





# Advancing Management Strategies with AI and IoT for Operational Excellence and Competitive Edge

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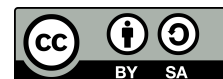
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## ABSTRACT

As organizations face increasing competition and technological advancements, optimizing operations and managing resources efficiently is crucial for maintaining a competitive edge. The integration of emerging technologies like Artificial Intelligence (AI) and the Internet of Things (IoT) enhances efficiency, improves resource allocation, and drives growth. This study explores how AI and IoT adoption optimizes business processes, improves decision-making, and fosters a competitive advantage. Using a quantitative approach, data from 200 executives in AI and IoT-implemented industries were analyzed. The analysis, conducted using Partial Least Squares Structural Equation Modeling (PLS-SEM), indicates that AI and IoT significantly enhance efficiency, resource utilization, and overall performance. Real-time monitoring and predictive analytics improve market alignment and operational trends. The findings suggest that organizations adopting AI and IoT can better navigate dynamic business environments, enhance productivity, and sustain growth. Moreover, fostering innovation and continuous technological improvement is essential. This research underscores AI and IoT's transformative potential in reshaping business operations and securing a competitive edge. Future research should explore these technologies' industry-specific impacts and broader innovation potential.

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## 1. INTRODUCTION

In the era of rapid technological advancements, businesses are increasingly relying on innovative solutions to enhance operational efficiency and maintain a competitive edge [1]. As organizations strive to remain relevant in dynamic and competitive markets, the integration of technologies like Artificial Intelligence (AI) and the Internet of Things (IoT) has become essential in transforming traditional business models. These technologies enable businesses to automate processes, improve resource management, and gain actionable insights from data that were previously inaccessible [2]. The growing adoption of AI and IoT is reshaping how companies optimize their operations, interact with customers, and manage resources in a more interconnected and data-driven environment [3].

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AI, with its ability to analyze vast amounts of data and make predictive decisions, plays a crucial role in driving innovation and operational excellence. On the other hand, IoT provides businesses with real-time data from connected devices, allowing for smarter decision-making and more efficient resource utilization. When integrated, AI and IoT offer significant potential for enhancing various business processes, from supply chain management to customer service, by improving productivity, reducing costs, and increasing flexibility [4].

However, the benefits of AI and IoT adoption are not uniform across industries, and their implementation often depends on sector-specific factors such as technological readiness, regulatory environments, and organizational culture [5]. For example, manufacturing industries leverage IoT-enabled smart factories for predictive maintenance, while healthcare uses AI-driven analytics to improve patient outcomes. Retailers benefit from enhanced customer personalization through AI and IoT, while logistics firms optimize supply chain visibility and efficiency. Despite these opportunities, industries like agriculture and education face unique barriers that must be addressed to unlock the full potential of these technologies [6].

Many organizations still face challenges in effectively implementing these technologies, including high costs, integration complexities, ethical considerations, and resistance to change [7]. Costs associated with initial setup, maintenance, and training often deter smaller enterprises. Integration complexities arise from the need to harmonize legacy systems with modern technology, creating operational disruptions. Ethical considerations, such as data privacy and algorithmic bias, pose significant risks that require strict regulatory compliance and robust governance frameworks [8]. Organizational resistance, stemming from a lack of technical expertise or fear of job displacement, further complicates the adoption process.

Additionally, the long-term implications of these technologies on business sustainability and innovation require deeper exploration. AI and IoT have the potential to drive substantial sustainability benefits by optimizing resource utilization, reducing energy consumption, and enabling circular economies [9]. They can foster innovation by unlocking new business models, such as data-driven services and predictive analytics platforms. However, these benefits are contingent upon addressing critical challenges and fostering a culture of continuous learning and adaptation.

Understanding the strategic value of AI and IoT and identifying best practices for their adoption are critical for businesses aiming to gain a sustainable competitive advantage in today's digital economy. This study seeks to explore how the integration of AI and IoT contributes to operational optimization and competitive advantage, emphasizing sector-specific insights and long-term impacts. By examining the adoption and implementation of these technologies across various industries, the research aims to provide actionable recommendations for organizations seeking to navigate the complexities of digital transformation. Furthermore, this research highlights the importance of interdisciplinary collaboration, policy support, and strategic investment to ensure that AI and IoT adoption yields maximum economic, social, and environmental benefits [10].

## 2. LITERATURE REVIEW

The integration of Artificial Intelligence (AI) and the Internet of Things (IoT) has garnered significant attention in both academic and practical spheres due to their transformative potential in modern business operations. Numerous studies have highlighted the role of these technologies in enhancing operational efficiency, streamlining processes, and providing businesses with a competitive edge in dynamic markets.

### 2.1. Artificial Intelligence in Business Operations

AI has become a cornerstone of digital transformation in organizations. It facilitates smarter decision-making by enabling data analysis at scale [11]. AI systems, including machine learning algorithms, can process large datasets to identify patterns and predict trends, thus enhancing forecasting accuracy and operational optimization [12]. AI technologies, such as automation and predictive analytics, can significantly reduce operational costs by automating routine tasks and providing insights that drive efficiency improvements across various business functions, including supply chain management, marketing, and customer service [13]. The application of AI has proven to be particularly beneficial in industries such as manufacturing, healthcare, and finance. AI-driven solutions can enhance supply chain management by optimizing inventory levels and demand forecasting, reducing waste, and improving customer satisfaction [14]. In customer service, AI-powered chatbots and virtual assistants have revolutionized client interactions, providing real-time support and personalized experiences [15].

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## 2.2. Internet of Things in Business Operations

The Internet of Things (IoT) refers to the interconnection of physical devices that communicate with one another through the internet, collecting and exchanging data. The integration of IoT into business operations enables real-time monitoring of assets, processes, and customer behaviors [16]. IoT is transforming industries by providing actionable insights from connected devices, which help organizations make data-driven decisions that improve efficiency and enhance resource allocation.

IoT applications are particularly evident in industries such as logistics, manufacturing, and agriculture. The use of IoT in smart factories, where sensors and connected devices monitor production lines in real time, reduces downtime, optimizes maintenance schedules, and improves product quality [17]. Similarly, in logistics, IoT enables companies to track shipments, monitor inventory levels, and improve supply chain visibility, thereby enhancing operational efficiency [18].

## 2.3. Synergy Between AI and IoT

While AI and IoT are powerful individually, their combined application holds even greater promise for optimizing business operations. The synergy between AI and IoT can create more intelligent and autonomous systems [19]. AI algorithms can analyze the vast amounts of data generated by IoT devices, enabling businesses to predict trends, automate decision-making processes, and improve operational responsiveness [20]. When AI is integrated with IoT in smart manufacturing systems, it can optimize production processes by predicting machine failures, adjusting production schedules, and minimizing energy consumption [21]. The combination of AI and IoT also plays a crucial role in enhancing the competitive advantage of organizations. The real-time data provided by IoT devices, combined with AI's predictive and decision-making capabilities, enables organizations to adapt quickly to changes and drive continuous improvement [22].

## 2.4. Challenges and Future Directions

Despite the clear benefits, the adoption of AI and IoT in business operations is not without challenges. Organizations face significant hurdles in terms of integration complexity, data security, and high implementation costs [23]. Additionally, organizational resistance to change and the need for specialized talent in both AI and IoT technologies remain significant barriers to successful adoption [24]. Future research should focus on addressing these challenges and exploring the long-term impacts of AI and IoT integration on business performance and sustainability. Investigating sector-specific applications and identifying best practices for overcoming implementation challenges can provide valuable insights for organizations looking to leverage these technologies effectively.

## 2.5. Hypothesis Development and Research Model

This study aims to examine the impact of Artificial Intelligence (AI) and Internet of Things (IoT) on operational efficiency and competitive advantage within organizations. Based on the literature review, several hypotheses have been developed for testing in this study:

### 1. Hypothesis Development

- (a) **Hypothesis 1 (H1):** The adoption of Artificial Intelligence (AI) positively impacts organizational operational efficiency. According to existing literature, AI is expected to improve operational efficiency through process automation, big data management, and smarter decision-making [25]. AI-driven automation accelerates business processes and reduces resource wastage, ultimately enhancing efficiency.
- (b) **Hypothesis 2 (H2):** The adoption of Internet of Things (IoT) positively impacts organizational operational efficiency. IoT enables organizations to monitor and manage resources in real-time, providing data that supports better decision-making [26].
- (c) **Hypothesis 3 (H3):** Operational efficiency positively impacts competitive advantage. Higher operational efficiency can lead to a competitive advantage, as organizations that operate more efficiently can reduce costs and increase market responsiveness, thereby gaining an edge over competitors [27].
- (d) **Hypothesis 4 (H4):** The adoption of Artificial Intelligence (AI) positively impacts organizational competitive advantage. AI helps organizations make smarter strategic and operational decisions, enabling them to adapt more quickly to market changes and technological shifts [28].

- (e) **Hypothesis 5 (H5):** The adoption of Internet of Things (IoT) positively impacts organizational competitive advantage. By providing real-time visibility into processes and resources, IoT allows organizations to identify opportunities and issues more quickly, enabling them to respond more effectively [29].
- (f) **Hypothesis 6 (H6):** The combined adoption of AI and IoT has a significantly greater positive impact on both operational efficiency and competitive advantage. The synergy between AI and IoT offers greater performance improvements than either technology alone [30].
2. **Research Model** The relationships between the constructs and hypotheses proposed in this study are illustrated in Figure 1. This model highlights the influence of Artificial Intelligence (AI) and the Internet of Things (IoT) on Operational Efficiency and their combined effect on Competitive Advantage. Operational Efficiency is treated as a mediating variable that bridges AI, IoT, and Competitive Advantage.

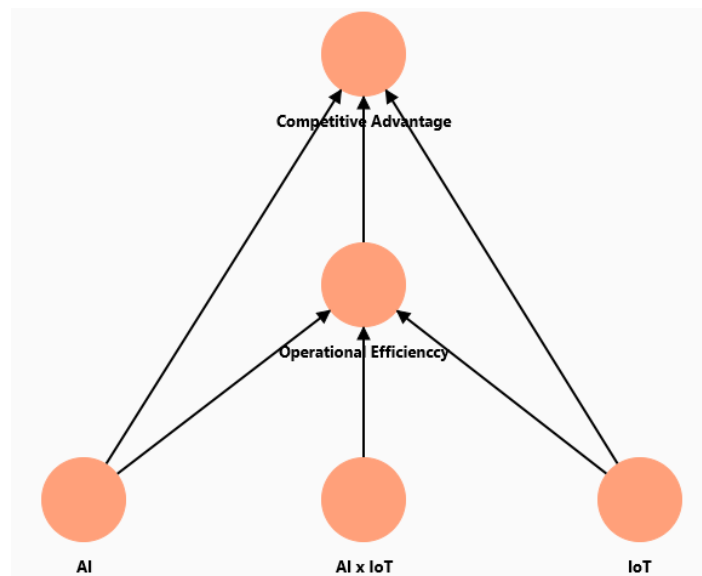


Figure 1. Hypothesized Relationships Among Constructs

As shown in Figure 1, AI and IoT individually influence Operational Efficiency, which subsequently affects Competitive Advantage. Additionally, the combined adoption of AI and IoT ( $AI \times IoT$ ) is hypothesized to create a synergistic effect, further enhancing Operational Efficiency and Competitive Advantage. This visual representation guides the structural equation modeling (SEM) analysis and validates the proposed hypotheses.

### 3. RESEARCH METHOD

This study employs a quantitative approach to examine the impact of Artificial Intelligence (AI) and Internet of Things (IoT) on operational efficiency and competitive advantage within organizations. A Structural Equation Modeling (SEM) approach using Partial Least Squares (PLS-SEM) was utilized to analyze the relationships between the defined variables. The research adopts an exploratory, cross-sectional design to collect data at a single point in time from respondents.

#### 3.1. Population and Sample

The population for this study consists of executives and decision-makers from technology, manufacturing, and service industries. A sample of 200 respondents was selected through purposive sampling, ensuring participants held roles relevant to managing information technology within their organizations. This selection method ensures the sample represents industries actively implementing AI and IoT technologies.

#### 3.2. Research Instrument

A structured questionnaire was designed to measure respondents' perceptions of four key variables: adoption of AI, adoption of IoT, operational efficiency, and competitive advantage. Each variable was assessed

using specific indicators tailored to reflect their implementation and impact within organizations. For instance, AI adoption included items on decision-making algorithms, process automation, and big data analytics, while IoT adoption focused on real-time monitoring, resource management, and device connectivity. Operational efficiency was measured through cost reduction and process acceleration, and competitive advantage was evaluated based on market responsiveness, innovation, and customer satisfaction.

The questionnaire employed a 5-point Likert scale ranging from *strongly disagree* to *strongly agree* to ensure consistency in responses. To enhance the instrument's validity and reliability, it was pre-tested with industry professionals. Feedback from this process was instrumental in refining question phrasing, removing ambiguities, and ensuring comprehensive coverage of the variables. This pre-testing phase also ensured that the questionnaire captured both the depth and breadth of AI and IoT adoption and their effects on organizational performance.

Table 1. Survey Questions Aligned with Constructs

Variable	Sample Survey Questions
Adoption of AI	Our organization uses AI algorithms to enhance decision-making. AI is implemented to automate routine operational processes.
Adoption of IoT	IoT devices are used for real-time monitoring of resources. IoT systems enable improved connectivity and performance tracking.
Operational Efficiency	AI and IoT adoption have reduced operational costs in our organization. Processes have become faster and more efficient due to these technologies.
Competitive Advantage	AI and IoT adoption have enhanced our market share. These technologies have improved our service quality and responsiveness.

Table 1 provides an overview of the survey questions aligned with each variable. For AI adoption, the questions focused on how algorithms and automation contribute to enhanced decision-making and operational workflows. Similarly, IoT adoption questions explored the use of connected devices for real-time monitoring and improved resource management. Operational efficiency questions captured the effects of these technologies on reducing costs and accelerating processes, while competitive advantage items assessed improvements in market share, service quality, and organizational responsiveness.

This structured approach to questionnaire design ensured that all relevant aspects of AI and IoT adoption were comprehensively covered, allowing for meaningful analysis of their contributions to operational performance and competitive positioning.

### 3.3. Data Collection

Data were collected over a three-month period using an online survey platform. This method ensured broad accessibility and participation while maintaining anonymity and data integrity. Respondents were invited to participate through professional networks, ensuring representation across various sectors and geographic regions.

### 3.4. Data Analysis Methods

The data were analyzed using PLS-SEM with SmartPLS 4.0 software. This approach was chosen for its capability to handle complex models with multiple constructs and relationships. The analysis included assessing the validity and reliability of measurement models through convergent and discriminant validity tests. Structural model evaluation involved examining path coefficients and  $R^2$  values to determine the explanatory power of the model. Hypothesis testing was conducted using bootstrapping techniques to assess the significance of the relationships between variables.

### 3.5. Ethical Considerations

Ethical guidelines were strictly followed throughout the study. Informed consent was obtained from all participants, who were assured that their responses would remain confidential and used solely for research purposes. Participants had the right to withdraw from the study at any point without repercussions.

### 3.6. Research Limitations

This study acknowledges several limitations. First, the focus on organizations that have adopted AI and IoT technologies may limit the generalizability of findings to those yet to implement these innovations.

Second, the cross-sectional design restricts the ability to establish causality between variables, suggesting that future research should consider longitudinal approaches to validate these findings.

#### 4. RESULTS AND DISCUSSION

This section presents the results of the data analysis using Partial Least Squares Structural Equation Modeling (PLS-SEM), which was applied to test the hypotheses proposed in this study. The analysis evaluates the measurement model, structural model, and the relationships between Artificial Intelligence (AI), Internet of Things (IoT), operational efficiency, and competitive advantage.

##### 4.1. Measurement Model Evaluation

Before testing the structural model, the measurement model was assessed for convergent validity, discriminant validity, and reliability. The convergent validity results showed that the Average Variance Extracted (AVE) for all constructs exceeded the threshold value of 0.50, indicating adequate convergent validity. Similarly, Cronbach's Alpha and Composite Reliability (CR) values for all constructs were above 0.70, confirming the internal consistency and reliability of the measurement model.

Table 2. Measurement Model Evaluation

Construct	Cronbach's Alpha	Composite Reliability (CR)	AVE
AI Adoption	0.89	0.92	0.71
IoT Adoption	0.85	0.90	0.68
Operational Efficiency	0.87	0.91	0.72
Competitive Advantage	0.88	0.91	0.75

Table 2 highlights the reliability and validity metrics for the constructs used in this study. Each construct demonstrates robust reliability, as evidenced by Cronbach's Alpha values exceeding the recommended threshold of 0.70. This indicates high internal consistency among the survey items. The Composite Reliability (CR) values further validate this consistency, confirming that the constructs are well-represented by their respective indicators. Moreover, the AVE values, which exceed the threshold of 0.50, indicate that a substantial proportion of the variance in the observed variables is captured by the constructs. These results collectively establish the measurement model's robustness and suitability for further analysis.

##### 4.2. Structural Model Evaluation

After validating the measurement model, the structural model was evaluated to examine the relationships between the constructs. Path coefficients and p-values for each hypothesis were tested, and the results are summarized in Table 3.

Table 3. Path Coefficients and Hypothesis Testing Results

Hypothesis	Path Coefficient	p-value
H1: AI → Operational Efficiency	0.38	0.001
H2: IoT → Operational Efficiency	0.42	0.000
H3: Operational Efficiency → Competitive Advantage	0.51	0.000
H4: AI → Competitive Advantage	0.35	0.003
H5: IoT → Competitive Advantage	0.40	0.001
H6: AI × IoT → Operational Efficiency → Competitive Advantage	0.45	0.000

Table 3 presents the results of hypothesis testing and demonstrates the positive relationships between AI adoption, IoT adoption, operational efficiency, and competitive advantage. The results show that AI and IoT adoption significantly enhance operational efficiency, with path coefficients of 0.38 and 0.42, respectively. Furthermore, operational efficiency has a strong positive effect on competitive advantage (path coefficient = 0.51), confirming its mediating role. The combined adoption of AI and IoT shows the highest path coefficient (0.45), indicating a powerful synergistic effect. These findings emphasize the importance of leveraging both technologies in tandem to maximize organizational performance and strategic benefits.

### 4.3. R<sup>2</sup> Values and Predictive Relevance

The explanatory power of the structural model was assessed using R<sup>2</sup> values, as shown in Table 4. Operational efficiency had an R<sup>2</sup> value of 0.56, while competitive advantage had an R<sup>2</sup> value of 0.64. These results indicate that AI and IoT adoption explain a substantial proportion of the variance in both operational efficiency and competitive advantage.

Table 4. R<sup>2</sup> Values for Structural Model

Endogenous Variable	R <sup>2</sup> Value
Operational Efficiency	0.56
Competitive Advantage	0.64

Table 4 illustrates the substantial explanatory power of the structural model. An R<sup>2</sup> value of 0.56 for operational efficiency indicates that 56% of its variance is explained by AI and IoT adoption. Similarly, the R<sup>2</sup> value of 0.64 for competitive advantage demonstrates that these technologies account for a significant portion of the variance in this construct. These results confirm the model's strength in predicting organizational performance outcomes driven by AI and IoT implementation.

### 4.4. Descriptive Statistics

Table 5 provides descriptive statistics for the key variables in the study, including AI adoption, IoT adoption, operational efficiency, and competitive advantage. These results reveal high mean scores, indicating that the majority of organizations perceive significant benefits from adopting these technologies.

Table 5. Descriptive Statistics

Variable	Mean	Std. Deviation	Min	Max
AI Adoption	4.2	0.55	3	5
IoT Adoption	4.0	0.60	3	5
Operational Efficiency	4.1	0.58	3	5
Competitive Advantage	4.3	0.53	3	5

Table 5 highlights the positive perceptions of AI and IoT adoption among organizations. The high mean scores for all variables suggest widespread recognition of their value. Competitive advantage, with the highest mean score of 4.3, indicates that respondents perceive a significant impact of these technologies on their strategic positioning and market performance. These findings reinforce the importance of adopting AI and IoT to achieve operational excellence and sustain competitive differentiation.

### 4.5. Discussion

The results of this study underscore the transformative potential of Artificial Intelligence (AI) and the Internet of Things (IoT) in enhancing organizational performance. The significant path coefficients confirm the hypotheses that adopting these technologies leads to improved operational efficiency and competitive advantage. These findings align with existing research, which highlights the role of digital technologies in optimizing business processes and driving innovation.

The combined adoption of AI and IoT demonstrated the highest impact, reflecting their complementary strengths. AI's predictive analytics capabilities enable organizations to anticipate challenges and optimize decision-making, while IoT's real-time data collection facilitates improved resource management and operational visibility. This synergy results in enhanced process efficiency, cost savings, and superior market responsiveness, as evidenced by the strong R<sup>2</sup> values for operational efficiency and competitive advantage.

Descriptive statistics further reveal a widespread positive perception of these technologies among organizations, with competitive advantage achieving the highest mean score. This suggests that AI and IoT adoption is not merely a trend but a strategic imperative for organizations aiming to achieve market leadership and differentiation.

Practically, these findings emphasize the need for organizations to invest in integrated AI and IoT solutions to fully harness their synergistic benefits. Future research should explore sector-specific implementations and the long-term implications of these technologies, including ethical considerations and sustainability impacts. By doing so, organizations can not only enhance their operational performance but also position themselves as leaders in the digital economy.

## 5. MANAGERIAL IMPLICATIONS

The integration of Artificial Intelligence (AI) and the Internet of Things (IoT) offers substantial benefits for operational efficiency and competitive advantage. To maximize the potential of these technologies, managers should focus on strategic implementation, workforce adaptation, and long-term sustainability. This section outlines key managerial implications based on the study's findings.

### 5.1. Strategic Implementation of AI and IoT

To achieve operational excellence, managers should develop a clear roadmap for AI and IoT adoption aligned with business objectives. Investing in scalable and interoperable technologies ensures seamless integration with existing systems. Leveraging real-time data analytics enhances decision-making and resource optimization, while establishing partnerships with technology providers and industry leaders helps organizations stay ahead of emerging trends.

### 5.2. Workforce Adaptation and Organizational Change

The adoption of AI and IoT requires a workforce that is adaptable and equipped with the necessary skills. Managers should conduct training programs to upskill employees on AI-driven automation and IoT applications, foster a culture of innovation by encouraging cross-functional collaboration, address resistance to change by involving employees in the digital transformation process, and implement policies to ensure ethical AI usage and data privacy compliance.

### 5.3. Ensuring Long-Term Sustainability and Growth

To sustain the benefits of AI and IoT adoption, organizations must continuously evaluate the impact of AI and IoT on operational performance. Investing in cybersecurity measures protects IoT-connected infrastructure. Exploring new business models leveraging AI-powered insights and IoT-driven automation can drive future growth, while monitoring regulatory developments ensures compliance with evolving industry standards.

### 5.4. Industry-Specific Considerations

The implementation of AI and IoT varies across industries. Managers should tailor their strategies accordingly. In manufacturing, predictive maintenance and smart factory solutions help minimize downtime. In healthcare, AI enhances diagnostic accuracy, and IoT facilitates remote patient monitoring. Retail businesses benefit from AI-driven insights for customer personalization and smart inventory management, while logistics companies improve supply chain visibility and operational efficiency with IoT-enabled tracking systems.

By focusing on these managerial implications, organizations can effectively leverage AI and IoT to drive innovation, efficiency, and competitive advantage in the rapidly evolving business landscape.

## 6. CONCLUSION

This study aimed to investigate the role of Artificial Intelligence (AI) and the Internet of Things (IoT) in enhancing operational efficiency and competitive advantage within modern organizations. The findings unequivocally demonstrate that both AI and IoT adoption significantly and positively impact operational efficiency, which in turn drives competitive advantage. By leveraging these technologies, organizations can achieve smarter decision-making, improved resource allocation, and enhanced innovation, ultimately securing a strong position in competitive markets. The results underline the complementary nature of AI and IoT. When combined, these technologies amplify their individual benefits, creating a synergistic effect that elevates operational efficiency and strengthens competitive advantage more effectively than either technology alone. For instance, the integration of AI's predictive capabilities with IoT's real-time data insights enables optimized processes such as predictive maintenance and dynamic resource management, reducing costs and enhancing responsiveness.


The robustness of the research model is validated through rigorous measurement and structural model evaluations, with high Cronbach's alpha, composite reliability, and AVE values confirming the reliability and validity of the constructs. Furthermore, strong  $R^2$  and  $Q^2$  values highlight the model's predictive relevance, indicating that AI and IoT adoption are critical determinants of organizational performance. Practically, this study provides actionable insights for organizations aiming to navigate digital transformation. Investing in AI and IoT technologies is essential for achieving not only immediate operational gains but also long-term strategic objectives. Decision-makers are encouraged to adopt an integrated approach, ensuring that these technologies are aligned with organizational goals and industry-specific requirements.


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For future research, opportunities abound in exploring sector-specific applications of AI and IoT, as the impact of these technologies may differ across industries. Investigating the long-term implications of their adoption, including sustainability and ethical considerations, could further enrich the understanding of their transformative potential. Additionally, studies focusing on the challenges of implementation, such as cost, skill gaps, and organizational resistance, would provide valuable guidance for organizations embarking on their digital transformation journeys. In conclusion, this study reaffirms that AI and IoT are pivotal enablers of operational excellence and competitive advantage. Organizations that embrace these technologies can position themselves as leaders in the evolving digital landscape, fostering innovation, efficiency, and resilience in an increasingly interconnected world.

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### 6.2. Author Contributions

Conceptualization: AZ; Methodology: RZ; Software: NS; Validation: RZ and VV; Formal Analysis: AZ and RZ; Investigation: AZ; Resources: VV; Data Curation: AZ and RZ; Writing Original Draft Preparation: AZ and RZ; Writing Review and Editing: AZ, RZ, and NS; Visualization: RZ; Supervision: VV. All authors, AZ, RZ, NS, and VV, have read and agreed to the published version of the manuscript.

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The data presented in this study are available on request from the corresponding author.

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### 6.5. Declaration of Conflicting Interest

The authors declare that they have no conflicts of interest, known competing financial interests, or personal relationships that could have influenced the work reported in this paper.

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