovation and technology.

Background of Study

In today's rapidly evolving manufacturing landscape, digital transformation is essential for enhancing productivity, competitiveness, and sustainability. At the core of this shift is IoT Smart Decision-Making Processes, a technology that connects machines, systems, and devices to enable real-time data collection and intelligent decision-making (Lee et al., 2015). As manufacturers face growing challenges such as global competition, resource constraints, and rising customer expectations, the ability to leverage IoT for smart, timely decisions has become a key success factor (Porter & Heppelmann, 2014). This paper focuses on the implementation of IoT Smart Decision-Making Processes to enhance organizational performance, aiming to identify relevant processes, assess their impact, and propose a tailored framework for the manufacturing industry.

IoT Smart Decision-Making Processes in Manufacturing

IoT use in industry has changed decision-making from experience-based and reactive methods to data-driven, real-time tactics. IoT Smart Decision-Making Processes enable businesses to make well-informed decisions with little assistance from humans by using networked sensors, devices, and digital platforms to gather, send, and analyse data quickly (Lee et al., 2015). Particularly in domains like production scheduling, asset management, and quality control, these technologies enhance the precision and velocity of operational reactions.

Manufacturers can use IoT to collect data from various sources, including temperature, vibration, material flow, and machinery performance, and then use centralized or edge computing platforms to transform that data into useful insights (Gilchrist, 2016). Intelligent decision support systems that can anticipate malfunctions, streamline processes, and cut down on inefficiencies before they worsen are the result of this approach. Manufacturers save downtime, avoid mistakes, and improve departmental synchronization by automating reactions based on real-time information.

Additionally, smart decision-making tools facilitate cross-functional coordination and visibility, guaranteeing that divisions like procurement, logistics, and manufacturing perform according to a common understanding of current circumstances. In a competitive manufacturing environment, this kind of horizontal integration, which is essential to smart factories, is essential for operational agility and resilience (Zhong et al., 2017). Understanding the workings of IoT-based decision-making is becoming more important as businesses expand their digital transformation to sustain innovation and sustainable growth.

Enhancing Organizational Performance Through IoT

A manufacturing organization's performance is measured by a number of important factors, including cost effectiveness, product quality, delivery time, adaptability, and customer happiness. By offering automated decision loops, predictive analytics, and real-time monitoring, IoT Smart Decision-Making Processes help to improve these aspects (Porter & Heppelmann, 2014). IoT technologies minimise delays, cut down on rework, and guarantee constant manufacturing quality by empowering machines and systems to respond proactively to changes or abnormalities.

IoT Smart Decision-Making Processes improve performance, and predictive maintenance is a good example. IoT systems can predict possible malfunctions and initiate repair before problems happen by continuously monitoring the state of the equipment. This lowers operating expenses by extending machine lifespan and decreasing downtime (Atzori et al., 2010). Similar to this, sensor feedback can be used by smart manufacturing lines to modify variables like load, temperature, or speed, increasing production precision and energy efficiency.

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Besides the shop floor, IoT Smart Decision-Making Processes also improve strategic performance. In order to make quicker and more informed decisions about inventory, capacity planning, and demand forecasting, managers are given access to real-time dashboards. Supply chain agility, customer responsiveness, and competitiveness are all enhanced by this data visibility along the whole value chain (Verdouw et al., 2016). IoT thus reinforces its role in improving organisational performance by driving both tactical efficiency and strategic agility.

Key Components of Effective IoT Smart Decision-Making Processes

The effective implementation of IoT Smart Decision-Making in manufacturing is contingent upon a number of essential elements that cooperate to facilitate scalable, secure, and effective operations. The most important is real-time data gathering and device connectivity, which are enabled by a strong Internet of Things architecture consisting of embedded systems, wireless networks, and sensors (Borgia, 2014). These tools collect detailed information on operational activities, environmental factors, and equipment performance. The second important factor in transforming unstructured data into insights is the integration of data analytics and AI. In order to facilitate both predictive and prescriptive decision-making, machine learning algorithms examine trends and patterns, allowing organisations to take precise and proactive action (Yaqoob et al., 2019). The automatic application of findings to existing operations is ensured by integrating these analytical tools with enterprise applications like ERP or MES.

Furthermore, human-machine interaction needs to be considered. Human oversight is still necessary for strategic judgement, exception handling, and continual improvement, even when IoT systems automate a large portion of data processing and decision execution (Mourtzis et al., 2016). To align staff with the digital transformation journey, this necessitates training programs, role-based dashboards, and user-friendly interfaces. Lastly, data governance and cybersecurity are essential. IoT networks' openness leads to vulnerabilities that need to be fixed via access control, encryption, and compliance guidelines (Zhou et al., 2015). Therefore, a system that combines organisational procedures, governance mechanisms, and technical capabilities into a coherent and flexible framework is an effective IoT Smart Decision-Making system.

Relevance to Industry 4.0 and Global Trends

The development of IoT-based decision-making is closely linked to the larger Industry 4.0 movement, which advocates for the digitization of production using big data analytics, cloud computing, robotics, artificial intelligence, and the Internet of Things (Lasi et al., 2014). In what is now known as the "smart factory," IoT is frequently seen as the underlying layer of this industrial revolution, allowing machines and systems to interact, self-optimize, and function independently (Brettel et al., 2014).

The strategic significance of this change has been acknowledged by governments and international organisations. Initiatives like Malaysia's Industry4WRD, China's Made in China 2025, and Germany's Industries 4.0 highlight how urgent it is for businesses to adopt IoT and related technologies in order to stay competitive in a global economy that is driven by digitalisation (Xu et al., 2018). The significance of decision-making frameworks that use IoT to improve productivity, sustainability, and innovation is also emphasized by these initiatives.

From a worldwide standpoint, IoT also tackles some of the manufacturing industry's most urgent problems. These include the need for sustainability and customisation, supply chain interruptions, labour shortages, and regulatory compliance. Businesses may satisfy environmental goals and customer expectations by optimising energy use, cutting waste, and improving product personalisation through IoT-enabled decision-making (Yaqoob et al., 2019). IoT is therefore a strategic transformation tool for the future of industrial development as well as a technological breakthrough.

Problem Statement

The manufacturing industry is currently undergoing a major digital transformation, largely driven by Industry 4.0 technologies such as the Internet of Things (IoT), artificial intelligence, and data analytics. Among these, IoT Smart Decision-Making plays a crucial role by enabling real-time data collection, machine-to-machine communication, and predictive insights that drive smarter, more efficient production environments (Caputo et al., 2016; Hu et al., 2023). Globally, IoT adoption has proven to enhance innovation performance through improved operational efficiency, reduced downtime, cost savings, and increased responsiveness to market demands.

Despite its clear benefits, the adoption of IoT in many Malaysian manufacturing firms remains limited and uneven. While larger or multinational firms have made strides toward smart factory transformation, a significant portion of local manufacturers, especially small and medium-sized enterprises (SMEs), have yet to implement IoT technologies in their operations (Adnan et al., 2023). The hesitance is often rooted in high upfront investment costs, cybersecurity concerns, lack of technical expertise, and uncertainty regarding the return on investment (Chinedu & Brendan,2023; Al-Khatib et al., 2025). Additionally, organizational factors such as resistance to change, absence of strategic digital roadmaps, and limited awareness of IoT capabilities further slowdown the pace of adoption.

Most existing studies in the field tend to focus on organizations that have already implemented IoT and report on post-adoption impacts, particularly on innovation performance and supply chain optimization (Mashat et al., 2024; Al-Khatib et al., 2025). However, there is a clear research gap in understanding the perspectives of firms that are still in the pre-adoption stage those that are aware of IoT but have not yet taken concrete steps toward implementation. Understanding this group is crucial, as their experiences, concerns, and perceived barriers can inform national digital transformation policies and industry-specific support mechanisms.

In light of this, it is imperative to investigate the perceptions, difficulties, and readiness of manufacturing organizations in Malaysia that have not yet implemented IoT Smart Decision-Making Processes, particularly with relation to its potential to enhance organizational performance. To further understand how decision-makers in these companies assess IoT Smart Decision-Making Processes, what barriers stand in their way, and what tactics can facilitate future deployment, this study will employ a qualitative methodology. By filling this knowledge vacuum, the research hopes to offer practical suggestions to technology companies, legislators, and industry participants looking to quicken Malaysia’s shift to smart manufacturing (Tan & Yee, 2023; Chong et al., 2022; Yusuf et al., 2024).

LITERATURE REVIEW

Introduction

This section reviews the existing literature on IoT implementation and smart decision-making in manufacturing, providing a foundation for understanding how IoT Smart Decision-Making Processes transform organizational performance (Farooq et al., 2023). It begins by exploring the evolution of IoT and its integration into smart manufacturing ecosystems, emphasizing the role of interconnected devices and real-time data analytics in enabling predictive maintenance, process optimization, and enhanced product customization (Atzori, Iera, & Morabito, 2010). The rapid advancement of sensor technologies and wireless communication has accelerated the adoption of IoT in manufacturing, allowing for seamless data flow across the production line. This connectivity supports the creation of cyber-physical systems that bridge the physical and digital worlds, fostering smarter and more agile manufacturing environments. Additionally, data-driven insights derived from IoT systems enable manufacturers to anticipate equipment failures and reduce downtime, thereby increasing operational efficiency. The integration of IoT also facilitates mass customization, allowing companies to meet diverse customer demands without sacrificing productivity or quality.

The section further examines organizational factors influencing IoT Smart Decision-making implementation, such as infrastructure readiness, workforce capabilities, and external market pressures (Ghobakhloo & Fathi, 2021). It highlights that successful IoT adoption requires not only technological investments but also a culture that embraces innovation and continuous learning. Workforce upskilling and training are critical to equip employees with the digital competencies necessary to interpret and act on IoT-generated data effectively. Moreover, external pressures such as global competition and evolving customer expectations compel organizations to adopt IoT-driven smart decision-making to maintain relevance and competitiveness. Barriers including cybersecurity concerns, high capital expenditure, and integration complexity are also discussed. These challenges often delay implementation and require strategic planning to mitigate risks and ensure seamless integration with existing systems. The section synthesizes these perspectives to establish the rationale for focusing on IoT Smart Decision-Making processes as a strategic lever to improve manufacturing organizational performance and innovation outcomes (McKinsey & Company, 2021). Ultimately, this approach positions IoT not just as a technology upgrade but as a catalyst for holistic organizational transformation.

IoT for Smart Factories in Industry 4.0: A Review

The article "Internet of Things for Smart Factories in Industry 4.0: A Review" provides a thorough analysis of how IoT technologies are a key component in making smart factories a reality. In order to achieve real-time monitoring, automation, and data-driven decision-making, the paper investigates the integration of sensors, actuators, communication networks, and cloud platforms in industrial settings. According to the authors, IoT is essential for facilitating connectivity and visibility at every stage of the manufacturing process, including supply chain, production, and delivery. This is in line with research by Hu et al. (2023), who highlighted how IIoT gives manufacturers access to intelligent, hierarchical systems that convert reactive processes into proactive, efficient workflows. Real-time monitoring, analysis, and decision-making are made possible by the interconnection and communication between machines and equipment in an Industry 4.0 smart factory as well as between them and a central control system. This enables producers to streamline their operations, reduce pollution in the environment, and boost their adaptability to swiftly meet shifting consumer expectations. IoT applications in smart factories have emerged recently to propel the digital revolution of production and help businesses run more sustainably, economically, and efficiently. The Internet of Things is a crucial technology that enables the growing popularity of smart manufacturing.

One of the central themes of the article is the capability of IoT systems to enhance production efficiency and reduce downtime through predictive maintenance. With sensors embedded into equipment and machinery, manufacturers are now able to gather real-time performance data and identify potential faults before they escalate into failures. This predictive capability reduces unexpected stoppages and extends machine life, resulting in cost savings and improved overall equipment effectiveness (OEE). Vishnuvardhan et al. (2022) reinforce this by showing how IIoT promotes continuous process improvement and reduces operational risks in intelligent manufacturing. Companies should spend on employee training or new hire recruitment to fill these jobs with highly skilled personnel. The more devices and systems that are linked to the internet, the greater the risk of cyberattacks on the data on the network. Strong security measures are necessary for Industry 4.0 implementation in order to ensure the safety of private information and intellectual property. For Industry 4.0 to flourish, communication networks must be dependable and quick. However, the necessary infrastructure may not be available in many locations, which might make it challenging for various businesses to implement Industry 4.0. Businesses might think about ways to get over these limitations and integrate Industry 4.0 into their part production process. Before expanding to larger businesses, enterprises might begin by using Industry 4.0 technology on a modest scale to acquire knowledge and experience.

Additionally, the assessment emphasizes how important data analytics and interoperability are. IoT in smart industries requires smooth communication between systems from many manufacturers. This necessitates following common platforms and standards that provide safe and scalable data sharing. Following data collection, insights that aid in innovation and decision-making may be produced using machine learning and advanced analytics techniques. According to Caputo et al. (2016), attaining technical innovation and long-term organizational performance depends on IoT systems being in line with business strategy. IoT devices may help manufacturers save money in component manufacturing processes by streamlining operations and decreasing downtime in smart factories. In order to identify possible safety dangers and avoid worker accidents and injuries, IoT sensors may also detect and inform workers. Nevertheless, it might be difficult to manage and integrate many IoT devices, necessitating substantial resources and specialist knowledge. Additionally, IoT devices may be susceptible to hacks, endangering important data and compromising the integrity of the production process. Integrating many IoT devices into a coherent system can be challenging since they may employ multiple communication protocols. Large volumes of data generated by IoT devices can be difficult to handle and evaluate.

The research concludes that the Internet of Things (IoT) is a pivotal driver of Industry 4.0, enabling manufacturers to move from conventional manual operations to intelligent, interconnected production environments (Lee et al., 2015). By supporting real-time data analytics, predictive maintenance, and automation, IoT helps organizations enhance agility, responsiveness, and overall operational performance (Farooq et al., 2023). However, successful implementation remains challenged by high investment costs, cybersecurity vulnerabilities, and a lack of skilled workforce (Ambrogio et al., 2022). These barriers highlight the need for a well-structured, financially supported digital transformation strategy that ensures long-term competitiveness and adaptability in the manufacturing sector (Ghobakhloo & Fathi, 2021). In order to develop the applications of the Internet of Things for smart factories in Industry 4.0, future research projects to address the gap between the accomplishments in published papers are also recommended. Therefore, the research can create Industry 4.0 smart factories to increase worker safety during component manufacture, optimize production processes, and improve quality control.

Intelligent Industrial IoT for Smart Manufacturing

Hu et al. (2023) look at how Industrial Internet of Things (IIoT) intelligence is changing factory settings. The perception layer (sensors and data collection), network layer (data transmission), data processing layer (analytics and edge computing), application layer (smart factory functions), and business layer (decision-making and strategic alignment) are the five layers of the authors' suggested five-layer hierarchical development architecture, which offers an organized viewpoint. This architecture provides a comprehensive understanding of the interactions and operations of IIoT systems at various levels of a manufacturing company. According to their findings, IoT may significantly increase real-time visibility and responsiveness throughout industrial activities when these layers are properly connected. The paper also highlights how IIoT intelligence enables sophisticated features like intelligent decision-making, adaptive production planning, and predictive maintenance. By decreasing downtime, enhancing product customisation, and quickening reaction to market shifts, these capabilities increase organizational performance. The assessment also highlights the ways in which IoT in conjunction with AI and machine learning may improve data interpretation and automate intricate procedures. Hu et al. Contend that a move toward more independent and innovation-driven industrial models is signaled by the Internet of Things' development from simple connection to fully functional intelligent systems. Their research highlights how crucial it is for firms to make strategic investments in IoT infrastructure if they want to remain competitive in the industrial age.

A combination of factors, including growing global competition, increasing demand for customized products, and continuous technological advancements, is driving a major shift in the global industrial landscape. Traditional manufacturing models, characterized by rigid production lines and a focus on mass production, are struggling to adapt to this dynamic environment (Ghobakhloo & Fathi, 2021). As a result, the concept of smart manufacturing, which utilizes advanced digital technologies to create more flexible, efficient, and intelligent production systems, has gained considerable momentum (Zhong et al., 2017). At the heart of this transformation is the Industrial Internet of Things (IIoT), particularly the integration of IoT intelligence, which is increasingly recognized as a core enabler of data-driven and autonomous manufacturing processes (Hu et al., 2023).

In their comprehensive review, Hu et al. (2023) argue that IoT intelligence represents a paradigm shift, offering not just incremental improvements but transformative value across the entire manufacturing value chain. They highlight critical challenges facing modern industry, such as stagnating productivity, labor cost pressures, and the demand for faster innovation, as key drivers behind this digital evolution (Farooq et al., 2023). IIoT intelligence is defined as a suite of technologies, methods, and platforms that enable autonomous capabilities across manufacturing, encompassing functions like predictive maintenance, adaptive control, and real-time decision-making (Hu et al., 2023). Moreover, the authors emphasize its application across a wide range of operations and deployment scenarios and propose a layered architectural framework consisting of equipment, network, software, modelling, analysis, and optimization layers to guide practical implementation.

The article further identifies a range of enabling technologies propelling the IoT transformation, including digital twins, deep learning, edge/cloud computing, industrial robots, machine vision systems, and smart sensors (Wuest et al., 2016; Hu et al., 2023). These technologies play a vital role in making factories more intelligent, autonomous, and responsive. The authors ultimately conclude that IoT intelligence is not merely a technological enhancement but a strategic necessity for modern manufacturers seeking to enhance efficiency, adaptability, and innovation in the era of Industry 4.0 (Mashat et al., 2024).

Impact of IoT Smart Decision-Making Processes

Enhance Supply Chain Visibility

The findings of the research align with those of Fatorachian and Kazemi (2021), who emphasised how Industry 4.0 technologies, such as the Internet of Things, enable intelligent and interconnected supply chains where people, machines, and systems can effectively collaborate and interact. In a similar vein, the study backs up the idea that real-time information exchange made possible by IoT technology improves supply chain performance by improving material and product monitoring, forecasting, and planning. In the context of supply chain management, digitalization is the use and use of external digital technologies, such as blockchain, machine learning, the Internet of Things, and Big Data, to enhance a company's SC and operational performance (OP). Organizations should modernize SC operations and infrastructure to be more technology-driven and to improve integration due to the growing reliance on technology. Consequently, businesses that use digital SCs by investing in the hardware, software, and human capital needed for cutting-edge technologies like cloud computing, artificial intelligence (AI), and the Internet of Things (IoT) may become more competitive due to the long-term return on investment of higher revenue and business value.

Nonetheless, the literature also acknowledges key challenges associated with IoT adoption, such as the need for organizational change management, heightened cybersecurity risks, and significant investment in infrastructure and digital technologies (Ghobakhloo & Fathi, 2021). Addressing these challenges requires a systematic and integrated strategy one that includes organizational readiness, employee upskilling, and phased technology deployment. For digital platforms to function effectively, organizations must establish a robust framework of capabilities defined as coordinated processes, group actions, and shared practices that can mitigate the disruptive impacts of digital information sharing on business performance (Fatorachian & Kazemi, 2021). These capabilities are most effective when foundational enablers such as leadership commitment, IT infrastructure, and strategic alignment are present. Digital transformation also presents trade-offs and complexities, particularly within supply chains. However, it offers significant potential to enhance traceability, responsiveness, and real-time visibility of products from origin to destination using IoT and sensor technologies (Yaqoob et al., 2019). Smart supply chains equipped with IoT can provide not only location tracking of goods but also detailed data on product conditions and histories, enabling informed and timely decisions. In this context, the study by Mashat et al. (2024) emphasizes the mediating role of supply chain integration, performance, and competitive advantage in the relationship between IoT adoption and organizational outcomes. To fully realize the transformative value of IoT in the industrial sector, the research underscores the importance of adopting a comprehensive implementation approach that accounts for both technological and organizational dimensions.

In conclusion, the adoption of Internet of Things (IoT) technology is expected to significantly enhance communication and collaboration among supply chain partners. By enabling real-time connectivity through smart electronic devices, IoT transforms traditional human-to-human interactions into more dynamic human-to-machine and machine-to-machine communication across the network (Yaqoob et al., 2019). The core objective of IoT in supply chain management is to improve visibility, responsiveness, and resource efficiency. Enhanced supply chain visibility allows for real-time monitoring of products from production to consumption, while supply chain efficiency ensures optimal resource usage to meet customer service demands at minimal cost (Mashat et al., 2024). To fully benefit from these capabilities, firms must invest in digital platforms that support real-time tracking of shipments, payments, and inventory levels, enabling improved control and faster decision-making. However, despite its potential, IoT adoption is often hindered by several challenges. Organizational resistance, trust issues, and the complexity of integrating IoT into existing systems remain key barriers (Haddud et al., 2017). Many managers continue to underestimate the strategic value of IoT, leading to delayed or avoided implementation. Additionally, a range of technological, social, and structural obstacles, including interoperability issues, big data management, cybersecurity concerns, insufficient technical expertise, and uncertain return on investment, further complicate the adoption process (Fatorachian & Kazemi, 2021). Therefore, while IoT offers transformative potential for supply chain operations, its successful deployment depends on a clear understanding of these multifaceted barriers and the strategic alignment of technology with organizational goals.

Cost and Time Savings

The research by Chinedu and Brendan (2023) highlights the significant cost and time savings achieved through the adoption of Internet of Things (IoT) technologies in manufacturing. Their study of 126 employees at Camanov Ltd., a manufacturing firm in Port Harcourt, Nigeria, reveals strong statistical evidence of these benefits (cost and time savings with $Z = 4.95$), demonstrating that IoT integration leads to more efficient operations and economic advantages. A primary driver of cost savings is IoT's ability to enable predictive maintenance through real-time data collection from smart sensors embedded in machinery. This capability allows manufacturers to anticipate equipment failures before they occur, thus reducing unplanned downtime and costly repairs. Minimizing downtime not only cuts maintenance expenses but also prevents production losses, directly impacting the bottom line. Additionally, IoT facilitates optimized asset and inventory management, reducing waste and excess stock, which further lowers operational costs.

Time savings are realized through automation and enhanced process efficiency enabled by IoT. Automated monitoring and control reduce the need for manual inspections and interventions, allowing maintenance personnel to focus on targeted, as-needed tasks rather than routine checks. This streamlining accelerates production cycles and shortens the time from product conception to market launch. Faster response to market fluctuations and improved supply chain coordination, supported by real-time tracking of goods and materials, contribute to reducing lead times and improving overall throughput. Supporting studies emphasize these advantages. For example, IoT's role in reducing time to market stems from faster decision-making and more agile manufacturing and supply chain operations, as noted by Onomondo (2025). Peerbits (2025) also stresses that predictive maintenance and real-time inventory management enabled by IoT lead to both cost reductions and enhanced operational speed. Furthermore, Up Keep (2025) highlights that lower downtime and streamlined processes collectively reduce costs while accelerating production timelines.

Despite these benefits, Chinedu and Brendan identify challenges that can affect cost and time savings during IoT implementation. High upfront investments in IoT infrastructure, cybersecurity, and integration pose financial burdens. Resistance from employees and lack of technical training may delay adoption and reduce efficiency gains. Hu et al. (2023) emphasize that addressing these challenges through focused change management and workforce development is essential to realize sustainable cost and time benefits. IoT adoption in manufacturing delivers substantial cost and time savings by enabling predictive maintenance, automating processes, and optimizing supply chains. While initial investment and organizational hurdles exist, strategic focus on technology integration and human capital development can maximize returns. This aligns with the broader Industry 4.0 framework, positioning IoT as a critical enabler of agile, efficient, and competitive manufacturing operations.

Smart Supply Chain Innovation and Strategic Big Data Analytics

Al-Khatib et al. (2025) investigate how the integration of IoT technologies with smart supply chain innovation significantly enhances manufacturing performance. Their study reveals that while IoT adoption alone improves productivity, the real performance gains emerge when IoT is combined with innovative, agile supply chain practices. Using structural equation modelling, the authors demonstrate that smart supply chain innovation acts as a critical mediator, transforming raw IoT data into actionable insights that optimize supply chain operations. This integration enables manufacturers to respond more rapidly to market demand fluctuations, reduce inventory waste, and ensure timely delivery, all of which contribute to improved customer satisfaction and competitive positioning. The research underscores that IoT should not be viewed as a standalone technology but as part of a broader digital transformation strategy where supply chain innovation is essential to unlocking IoT's full potential. This research contributes to the ongoing industry conversation by showing that achieving significant improvements in manufacturing performance requires the convergence of IoT, big data, and supply chain innovation.

Al-Khatib et al.'s research from 2025 concentrated on the moderating effect of big data-driven supply chains and the mediating impact of smart supply chain innovation. The study emphasizes that better industrial performance is not a given just because IoT is implemented successfully. Rather, the real advantages come from combining IoT with cutting-edge supply chain innovation techniques. As manufacturing companies look to

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improve operational effectiveness and competitiveness in an Industry 4.0 environment where data-driven decision-making is emerging as a key component of strategic planning, this viewpoint is becoming more and more pertinent. The authors emphasize that smart supply chain innovation serves as a vital bridge, converting the unprocessed data gathered through the Internet of Things into useful insights that optimize supply chain operations. These developments provide businesses with the ability to react to demand changes more quickly, waste less inventory, and guarantee on-time delivery, all of which improve customer satisfaction and market positioning. This opinion is in line with Caputo et al. (2016), who claim that by encouraging real-time responsiveness and process optimization, coordinating IoT adoption with strategic innovation processes may greatly improve organizational performance.

The research also presents big data analytics' function as a moderating element in the link between IoT and performance. According to Al-Khatib et al. (2025), businesses may make better decisions by extracting deeper insights from IoT-collected data when they have strong big data skills. This backs up the findings of Hu et al. (2023), who note that big data architecture enhances IoT systems' predictive and adaptive capacities, increasing their efficacy in handling intricate industrial problems including demand forecasting, quality assurance, and equipment maintenance. The results highlight the necessity of an integrated and comprehensive strategy for IoT deployment in manufacturing. Businesses should think about IoT as a component of a larger digital transformation plan that also involves supply chain management innovation and big data technology investment, rather than as a stand-alone solution. By doing this, businesses can unleash the full potential of the Internet of Things and promote long-term gains in industrial efficiency. This all-encompassing perspective fits in nicely with Industry 4.0's present course and offers manufacturers a useful road map for innovation and successful competition in marketplaces that are becoming more and more data-centric.

Predictive Maintenance and Operational Effectiveness

The research in the Innovation and Educational Research article examines how the Internet of Things (IoT) plays a major role in manufacturing's transformation under the Industry 4.0 paradigm. It highlights how real-time monitoring, predictive maintenance, and automation, all of which are essential for process optimization and quality control, are made possible by IoT technologies, which boost productivity. These developments increase innovation performance throughout industrial processes by streamlining production lines and enhancing supply chain effectiveness (JIER, 2024). Additionally, IoT integration with other technologies like artificial intelligence (AI) and big data analytics results in networked systems that enable businesses to react quickly to operational irregularities and market needs. The paper also emphasizes that although adopting IoT has many advantages, there are drawbacks. Full integration is nevertheless hampered by high implementation costs and cybersecurity threats, highlighting the necessity of strong frameworks and careful planning (JIER, 2024; Caputo et al., 2016). This is consistent with other research that indicates that for sustained innovation outcomes, IoT strategy must be in line with corporate objectives.

This research validates the findings of earlier research by analyzing the transformative implications of Industry 4.0 and the Internet of Things on supply chain management and industrial operations. According to the study, the application of IoT technology in industrial settings has significantly increased operational effectiveness and the capacity to anticipate maintenance requirements. In line with Wittkowski's (2017) findings, the current study shows that using real-time data from IoT sensors allows predictive maintenance strategies to be implemented, which reduces equipment downtime and improves production schedules. The results are consistent with those of Chauhan et al. (2022), who emphasized the benefits of IoT-based predictive analytics on maintenance practices and operating costs, hence improving total company efficiency. Furthermore, this study supports the claim stated by Ghadge et al. (2020) that the combination of Industry 4.0 and IoT technology leads to greater personalization and adaptability in industrial processes. Increased degrees of personalization in industrial processes are made possible by the confluence of IoT technology with artificial intelligence (AI) and big data, which enables businesses to respond more quickly to changing consumer requirements. In line with the findings of Ghadge et al. (2020), the current study also showed that despite these benefits, significant upfront investment costs and a skills gap remain significant barriers, particularly for small and medium-sized businesses (SMEs). For smaller businesses, the scalability of these technologies is limited by the need for highly skilled personnel and the deployment of complex IoT infrastructure.

The research results support Azevedo et al.'s (2021) claim that the Internet of Things improves visibility and transparency in the context of supply chain management. According to this research, supply chains that use real-time tracking and data collection have more effective inventory and logistics management, which enables businesses to cut waste and react to market developments faster. Furthermore, the research in this study has brought attention to cybersecurity risks as a persistent challenge faced by organizations that rely on IoT technology, in addition to the results of Ambrogio et al. (2022) and Sharma, Jain, & Maurya (2018). These businesses might be vulnerable to operational disruptions and data breaches as a result of the threats. The analysis supports the idea that there are no opportunities for the Internet of Things to improve supply chains' responsiveness and sustainability. However, increased complexity and susceptibility frequently offset these benefits.

Existing IoT Framework in Manufacturing Industry

Framework for Data-Driven Decision Making

The Advanced Manufacturing System (AMS) is poised for a revolution in automation by integrating state-of-the-art technologies including high-speed connectivity, vision systems, and machine learning (Kumar et al., 2024). Industries can overcome challenges in building highly automated facilities with these technical breakthroughs. The existing degrees of automation and those that may be successfully attained from a technological and business standpoint differ significantly because of the limitations of traditional decision-making techniques (Babu et al., 2024). According to a recent BCG research, reducing the "automation gap" can lead to improvements in labor and quality, which can lower conversion costs by as much as 25% (Küpper et al., 2022). A Deloitte poll projects that the artificial intelligence (AI) industry in the industrial sector will reach USD 2 billion by 2025, growing at an average annual rate of more than 40% from 2019 (Deloitte Consulting, 2020). Every year, the manufacturing industry produces around 1,812 petabytes (PB) of data, more than industries like retail, communications, and finance (KPMG, 2022). Manufacturers are using smart technology to analyze data patterns and handle unanticipated issues as a result of the proliferation of digital information in AMS, which has complicated decision-making processes (Dohale et al., 2023). The necessity to transition from traditional decision-making techniques to data-driven decision-making (DDDM) is highlighted by the growing data and AI landscape (Friederich et al., 2022). Modern industrial systems need sophisticated, data-centric decision-making techniques to reach a high degree of automation.

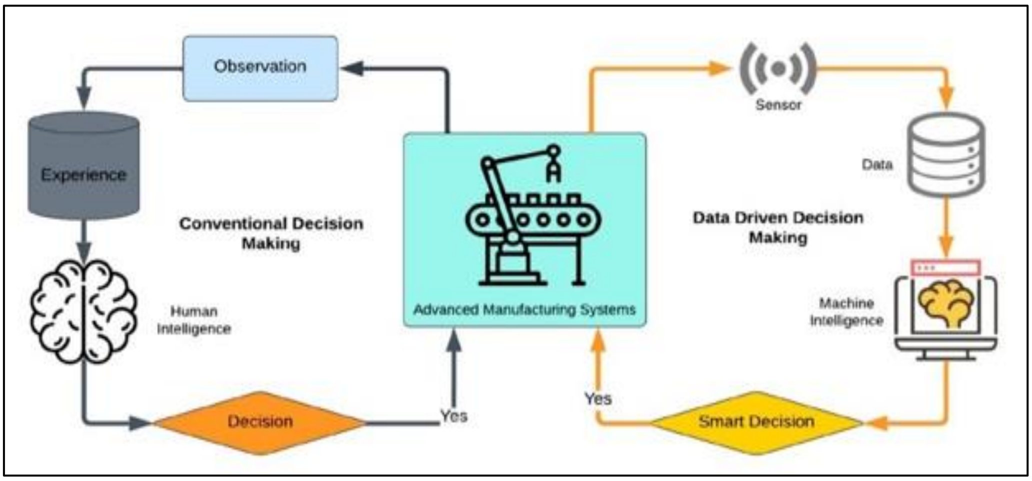

Figure 1: Sensing-data-machine intelligence-smart decision

The paradigm of industrial decision-making has changed dramatically in the age of Industry 4.0, moving away from traditional, experience-based methods and toward data-driven, intelligent systems. The framework that contrasts traditional and data-driven decision-making models in modern manufacturing systems provides a clear illustration of this shift. Human intelligence is the foundation of conventional decision-making, which mostly draws from observations and prior experiences. Under this paradigm, operators keep an eye on industrial processes, use their knowledge and intuition to analyze data, and base their judgments on their own subjective assessments. Despite serving as the foundation of industrial operations for many years, this strategy is becoming less and less responsive, particularly in complex, high-velocity production situations. Lee et al. (2015) draw attention to the increasing shortcomings of conventional models, pointing out that depending too much on past performance and manual observation can result in inconsistent and slow reactions in dynamic systems.

On the other hand, data-driven decision-making makes use of real-time information obtained from sophisticated sensors included in the production process. These sensors continually provide data to centralized systems, where computers using artificial intelligence and machine learning examine trends, spot irregularities, and offer suggestions or judgments. This methodology increases decision-making accuracy, speed and decreases human bias. According to Wuest et al. (2016), machine intelligence makes it possible to undertake performance optimization, defect detection, and predictive maintenance in ways that are not possible with just human cognition.

The Advanced Manufacturing System, a cyber-physical interface where choices are operationalized, is at the center of both decision-making procedures. The system performs functions including modifying machine settings, starting maintenance procedures, or stopping operations for quality control, whether it is powered by artificial intelligence or human intuition. According to Lu (2017), innovative manufacturing systems integrate machine and human input into smooth production processes by acting as the operational platform where conventional and intelligent decision-making techniques intersect.

The type of intelligence used is a key difference between the two strategies. Human intellect is flexible and sensitive to context, yet it is also prone to weariness and irregularities. On the other hand, machine intelligence provides a scalable solution for real-time decision assistance by processing enormous volumes of data quickly and reliably. According to Bousdekis et al. (2019), the use of predictive analytics changes decision-making from reactive to proactive by allowing systems to not only respond to problems but also foresee and stop them.

In the end, data-driven decision-making produces “smart decisions,” or choices that are timely, optimal, and contextually aware. These choices result in more operating efficiency, less downtime, and better production quality. Zhou et al. (2015) point out that the achievement of Industry 4.0, in which intelligent, networked systems adapt constantly to the needs of contemporary production, depends heavily on intelligent decision-making.

In conclusion, integrating data-driven approaches is crucial for attaining the agility, accuracy, and efficiency required by today’s industrial environments, even while traditional decision-making is still useful in situations requiring human intuition and moral judgment. The framework that is depicted highlights how digital technology and machine intelligence have the capacity to revolutionize industrial decision-making in the future.

Smart Manufacturing Framework

In this research, A Framework for IoT-Enabled Smart Manufacturing for Energy and Resource Optimisation, Alex and Johnson (2025) suggest a multi-layered IoT framework created especially to improve operational effectiveness and sustainability in industrial settings. The framework concentrates on optimising resource usage and energy consumption, two crucial facets of contemporary smart manufacturing. The authors confirm the efficacy of their approach through simulations using MATLAB Simulink, citing observable results including a 22% drop in machine downtime and an 18% reduction in energy use. In addition to confirming the usefulness of IoT in smart industries, this empirical validation shows how it may optimise processes while lessening its negative effects on the environment.

The research highlights the strategic importance of incorporating IoT into more comprehensive sustainability objectives within the industrial sector, in addition to the operational advantages. The system uses process automation, predictive analytics, and real-time data monitoring to dynamically modify energy and resource usage. The IoT system promotes ongoing efficiency and cost-effectiveness improvements, which are important performance metrics in industrial innovation, by enabling such intelligent response. The study of Alex and Johnson (2023) makes a significant contribution to the literature by showing how IoT technology may assist economic and environmental sustainability while also improving performance. Their results provide manufacturers with a strong platform for integrating technology to drive smart, green innovation.

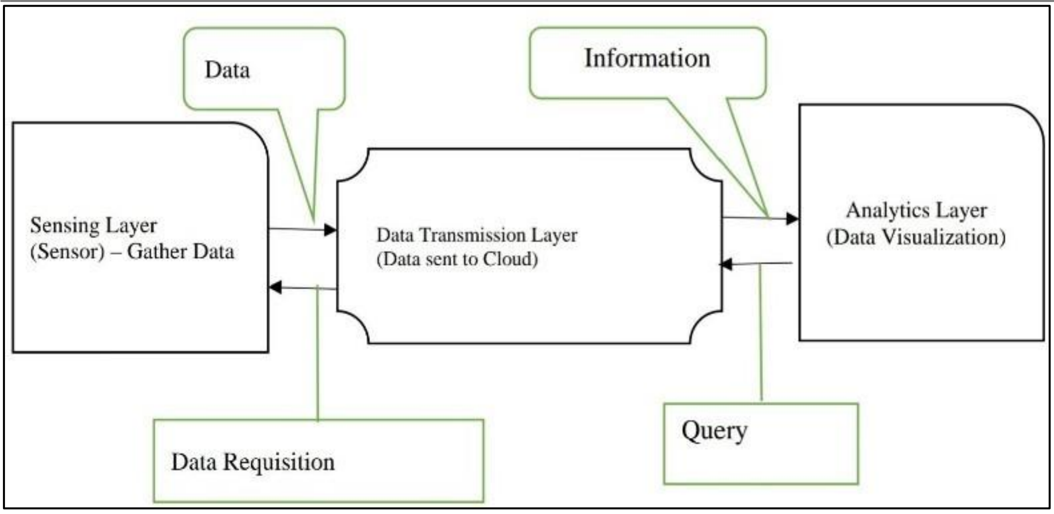

Figure 2: Sensing (Gather Data-Data Transmission Layer (Cloud)-Data Visualization (Data Analytics)

Traditional production methods are being transformed into intelligent, data-driven operations in the industrial sector by the incorporation of Internet of Things (IoT) technologies. An IoT-enabled smart manufacturing environment's data flow via several functional levels is clearly depicted by the structure shown in the supplied image. It starts with the Sensing Layer, where actual sensors gather data in real time from industrial lines, machinery, and environmental factors. To guarantee smooth and centralised data administration, this raw data is then sent over the Data Transmission Layer, sometimes with the aid of cloud technologies (Hu, Liu, & Zhang, 2023).

The integration of Internet of Things (IoT) technology in the manufacturing sector is transforming traditional production systems into intelligent, data-driven operations. The framework illustrated in the provided figure offers a clear representation of how data flows through various functional layers in an IoT-enabled smart manufacturing environment. It begins with the Sensing Layer, where physical sensors collect real-time data from machinery, environmental conditions, or production lines. This raw data is then transmitted via the Data Transmission Layer, often using cloud technologies, to ensure seamless and centralized data management.

Once transmitted, the data travels to the Analytics Layer, where sophisticated analytics tools and data visualization are used to process and convert it into actionable insights. This enables producers to decide on maintenance plans, quality assurance, and process optimisation with knowledge. Hu et al. (2023) claim that this layered design greatly increases operational efficiency by giving manufacturers access to features like real-time monitoring and predictive maintenance. Additionally, Caputo et al. (2016) stress the need to match these IoT frameworks with strategic innovation objectives, emphasizing that data-driven decision-making is essential to attaining Industry 4.0's sustained technological development.

Essentially, by turning data into useful information, this framework supports a larger innovation strategy in addition to making the technical deployment of IoT systems easier. The paradigm is the basis for successful digital transformation in manufacturing and includes elements such as data requisition, cloud-based processing, and query-based analytics.

Summary of Existing IoT Framework

Both frameworks begin with sensor-based real-time data acquisition as the foundation for further processing. Both frameworks ensure data is transmitted and stored for further use; IoT- Enabled emphasizes cloud transmission, while Sensing-Data focuses on storage readiness. Both use advanced analytics; the Sensing-Data framework places stronger emphasis on AI/ML-driven autonomous processing. IoT-Enabled framework follows a layered, hierarchical data flow, whereas the Sensing-Data framework uses a cyclical, continuous loop. Both rely on sensors and cloud computing; IoT-Enabled emphasizes edge computing and user applications, while Sensing-Data highlights AI and automation.

IoT Smart Decision-Making Processes

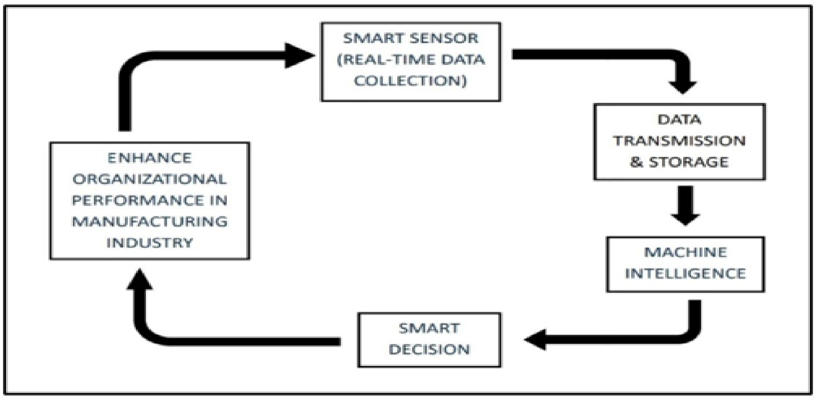

Figure 3: IoT Smart Decision-Making Processes

This section proposes IoT smart decision-making processes based on the two previous frameworks. The process of IoT Smart Decision-Making starts with smart sensors, which are essential for gathering data in real time from production settings. These sensors are the main source of information for data-driven decision-making and can identify changes in motion, temperature, pressure, or machine conditions. By using smart sensors, businesses can improve responsiveness and decrease downtime by moving from reactive to predictive operations (Zhou et al., 2015; Farooq et al., 2023).

Once the data is captured, it moves to the data collection and transmission stage, where raw sensor data is compiled, structured or sometimes unstructured, and transmitted to centralized systems, such as cloud platforms or edge devices. This data can be extremely large in volume and must be handled with secure and scalable infrastructure. Effective data aggregation is critical to ensuring the integrity and accuracy of downstream analytics (Gubbi et al., 2013; Shojaei et al., 2023).

Following this, the data is processed through machine intelligence, which includes artificial intelligence (AI), machine learning (ML), and advanced analytics. These technologies identify trends, detect anomalies, and generate insights into strategic decisions. Machine intelligence enables automated reasoning, making it possible for the system to recommend actions or adjustments based on real-time conditions (Zheng et al., 2021; Babu et al., 2024).

The next phase is smart decision-making, in which machine intelligence-derived insights are converted into decisions that can be implemented. These choices may be helpful, such as notifying a supervisor, or automated, such as modifying machine speeds. In manufacturing operations, smart decision-making promotes greater agility, safety, and resource optimisation (Chinedu & Brendan, 2023).

Ultimately, the industrial sector benefits from improved organisational performance as a result of these choices. Increased output, lower operating expenses, better product quality, and quicker reaction to market demands are among the advantages. The loop for innovation and continuous improvement is maintained by this cyclical process, which guarantees that feedback from organisational outcomes is transmitted back to sensors (MITI, 2018; Ghobakhloo & Fathi, 2021).

DISCUSSION AND CONCLUSION

This paper reviews the growing significance of the Internet of Things (IoT) in the manufacturing industry, highlighting its transformative impact on operational efficiency, product quality, and innovation capacity. Numerous studies confirm that effective IoT adoption enables real-time monitoring, predictive maintenance, and data- driven decision-making, all of which contribute to enhanced performance (Farooq et al., 2023). However, the literature also emphasizes that technological readiness alone is not enough.

The success of IoT initiatives depends heavily on factors such as organizational readiness, strategic alignment, employee engagement, and infrastructure preparedness (Ghobakhloo & Fathi, 2021). Additionally, common barriers including data management complexity, cybersecurity concerns, and resistance to cultural change must be addressed to ensure successful implementation.

Other than that, this paper also reviews and compares various IoT and smart manufacturing frameworks, identifying core components such as data collection, data handling, and data processing. The findings from this paper propose an IoT smart decision-making process to enhance organizational performance outcomes through strategic and technology-driven transformation (McKinsey & Company, 2021; Farooq et al., 2023), which will then be interviewed to verify by industry practitioners in the future.

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