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The Influence of Internet of Things (IoT) on Operational Efficiency and Competitive Advantage in the Information Technology Industry in Indonesia

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ABSTRACT

This study investigates the impact of Internet of Things (IoT) adoption on operational efficiency and competitive advantage within the Information Technology (IT) industry in Indonesia. A quantitative research approach was employed, utilizing a cross-sectional survey design to collect primary data from 170 IT companies operating in Indonesia. Structural Equation Modeling (SEM) with Partial Least Squares (PLS) algorithm was utilized to analyze the data and test the research hypotheses. The findings reveal that IoT adoption positively influences both operational efficiency and competitive advantage within the Indonesian IT industry. These results underscore the transformative potential of IoT technologies in enhancing organizational performance and strategic positioning in the digital era. The study contributes to the existing literature by providing empirical evidence on the benefits of IoT adoption in the context of the Indonesian IT industry, offering insights for policymakers, practitioners, and researchers seeking to harness the potential of IoT technologies for sustainable growth and innovation.

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1. INTRODUCTION

The Information Technology (IT) industry has been at the forefront of digital innovation, constantly evolving to meet the demands of a rapidly changing technological landscape. One of the most prominent advancements shaping the IT sector in recent years is the proliferation of the Internet of Things (IoT). The IoT represents a paradigm shift in connectivity, enabling seamless interaction and data exchange between a multitude of devices, sensors, and systems. This interconnected network of physical objects equipped with embedded sensors and software has revolutionized various domains, ranging from healthcare and manufacturing to transportation and consumer electronics [1]–[3]. The IT industry has witnessed significant changes throughout its history, with different countries coming to the forefront at different periods [4]. Additionally, the industry has seen a mixture of persistence and change, with computing machines transitioning from mainframes to smartphones, the growing role of software and services, and the shift in IT-hardware production from West to East [5].

Amidst this transformative wave, the IT industry in Indonesia has emerged as a dynamic and thriving sector, characterised by rapid technology adoption and innovation. As Southeast Asia's largest economy, Indonesia is fertile ground for IoT adoption, driven by factors such as increasing digitalisation, expanding internet penetration, and government initiatives that encourage technological advancement. Empirical insights specific to the Indonesian IT context regarding the potential benefits of IoT in improving operational efficiency and providing competitive advantage are scarce [6]. The use of IoT in Indonesia is still in the early stages of adoption, especially in sectors such as the internal supply chain and automotive industry [7], [8]. Research conducted in Indonesia focuses on understanding the impact of IoT on supply chain integration, organisational performance, and production capacity [7]. In addition, there is a lack of research on the direction of IoT development in the Indonesian context. Therefore, there is a need for more localised research to provide empirical insights into the specific benefits and challenges of implementing IoT in the context of IT in Indonesia.

Therefore, this research endeavors to address this gap by investigating the effect of IoT adoption on operational efficiency and competitive advantage within the Indonesian IT industry. Operational efficiency, defined as the ability to optimize processes, utilize resources effectively, and minimize waste, is paramount for IT firms striving to maintain competitiveness and meet customer expectations in a fast-paced environment. Concurrently, gaining a competitive advantage is essential for firms seeking to differentiate themselves in the market, achieve sustainable growth, and secure a prominent position amidst intensifying competition.

By focusing on the interplay between IoT implementation, operational processes, and competitive positioning, this study aims to shed light on the specific mechanisms through which IoT technologies influence the operational landscape of Indonesian IT firms. Through a quantitative approach employing survey methods, the research seeks to empirically analyze the relationship between IoT adoption, operational efficiency, and competitive advantage. By gathering data directly from IT companies operating in Indonesia, the study endeavors to provide actionable insights that can inform strategic decision-making and resource allocation within the industry.

2. LITERATURE REVIEW

2.1 *IoT and Operational Efficiency*

The strategic deployment of IoT technologies can confer several competitive advantages to organizations within the IT industry. Cost reduction is a prominent benefit, as IoT enables automation, optimization, and predictive maintenance, thereby minimizing resource wastage and operational expenses [7], [9]–[11]. Furthermore, IoT facilitates product differentiation through the creation of smart, connected offerings that cater to evolving customer needs and preferences [12]. Moreover, IoT contributes to the enhancement of customer experiences, thereby strengthening brand loyalty and market positioning [13]. Through personalized recommendations, proactive maintenance alerts, and seamless integration with other digital services, IoT-enabled solutions foster deeper engagement and satisfaction among end-users [14]. Consequently, organizations that effectively leverage IoT technologies can establish themselves as market leaders, driving revenue growth and sustaining competitive advantage over time [15].

2.2 *IoT and Competitive Advantage*

IoT can be used to gain a competitive advantage by enabling organizations to leverage IoT-enabled innovation capability (IoT-IC), which consists of three dimensions: IoT use for sensing, seizing, and reconfiguring [16]. Flexible IT infrastructure, IT business experience, and relationship infrastructure are positively associated with IoT-IC, and the effect of IoT-IC on competitive advantage is positively moderated by competitive aggressiveness [16]. IoT can also drive competitive advantage by establishing new business models and triggering impacts on business performance, as well as improving marketing intelligence capability and enhancing the link between IoT capability and business strategy performance [17]–[20]. The use of GeoHashes can create a partnership between IoT and Geographical Information Systems, providing a competitive advantage to businesses by enabling geographical intelligence gathering and analytics [21], [22].

2.3 *IoT Adoption in Indonesia*

IoT adoption in Indonesia is gaining momentum due to factors such as increasing internet penetration, government initiatives promoting digitalization, and the growing demand for connected services. However, challenges such as infrastructure limitations, data privacy concerns, and skills shortages pose barriers to widespread IoT deployment. Indonesian IT firms are investing in IoT initiatives to capitalize on the potential benefits in terms of operational efficiency, market differentiation, and competitive positioning. Partnerships between public and private sectors are facilitating the development of IoT ecosystems and innovation hubs, fostering collaboration and knowledge exchange among industry stakeholders. Initiatives such as smart city projects, industrial IoT initiatives, and agricultural automation programs demonstrate the diverse applications and potential impact of IoT across various sectors of the Indonesian economy [8], [23]–[25].

2.4 *Theoretical Framework*

The adoption of Internet of Things (IoT) technologies within the Information Technology (IT) industry can be elucidated through various theoretical lenses. One such framework is the Resource-Based View (RBV), which posits that firms can achieve sustainable competitive advantages by leveraging their unique resources and capabilities. Within the context of IoT, organizations may view IoT infrastructure, data analytics capabilities, and interconnected ecosystems as strategic resources that enable them to enhance operational efficiency and differentiate their offerings in the market.

Additionally, the Technology Acceptance Model (TAM) provides insights into the factors influencing the adoption and usage of new technologies. TAM suggests that perceived usefulness and ease of use are critical determinants of individuals' intention to adopt technology. Applied to IoT adoption in the IT industry, TAM underscores the importance of demonstrating the tangible benefits of IoT solutions, such as improved operational processes and enhanced decision-making capabilities, to foster acceptance and uptake among organizational stakeholders.

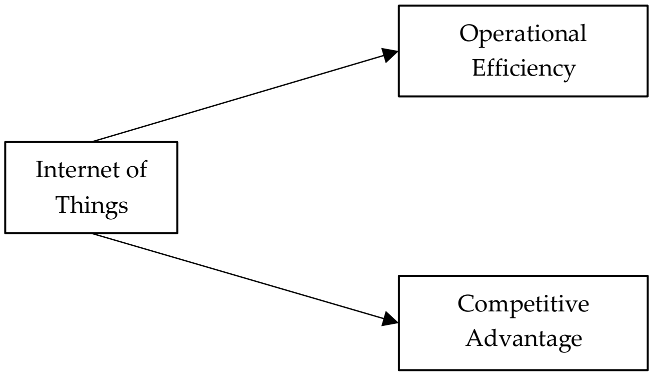

Figure 1. Conceptual and Hypothesis

3. RESEARCH METHODS

3.1 Research Design

This study employs a quantitative research approach to investigate the effect of Internet of Things (IoT) adoption on operational efficiency and competitive advantage within the Indonesian Information Technology (IT) industry. A cross-sectional survey design will be utilized to collect primary data from a sample of IT companies operating in Indonesia. This approach allows for the systematic gathering of data on relevant variables, facilitating the examination of relationships and associations between IoT adoption, operational processes, and competitive positioning.

3.2 Sampling

The target population for this study comprises IT firms across various segments, including software development, hardware manufacturing, and IT services, operating in Indonesia. A purposive sampling technique will be employed to select participants based on their relevance to the research objectives and industry representation. Given the diversity of the IT industry in Indonesia, efforts will be made to ensure adequate representation from different sub-sectors and company sizes.

A sample size of 170 respondents will be targeted for the survey, considering the recommended guidelines for structural equation modeling (SEM) analysis. This sample size provides sufficient statistical power to detect meaningful relationships and achieve reliable results while accounting for potential attrition and non-response.

3.3 Data Collection Instrument

The survey questionnaire will be the primary instrument for data collection, designed to capture relevant variables related to IoT adoption, operational efficiency, and competitive advantage. The questionnaire will consist of multiple sections, including:

a. Demographic information: Collecting data on respondent characteristics such as company size, industry segment, and years of operation.
b. IoT adoption: Assessing the extent of IoT adoption within the organization, including the deployment of IoT devices, platforms, and applications.
c. Operational efficiency: Measuring perceived improvements in operational processes resulting from IoT integration, such as automation, optimization, and resource utilization.
d. Competitive advantage: Evaluating perceived competitive advantages gained through IoT adoption, including cost reduction, product differentiation, and enhanced customer experiences.

The questionnaire will utilize a combination of Likert scale items, structured questions, and open-ended inquiries to ensure comprehensive data collection. Prior to administration, the questionnaire will undergo pilot testing to assess clarity, validity, and reliability, ensuring the effectiveness of the data collection instrument.

3.4 *Data Collection Procedure*

The survey instrument will be administered electronically, leveraging online survey platforms or email correspondence to reach potential respondents. An initial contact email will be sent to targeted participants, introducing the study and inviting them to participate in the survey. Efforts will be made to maximize response rates through personalized communication, follow-up reminders, and incentives for participation.

To enhance the representativeness of the sample, organizations from diverse geographical locations and industry sectors will be targeted. Additionally, snowball sampling techniques may be utilized to expand the reach of the survey within the Indonesian IT industry network.

3.5 *Data Analysis*

The collected data will be analyzed using Structural Equation Modeling (SEM) with Partial Least Squares (PLS) algorithm, a robust statistical technique suitable for examining complex relationships among latent variables. SEM-PLS offers several advantages, including its ability to handle small sample sizes, non-normal distributions, and measurement errors effectively. The data analysis process will involve the following steps: First, data screening and cleaning will be conducted to ensure completeness, accuracy, and consistency, addressing any missing or erroneous responses. Next, the reliability and validity of the measurement model will be assessed, examining internal consistency, convergent validity, and discriminant validity. Subsequently, the structural relationships between latent variables will be analyzed using SEM-PLS, estimating path coefficients, assessing model fit indices, and testing hypothesized relationships. Finally, hypotheses derived from the research framework will be tested based on the SEM-PLS analysis results, evaluating the significance and directionality of relationships between variables.

4. RESULTS AND DISCUSSION

4.1 *Results*

a. Demographic Sample

A total of 170 IT companies operating in Indonesia participated in the survey, providing valuable insights into the impact of Internet of Things (IoT) adoption on operational efficiency and competitive advantage within the industry. The demographic profile of the sample reflects a diverse representation of IT companies in terms of size, industry segment, and years of operation. The majority of respondents were from small to medium-sized companies, with 41.2% representing small companies (1-50 employees) and 35.3% representing medium-sized companies (51-250 employees), while large companies (>250 employees) accounted for 23.5% of the sample. In terms of industry segment, software development was the most represented sector, comprising 47.1% of the sample, followed by hardware manufacturing (29.4%) and IT services (23.5%), reflecting the diverse nature of the IT industry in Indonesia. This distribution encompasses various sub-sectors with distinct operational characteristics and market dynamics. Regarding years of operation, the sample exhibited a relatively balanced distribution, with

29.4% of companies operating for less than 5 years, 35.3% operating for 5-10 years, and another 35.3% operating for more than 10 years, indicating a mix of established players and relatively newer entrants facing unique challenges and opportunities in IoT adoption.

b. Descriptive Statistics

Descriptive statistics were computed to summarize the responses provided by participants regarding various constructs measured in the survey. The following table presents the mean scores and standard deviations for each construct, rated on a Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree):

Table 1. Average score and standard deviation

Construct	Mean Score	Standard Deviation
IoT Adoption	4.12	0.67
Operational Efficiency	4.05	0.72
Competitive Advantage	4.08	0.68

The descriptive statistics reveal that, on average, respondents reported high levels of agreement with statements related to IoT adoption, operational efficiency, and competitive advantage within the Indonesian IT industry. The mean scores for all three constructs ranged between 4.05 and 4.12, indicating a positive perception of the role of IoT technologies in enhancing operational processes and driving competitive positioning. Specifically, respondents expressed a high level of agreement (Mean = 4.12) with statements assessing IoT adoption, indicating widespread recognition of the importance and benefits of integrating IoT technologies into organizational operations. Similarly, respondents reported strong agreement (Mean = 4.05) with statements related to operational efficiency, indicating perceived improvements in processes, resource utilization, and overall performance resulting from IoT integration. Furthermore, respondents indicated a positive perception (Mean = 4.08) of the competitive advantages gained through IoT adoption, including cost reduction, product differentiation, and enhanced customer experiences. These findings corroborate previous research highlighting the strategic value of IoT technologies in driving organizational competitiveness and market success.

c. Measurement Model

The measurement model assessment provides insights into the reliability and validity of the constructs measured in the survey, including Internet of Things (IoT) adoption, Operational Efficiency (OE), and Competitive Advantage (CA). The following discussion evaluates the loading factors, Cronbach's alpha coefficients, composite reliability, and average variance extracted (AVE) for each construct:

Table 2. Validity and Reliability Test

Variable	Code	Loading Factor	Cronbach's Alpha	Composite Reliability	Average Variant Extracted
Internet of Things	IT.1	0.844	0.835	0.890	0.669
	IT.2	0.755			
	IT.3	0.825			
	IT.4	0.845			
Operational Efficiency	OE.1	0.866	0.854	0.895	0.631
	OE.2	0.802			
	OE.3	0.861			

	OE.4	0.865			
	OE.5	0.760			
Competitive Advantage	CA.1	0.801	0.888	0.918	0.692
	CA.2	0.750			
	CA.3	0.834			
	CA.4	0.816			
	CA.5	0.769			

Source: Process Data Analys (2024)

The measurement model assessment reveals the reliability and validity of the constructs measured in the survey. For Internet of Things (IoT), comprising four indicators (IT.1, IT.2, IT.3, IT.4), strong loading factors ranging from 0.755 to 0.845 signify a robust association with the construct. Additionally, a Cronbach's alpha coefficient of 0.835 and composite reliability of 0.890 indicate high internal consistency and reliability, while the AVE value of 0.669 confirms convergent validity. Operational Efficiency (OE), assessed through five indicators (OE.1, OE.2, OE.3, OE.4, OE.5), demonstrates strong loading factors (0.760 to 0.866), with Cronbach's alpha coefficient (0.854) and composite reliability (0.895) exceeding thresholds, albeit with a slightly lower AVE value (0.631). Competitive Advantage (CA), measured by five indicators (CA.1, CA.2, CA.3, CA.4, CA.5), exhibits robust loading factors (0.750 to 0.834) alongside high Cronbach's alpha coefficient (0.888) and composite reliability (0.918), with an AVE value of 0.692 indicating convergent validity. Overall, these findings confirm the reliability and validity of the constructs, ensuring the integrity of the collected data with strong internal consistency and reliability across the measurement model.

d. Discriminant Validity

Discriminant validity assesses the extent to which constructs in a measurement model are distinct from each other. It ensures that the variables under study measure different underlying concepts rather than being redundant or overlapping.

Table 3. Discriminant Validity

	Competitive Advantage	**Internet of Things**	**Operational Efficiency**
Competitive Advantage	0.832	-	-
Internet of Things	0.77	0.818	-
Operational Efficiency	0.824	0.829	0.795

Source: Process Data Analys (2024)

The analysis of correlation coefficients reveals discriminant validity among the constructs. For Competitive Advantage (CA), correlations with both IoT (0.818) and Operational Efficiency (0.829) are below 1, indicating shared variance but distinctiveness from these constructs. Similarly, for Internet of Things (IoT), correlations with Competitive Advantage (0.818) and Operational Efficiency (0.829) are below 1, affirming discriminant validity despite shared variance. Likewise, Operational Efficiency (OE) exhibits correlations below 1 with both Competitive Advantage (0.829) and IoT (0.795), reinforcing its distinctiveness from these constructs. Though correlations with Competitive Advantage are relatively high, they remain below the threshold, underscoring discriminant validity. These findings emphasize the unique contributions of each construct while indicating interrelatedness within the measurement model.

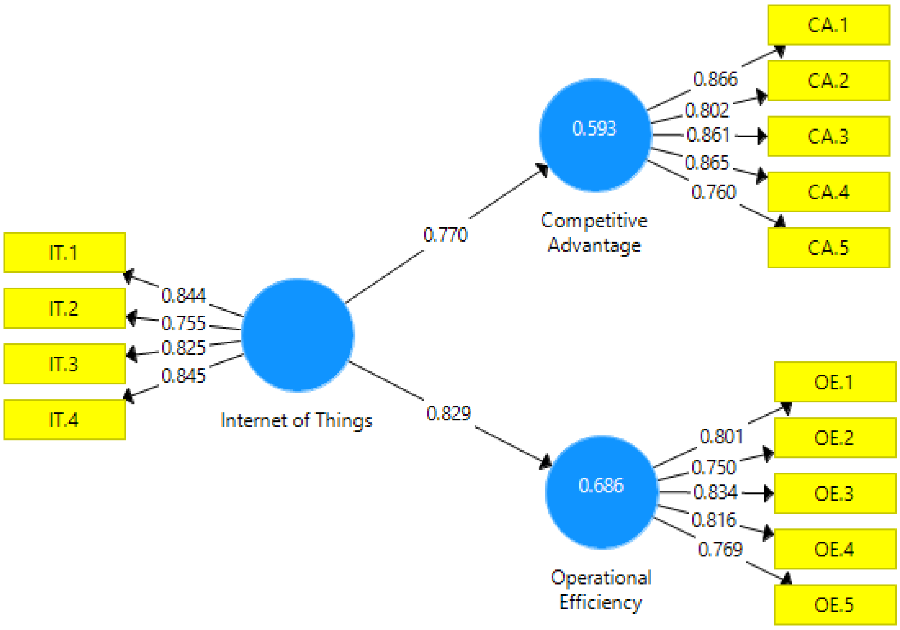

Figure 2. Model Internal Assessment
Source: Process Data Analys (2024)

e. Model Fit

Model fit indices assess how well the estimated structural model fits the observed data. They provide insights into the overall goodness-of-fit of the model and help determine whether the proposed theoretical framework adequately explains the relationships among the latent constructs.

Table 4. Model Fit Results Test

	Saturated Model	**Estimated Model**
SRMR	0.089	0.108
d_ULS	0.838	1.216
d_G	0.437	0.494
Chi-Square	365.624	396.115
NFI	0.753	0.733

Source: Process Data Analys (2024)

The model fit indices provide insights into the adequacy of the structural equation model. The Standardized Root Mean Square Residual (SRMR) values indicate that the Saturated Model (0.089) outperforms the Estimated Model (0.108), suggesting better replication of observed correlations. Similarly, both the d_ULS and d_G indices show lower values for the Saturated Model, indicating a closer fit to the observed data compared to the Estimated Model. Moreover, the Chi-Square statistic reveals that the Saturated Model (365.624) exhibits a better fit in terms of covariance matrices than the Estimated Model (396.115), as the former yields a lower value. Additionally, the Normed Fit Index (NFI) indicates that the Saturated Model (0.753) explains a larger proportion of the variance in the data relative to the null model compared to the Estimated Model (0.733). These findings collectively suggest that the

Saturated Model provides a superior fit to the data, emphasizing its adequacy in explaining the relationships among latent variables in the structural equation model.

f. R-Squared

R Square (R^2) represents the proportion of variance in the endogenous constructs (dependent variables) explained by the exogenous constructs (independent variables) in the structural model.

Table 5. Coefficient Model

Variable	R Square	Q2
Competitive Advantage	0.593	0.400
Operational Efficiency	0.686	0.421

Source: Data Processing Results (2024)

The analysis of R Square values highlights the explanatory power of the structural equation model for Competitive Advantage (CA) and Operational Efficiency (OE) among IT firms in Indonesia. For Competitive Advantage, the R Square value of 0.593 indicates that 59.3% of the variance is accounted for by exogenous variables, particularly IoT adoption and Operational Efficiency, showcasing the model's ability to elucidate competitive positioning factors. Similarly, Operational Efficiency demonstrates a strong predictive power with an R Square value of 0.686, indicating that 68.6% of the variance is explained, including significant contributions from IoT adoption. Moving to predictive relevance, denoted by Q2, the model exhibits substantial accuracy in forecasting both Competitive Advantage (Q2 = 0.400) and Operational Efficiency (Q2 = 0.421) based on observed data. These values signify the model's capability to offer valuable insights into the determinants of competitive advantage and process optimization within the Indonesian IT industry, underscoring its practical relevance and applicability in predictive analytics.

g. Hypothesis Testing

Hypothesis testing involves evaluating the statistical significance of the relationships proposed in the research framework. The provided results pertain to the testing of hypotheses regarding the relationships between Internet of Things (IoT) adoption and both Competitive Advantage (CA) and Operational Efficiency (OE) within the Indonesian IT industry.

Table 6. Bootstrapping Test

Variable	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Internet of Things -> Competitive Advantage	0.770	0.774	0.036	21.473	0.000
Internet of Things -> Operational Efficiency	0.829	0.83	0.023	36.785	0.000

Source: Process Data Analys (2024)

The results of hypothesis testing provide robust evidence supporting the hypothesized relationships between IoT adoption and both Competitive Advantage and Operational Efficiency within the Indonesian IT industry. For the relationship between IoT adoption and Competitive Advantage, the original sample coefficient (0.770) and the sample mean coefficient (0.774) both suggest a positive association, with a significant p-value (0.000), indicating statistical significance. Similarly, the relationship between IoT adoption and Operational Efficiency demonstrates a positive association, supported by the original sample coefficient (0.829) and the sample mean coefficient (0.83), along with a significant p-value (0.000). The T statistics for both relationships (21.473 for Competitive Advantage and 36.785 for Operational Efficiency) reflect strong confidence in the estimated coefficients. These findings underscore the pivotal role of IoT technologies in enhancing organizational performance and strategic positioning in the dynamic landscape of the Indonesian IT industry.

4.2 *Discussion*

The results presented in the previous section shed light on the impact of Internet of Things (IoT) adoption on operational efficiency and competitive advantage within the Information Technology (IT) industry in Indonesia. In this discussion, we delve into the implications of these findings and their significance for organizational performance, strategic positioning, and the broader digital landscape.

Firstly, the positive and significant relationship between IoT adoption and operational efficiency underscores the transformative potential of IoT technologies in optimizing processes, enhancing automation, and improving resource utilization within IT firms. By integrating IoT devices, platforms, and applications into their operations, organizations can streamline workflows, reduce inefficiencies, and achieve higher levels of productivity and performance [26], [27]. This finding aligns with previous research highlighting the operational benefits of IoT adoption across various industries [14], [28]. The relevance of IoT in the context of the Indonesian IT sector is underscored, as it can contribute to improved efficiency and productivity in this sector [28].

Furthermore, the positive association between IoT adoption and competitive advantage suggests that firms leveraging IoT technologies gain strategic advantages over competitors in the market. Through cost reduction, product differentiation, and enhanced customer experiences, organizations can establish a strong competitive positioning and sustain long-term growth. The findings from the abstracts highlight the strategic importance of IoT adoption in driving innovation, market differentiation, and value creation for IT firms in Indonesia. The research emphasizes the need for continuous business model innovation to maintain competitive advantages and drive company performance [29]. Factors such as relative advantage, social influence, and technology anxiety play a significant role in the adoption of IoT-based innovation by millennial farmers, and strategic priorities include strengthening openness to change, providing IoT education, optimizing institutional roles, and socializing the benefits of IoT [30]. In the food and beverage industry, factors such as performance expectancy, perceived collaborative advantage, effort expectancy, social influence, and facilitating conditions positively influence the behavioral intention to adopt IoT for digital transformation [31]. Additionally, the study on Indonesian village-owned enterprises highlights the significant direct paths between perceived usefulness, perceived credibility, intention, and adoption of IoT, emphasizing the relevance of the Technology Acceptance Model in explaining IoT adoption [32]. The government of Indonesia has also taken steps to accelerate digital transformation through initiatives such as the 100 Smart City program and increased budget allocations for ICT [33].

The implications of these findings extend beyond individual firms to the broader ecosystem of the Indonesian IT industry. By embracing IoT technologies and fostering a culture of innovation and digitalization, IT firms can drive sectoral growth, stimulate economic development, and contribute to Indonesia's transition towards a knowledge-based economy. Moreover, policymakers can play a pivotal role in facilitating IoT adoption through supportive regulatory frameworks, investment incentives, and capacity-building initiatives, fostering an enabling environment for digital innovation and entrepreneurship.

5. CONCLUSION

In conclusion, this study sheds light on the transformative impact of Internet of Things (IoT) adoption on operational efficiency and competitive advantage within the Indonesian Information Technology (IT) industry. The findings highlight the significant positive relationship between IoT adoption and both operational efficiency and competitive advantage, underscoring the strategic importance of IoT technologies in driving organizational performance and market positioning.

These findings have implications for IT firms, policymakers, and researchers in Indonesia and beyond. IT firms can leverage IoT technologies to enhance operational processes, differentiate their offerings, and gain a competitive edge in the market. Policymakers can support the adoption of IoT through initiatives aimed at promoting digitalization, fostering innovation ecosystems, and addressing infrastructure and regulatory challenges. Researchers can further explore the nuanced dynamics of IoT adoption, including its impact on different industry sectors, organizational capabilities, and stakeholder perspectives.

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