The Strategic Orientation of Internet of Things Utilization and Firm Performance: An Empirical Investigation of Korean Firms

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Abstract

This study investigates the differential impact of internal-oriented versus external-oriented Internet of Things (IoT) technology utilization on firm performance. While IoT technology has been widely adopted across various industrial domains, its strategic deployment may yield varying outcomes depending on the orientation of implementation. Using panel data of 571 Korean firms from 2017 to 2022, this research conducts an empirical analysis to examine the relationship between orientation of IoT utilization and firm performance. The findings demonstrate that firms adopting IoT technology for external-oriented purposes, such as sales strategy and marketing, experience significantly higher performance compared to those primarily focused on internal operational efficiencies, including product development, production processes, and organizational management. Robustness checks using return on assets (ROA) reveal that while the effect remains positive, it is not statistically significant, suggesting that external-oriented IoT's value creation mechanism operates primarily through capital efficiency rather than asset-based returns. The results indicate that IoT's strategic value is most effectively realized when leveraged to enhance customer interactions and market responsiveness, transcending mere internal optimization to become a tool for competitive advantage. These insights provide valuable implications for strategic technology deployment decisions and highlight the importance of market-facing IoT applications in driving superior firm performance.

Keywords: Internet of Things, Technology utilization, Internal orientation, External orientation, Firm performance

1 Introduction

The rapid advancement of information and communication technologies has profoundly reshaped the global business landscape, with the Internet of Things (IoT) emerging as a transformative force across diverse industries [1]. IoT represents a network of interconnected devices equipped with sensors, processing capabilities, and software that enable them to collect, exchange, and act upon data without human intervention [2]. This pervasive technology is being integrated into various facets of business operations, including product and service development, production processes, sales strategies, marketing, and organizational management [3]. The widespread adoption of IoT is driven by its potential to enhance efficiency, transparency, and productivity across supply chains and internal operations [4].

The scope of IoT applications is vast, extending across numerous sectors. Common application domains include smart homes and buildings for energy management and predictive maintenance; healthcare and wellness for remote patient monitoring and wearable devices; industrial IoT and manufacturing for asset tracking, predictive maintenance, process automation, and energy management; agriculture for soil monitoring and livestock tracking; and transportation and logistics for fleet management, smart parking, and public transport optimization [5]. These examples underscore the extensive reach and potential utility of IoT across various operational contexts.

Despite growing investment in IoT technologies and their widespread application, a critical question remains regarding how different strategic orientations of IoT utilization translate into tangible improvements in firm performance [6]. While many firms focus on internal applications to streamline operations and reduce costs, strategic management literature suggests that competitive advantage often stems from external market engagement and responsiveness [7]. This implies that merely adopting IoT is insufficient; the strategic intent behind its deployment is crucial for realizing performance [8].

The value derived from IoT implementation is not solely a function of its technical capabilities or widespread adoption, but rather how strategically it is aligned with a firm's market objectives [9]. Companies must transcend a focus on technology for its own sake to adopt a perspective that views technology as a strategic enabler for competitive advantage [10]. While the diverse application areas and industry adoption patterns of IoT are well-documented, the question of which application orientation proves more effective for performance enhancement remains inadequately addressed—a gap this study aims to fill.

This research addresses the identified gap by empirically examining how the strategic orientation of IoT

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DOI: https://doi.org/10.70003/160792642025112606012

utilization affects firm performance among Korean firms. The study contributes to both the technology management literature and strategic management theory by providing empirical evidence on the performance implications of strategic technology deployment decisions. The analysis focuses on distinguishing between internal-oriented IoT applications, which primarily target operational efficiency improvements, and external-oriented applications, which emphasize customer engagement and market responsiveness.

The remainder of this paper is organized as follows. Section 2 provides a comprehensive literature review and establishes the theoretical framework, drawing on dynamic capabilities theory to develop our research hypothesis. Section 3 describes the research methodology, including data collection procedures, variable measurement, and empirical estimation strategy. Section 4 presents the empirical results, including descriptive statistics, main regression findings, and robustness checks using alternative performance measures. Section 5 discusses the theoretical and practical implications of the findings, with particular attention to the differential effects observed across performance metrics. Finally, section 6 concludes with a summary of key contributions, limitations, and directions for future research.

2 Literature Review and Theoretical Framework

This section establishes the theoretical foundation for understanding the relationship between orientation of IoT technology utilization and firm performance, drawing upon established management strategy theories.

2.1 Internet of Things (IoT) and Firm Performance

The Internet of Things encompasses devices embedded with sensors, software, and other technologies that connect and exchange data over the internet or other communication networks [11]. These devices possess capabilities for sensing, processing, communicating, and data storage, enabling them to interact with the physical world through sophisticated connectivity and intelligence [12]. The integration of IoT into business operations offers numerous benefits that can significantly contribute to firm performance and financial growth [13].

IoT applications in manufacturing contexts have demonstrated substantial improvements in operational efficiency through predictive maintenance, quality control, and supply chain optimization [14]. In retail environments, IoT enables enhanced customer experiences through personalized services, inventory optimization, and omnichannel integration [15]. Healthcare applications of IoT have shown potential for improving patient outcomes while reducing costs through remote monitoring and data-driven treatment decisions [16].

Specifically, within internal supply chains, IoT implementation has been demonstrated to reduce work delays, optimize time usage, and enhance overall performance and productivity, leading to more sustainable firm operations [17]. The extensive characteristics and benefits of IoT highlight its inherent dual value proposition. While some advantages, such as operational efficiency and reduced work delays, clearly align with internal-oriented utilization, others, including enhanced customer experience, innovative products and services, and market expansion, point towards external-oriented utilization [18]. This duality implies that firms must make strategic choices about how to prioritize these value propositions.

2.2 Dynamic Capabilities and Strategic Adaptation to IoT

While traditional resource-based approaches focus on static resource possession, the dynamic capabilities framework emphasizes a firm's ability to adapt, innovate, and respond effectively to rapidly changing environments [19]. Dynamic capabilities are defined as the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments [20]. They differ from ordinary capabilities, which pertain to current operations, by focusing on purposefully creating, extending, or modifying a firm's resource base [21].

The dynamic capabilities framework consists of three key components. First, sensing opportunities and threats involves identifying and leveraging market opportunities through market analysis, competitor insights, and understanding customer behavior [22]. Second, seizing opportunities entails actively leveraging identified business opportunities by taking actions, allocating resources, and managing risks [23]. Third, reconfiguring resource bases involves adapting resources by adding, divesting, or recombining assets for optimal utilization [24].

The adoption of new technologies like IoT necessitates the exercise of dynamic capabilities [25]. Firms must develop processes to scan the environment, evaluate markets, and quickly reconfigure and transform their asset structure ahead of the competition [26]. External-oriented IoT applications, which involve engaging with dynamic customer needs and market shifts, inherently demand higher levels of dynamic capabilities compared to internal-oriented applications that primarily require ordinary capabilities for execution [27].

2.3 Internal-oriented versus External-oriented IoT Utilization

This study categorizes IoT utilization into two distinct orientations based on their primary strategic focus. Internal-oriented IoT utilization focuses on optimizing internal operations and processes, including applications such as product and service development, production process improvements, and organizational management [28]. These applications primarily aim at enhancing efficiency, reducing costs, and improving productivity within the firm's boundaries through enterprise asset management, predictive maintenance, industrial process automation, and energy management within smart factories [29].

External-oriented IoT utilization, conversely, focuses on enhancing interactions with customers and the broader market [30]. This category includes applications related

to sales strategy and marketing, such as leveraging IoT data for personalized customer experiences, targeted advertising, real-time customer feedback loops, and new product launches based on market insights [31]. The primary goal is to strengthen customer relationships, capture market share, and drive revenue growth by responding to or proactively shaping market demands [32].

While both orientations offer benefits, their strategic implications for firm performance may differ substantially [33]. Internal efficiencies often lead to cost savings, whereas external market engagement typically drives revenue growth and competitive differentiation [34]. The dynamic capabilities perspective suggests that external-oriented IoT utilization may have a more pronounced positive effect on overall firm performance due to its focus on revenue generation, market share expansion, and competitive differentiation rather than solely on cost reduction and efficiency improvements [35]. Therefore, the following hypothesis is proposed:

Hypothesis 1: Firms with an external-oriented IoT utilization show higher performance than those with an internal-oriented IoT utilization.

3 Methodology

This section outlines the research design, data collection procedures, variable measurement, and estimation strategy employed in this empirical investigation.

3.1 Sample and Data Collection

This study utilized panel data from 571 Korean companies for the period from 2017 to 2022. The data were sourced from the Corporate Activity Survey, conducted by the Ministry of SMEs and Startups of the Republic of Korea. Panel data analysis is particularly suitable for this study as it allows for the examination of changes over time within the same firms while controlling for unobserved heterogeneity that might bias cross-sectional analyses [36]. The total number of observations used in the regression analysis was 1,468 firm-year observations.

3.2 Measurement

3.2.1 Dependent Variable

Firm performance was primarily measured using a financial variable, return on equity (ROE), which serves as a key indicator of a company's profitability in relation to its equity [37]. Due to the unavailability of net income data in the dataset, a modified ROE was constructed using operating income instead of net income as the numerator. This modification is a common practice in empirical studies when direct net income figures are not accessible, providing a reasonable approximation of profitability relative to capital [38]. To account for the time lag often observed between technology adoption and its impact on financial performance, the dependent variable was measured for performance one year after the IoT technology utilization [39].

3.2.2 Independent Variable

The independent variable, orientation of IoT utilization, was categorized into five areas based on the survey instrument: product and service development, production processes, sales strategy, marketing, and organizational management. These categories were subsequently binary coded to represent the two strategic orientations under investigation. Internal-oriented utilization, coded as 0, encompasses product and service development, production processes, and organizational management. These activities primarily focus on internal efficiencies and operational improvements. External-oriented utilization, coded as 1, includes sales strategy and marketing. These activities are directly aimed at engaging with the market and customers.

3.2.3 Control Variables

To mitigate the influence of alternative factors on firm financial performance, several control variables were incorporated into the analytical model based on established empirical literature.

Total assets serves as a comprehensive measure of firm size, representing the scale and scope of a company's operations. Firm size has been extensively documented as a fundamental determinant of performance outcomes, as larger firms often benefit from economies of scale and enhanced resource access, while potentially facing bureaucratic inefficiencies [40].

Number of employees functions as an indicator of both firm size and human capital scale, capturing the organizational capacity for knowledge creation and technology absorption [41]. This variable reflects the firm's ability to effectively utilize new technologies like IoT and serves as a proxy for organizational complexity in technology integration.

Outsourcing cost represents a firm's strategic approach to resource allocation and operational efficiency, factors frequently associated with IoT technology adoption [42]. This variable helps control for heterogeneity in firms' make-or-buy decisions and their reliance on external partners, which could influence both IoT adoption propensity and performance outcomes.

All continuous control variables were standardized (mean-centered and scaled by standard deviation) to ensure that their differing units did not disproportionately influence the regression results and to facilitate comparison of relative effects across variables.

3.3 Estimation

This study employed a fixed effects estimation model to address potential endogeneity concerns and control for unobserved heterogeneity [43]. Fixed effects models are particularly appropriate for panel data analysis as they control for time-invariant unobserved factors that might correlate with both IoT utilization orientation and firm performance.

The basic regression model is specified as:

(1) $\text{Performance}_{it+1} = \beta_0 + \beta_1 \times \text{IoT orientation}_{it} + \beta_2 \times \text{Total assets}_{it} + \beta_3 \times \text{Employees}_{it} + \beta_4 \times \text{Outsourcing cost}_{it} + \gamma_i + \delta_t + \varepsilon_{it}$

Table 1. Descriptive statistics and correlation

	Mean	S.D.	Min	Max	ROE	IoT orientation	Total assets	Employees	Outsourcing cost
ROE	0.59	1.04	-4.12	5.28	1				
IoT orientation	0.19	0.39	0	1	0	1			
Total assets	0	1	-0.14	16.4	-0.1	0	1		
Employees	0	1	-0.23	25.48	-0.06	-0.04	0.56	1	
Outsourcing cost	0	1	-0.19	13.51	0.02	-0.06	0.16	0.35	1

Where $Performance_{it+1}$ represents the modified return on equity for firm i in year t+1, and IoT $orientation_{it}$ denotes the strategic orientation of IoT utilization. Total $assets_{it}$, $Employees_{it}$, and Outsourcing $cost_{it}$ represent control variables respectively. γ_i represents firm fixed effects, δ_t represents year fixed effects, and ε_{it} is the error term.

The model also included industry fixed effects using one-digit standard industrial classification codes to control for industry-specific trends and year fixed effects to account for macroeconomic shocks and temporal variations across the analysis period.

4 Results

This section presents the descriptive statistics, correlation analysis, and main regression results of the empirical investigation.

4.1 Descriptive Statistics and Correlation Analysis

Table 1 shows the correlation matrix that reveals relatively low correlations among the key variables, suggesting that multicollinearity is not a significant concern. Following the correlation analysis, a variance inflation factor (VIF) analysis was conducted to assess potential multicollinearity among the independent variables. The results demonstrated that all VIF indices for the variables were less than 2, with an average VIF index of 1.31. These values are substantially below the commonly accepted threshold of 10.0, indicating that multicollinearity does not pose a significant threat to the reliability of the regression estimates [44].

4.2 Main Results

The primary finding, as demonstrated in the Full model, reveals that IoT orientation (representing external-oriented utilization) has a positive and statistically significant impact on firm performance (coefficient = 0.0909, $p < 0.1$). This result indicates that, holding all other factors constant, firms utilizing IoT for external-oriented purposes experience approximately a 0.09-point higher modified ROE compared to those focusing on internal-oriented utilization. This finding provides empirical support for Hypothesis 1. Table 2 shows the results.

4.3 Robustness Check

Table 3 shows the results of robustness check. For robustness checks, return on assets (ROA) was employed as an alternative performance measure, calculated as operating revenue divided by total assets. ROA is widely recognized as a crucial financial ratio that measures a company's ability to generate profits from its assets and indicates the efficiency of asset utilization [45].

Table 2. Main results

Variables	Base	Full
IoT orientation		0.0909*
		(0.0531)
Total assets	-0.0935	-0.0799
	(0.158)	(0.158)
Employees	0.323***	0.323***
	(0.116)	(0.116)
Outsourcing cost	-0.0451	-0.0470
	(0.0351)	(0.0351)
Constant	0.696***	0.681***
	(0.0700)	(0.0705)
Industry dummies	Yes	Yes
Year dummies	Yes	Yes
Firm fixed effects	Yes	Yes
Observations	1,468	1,468
R-squared (within)	0.045	0.048
Number of firm	571	571

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

This measure provides insights into how efficiently a firm utilizes its total asset base to generate revenue, offering a complementary perspective to the equity-focused ROE measure [46]. ROA is particularly valuable as it captures both income statement performance and the assets required to run a business, making it less vulnerable to financial engineering compared to equity-based measures [47]. As with the previous estimation, performance was measured by ROA one year later to account for the time lag in technology adaptation.

The results yield important complementary insights. While the coefficient for IoT orientation remains positive (0.0267), it is not statistically significant at conventional levels. This differential response pattern between ROE and ROA provides valuable theoretical and practical implications for understanding the nature of external-oriented IoT's value creation mechanism.

Table 3. Results of robustness check

Variables	Base	Full
IoT orientation		0.0267
		(0.0418)
Total assets	-0.1219	-0.1178
	(0.1260)	(0.1262)
Employees	0.2500***	0.2504***
	(0.0929)	(0.0929)
Outsourcing cost	-0.0236	-0.0242
	(0.0280)	(0.0280)
Constant	-0.0445	-0.0492
	(0.0546)	(0.0551)
Industry dummies	Yes	Yes
Year dummies	Yes	Yes
Firm fixed effects	Yes	Yes
Observations	1,506	1,506
R-squared (within)	0.0400	0.0404
Number of firm	584	584

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5 Discussion

The empirical findings of this study provide valuable insights into the strategic utilization of IoT technology and its differential impact on corporate performance. The most salient result is the positive and statistically significant effect of external-oriented IoT utilization on firm performance, as measured by modified ROE. This outcome strongly supports the research hypothesis and aligns with established strategic management theories.

5.1 Differential Performance Measure Response

The differential response pattern between ROE (significant positive effect) and ROA (positive but non-significant effect) reveals important insights about the nature of external-oriented IoT's value creation mechanism. This pattern suggests that external-oriented IoT primarily enhances capital efficiency rather than total asset utilization [48]. Several theoretical explanations emerge from this finding.

5.1.1 Relational Asset Development

External-oriented IoT investments primarily build relational assets and customer capital that may not be fully captured in traditional asset-based measurements. These intangible assets contribute to revenue generation and capital efficiency but do not immediately translate to improved total asset returns due to the concurrent asset investments required for IoT implementation.

5.1.2 Investment Time Lag

The ROA results indicate that while external-oriented IoT generates immediate improvements in capital efficiency (ROE), the benefits relative to total assets require more time to materialize. This suggests that IoT investments initially increase the asset base faster than they generate proportional returns, creating a temporary dilution effect on asset-based performance measures.

5.1.3 Capital Structure Optimization

The significant ROE effect combined with non-significant ROA effect implies that external-oriented IoT may work through improved capital structure efficiency rather than purely operational asset optimization. This aligns with the notion that market-facing IoT applications leverage existing assets more effectively rather than requiring proportional asset expansion.

5.2 Strategic Value Creation Mechanism

The dynamic capabilities framework helps explain these findings. External-oriented IoT utilization inherently demands a firm's ability to sense market opportunities and threats through real-time customer feedback and market trend analysis, seize these opportunities by developing new customer-facing solutions or adapting sales strategies, and reconfigure resources to support these external engagements [49]. This continuous adaptation and strategic agility, enabled by IoT capabilities, proves crucial in rapidly changing business environments. Internal efficiency improvements, while important, may require less dynamic adaptation compared to navigating external market shifts and customer demands.

The observed low mean for external-oriented IoT utilization (0.19) among Korean firms represents a critical practical implication. This finding suggests that a substantial majority of companies may be underutilizing IoT's potential for market engagement, instead focusing predominantly on internal efficiency improvements. While internal optimization proves valuable for cost reduction and operational efficiency, the study's findings indicate that greater potential for overall performance improvement lies in strategically leveraging IoT to enhance customer interactions and market responsiveness [50].

5.3 Methodological Implications

The differential results across performance measures highlight the importance of measurement choice in digital technology research [51]. Traditional asset-based performance indicators may not fully capture the value creation mechanisms of modern digital technologies, particularly those focused on relational and intangible asset development [52]. This finding suggests that researchers should employ multiple performance measures to gain comprehensive insights into technology investment outcomes.

The significant positive impact of employee count on firm performance across both measures, even in a technology-intensive context, highlights the crucial complementary role of human capital. This finding suggests that IoT technology serves not as a substitute for human capabilities but rather as a powerful enabler that complements human skills and organizational processes [53]. Successful IoT implementation, particularly for external-oriented purposes, likely requires skilled personnel capable of interpreting IoT-generated data, translating insights into strategic actions, and managing complex customer relationships effectively.

6 Conclusions

This study provides compelling evidence that the strategic orientation of IoT utilization significantly affects firm performance. Using comprehensive panel data from 571 Korean firms between 2017 and 2022, we examined how internal-oriented versus external-oriented IoT strategies impact firm performance. The study employed both return on equity (ROE) and return on assets (ROA) as performance measures to provide a comprehensive assessment of IoT's value creation mechanisms.

The primary findings demonstrate that firms pursuing external-oriented IoT strategies—focusing on sales strategy and marketing applications—achieve significantly superior capital efficiency (ROE) compared to those concentrating on internal operational improvements such as product development, production processes, and organizational management. However, robustness checks using ROA revealed that while the effect remains positive, it is not statistically significant, suggesting that external-oriented IoT's value creation operates primarily through capital efficiency enhancement rather than immediate total asset optimization.

This study makes several distinct contributions to the literature and practice. First, from a theoretical perspective, we advance the understanding of IoT's strategic value by demonstrating that the orientation of technology deployment—rather than adoption per se—determines performance. This finding enriches the dynamic capabilities literature by providing empirical evidence that external-oriented digital technologies enhance firms' sensing, seizing, and reconfiguring capabilities more effectively than internal-oriented applications.

Second, we contribute methodologically by revealing the differential impact of IoT strategies across multiple performance measures. The finding that external-oriented IoT significantly improves capital efficiency (ROE) while showing non-significant effects on asset efficiency (ROA) provides new insights into the temporal and structural nature of digital technology's value creation mechanisms. This dual-measure approach offers a more nuanced understanding of how digital investments create value and suggests that researchers should employ multiple performance indicators to capture the full spectrum of technology benefits.

Third, from a practical standpoint, our findings provide actionable guidance for strategic technology investment decisions. The evidence that external-oriented IoT applications yield superior performance challenges the prevalent focus on internal operational improvements and suggests that firms should prioritize customer-facing and market-responsive IoT initiatives. This insight is particularly valuable given our finding that only 19% of Korean firms currently pursue external-oriented IoT strategies, indicating substantial untapped potential.

This study has several limitations that point to opportunities for future research. First, the analysis is limited to Korean firms, which may constrain the generalizability of findings to other cultural and institutional contexts. Future research could examine whether these differential performance patterns hold across different countries and economic systems with varying levels of technological infrastructure and market development.

Second, the binary classification of IoT orientation may oversimplify the complexity of real-world IoT deployment strategies. Future studies could develop more sophisticated measurement approaches that capture hybrid or multi-dimensional approaches to IoT utilization, potentially revealing more nuanced relationships between strategic orientation and different types of performance outcomes.

Third, the temporal aspect of IoT's impact deserves further investigation. Future research could examine longer-term effects to understand how the differential impact on ROE versus ROA evolves over time, potentially revealing convergence or divergence patterns in performance effects. Additionally, investigating the optimal timing for transitioning from internal-oriented to external-oriented IoT applications could provide valuable insights for strategic planning.

The findings of this study have important implications for both managers and policymakers. For managers, the results suggest that organizations should prioritize external-oriented IoT applications over purely internal efficiency improvements when seeking to maximize benefits. However, managers should also understand that the benefits manifest differently across various performance dimensions, with capital efficiency improvements preceding total asset return enhancements. This suggests the need for sophisticated performance measurement systems that can accurately assess the value created by customer-facing digital investments.

Organizations should develop the organizational capabilities necessary to support customer-centric technology deployment strategies, including skills in data analytics, customer relationship management, and market sensing. The finding that human capital remains crucial even in technology-intensive contexts underscores the importance of investing in employee development alongside technological infrastructure.

For policymakers, the study suggests that government initiatives supporting IoT adoption should emphasize not just technology deployment but strategic orientation toward market engagement. Programs that encourage firms to leverage IoT for customer interaction and market responsiveness may yield greater economic benefits than those focused solely on operational efficiency improvements. Additionally, the low prevalence of external-oriented IoT strategies among Korean firms (19%) suggests opportunities for targeted interventions to help firms realize the untapped potential of market-facing IoT applications.

This perspective shift from technology-centric to market-centric IoT deployment, combined with nuanced performance evaluation, represents a fundamental consideration for firms seeking to maximize their return on digital technology investments in an increasingly competitive and dynamic business environment.

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Biography

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