A Conceptual Framework to Examine the Time-Lag Effect of ICT Investment on Firm Performance

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ABSTRACT

This study proposes a conceptual research framework to explain how ICT investment influences firm performance by integrating two theoretical foundations: the Resource-Based View (RBV) and Dynamic Capabilities Theory (DCT). The RBV highlights ICT as a strategic resource and DCT emphasizes a firm's ability to adapt and reconfigure ICT resources in response to changing environments. Recognizing that ICT investments involve high initial costs and delayed payoffs, the framework incorporates time-lag effects, suggesting that the impact of ICT investment may only materialize after several years. The study develops hypotheses to capture both immediate and delayed effects of ICT investment across time periods from year t to t-7. By aligning theoretical perspectives with the time-sensitive nature of ICT returns, the framework offers a comprehensive view of how ICT investment contributes to long-term firm performance. The findings are expected to provide practical guidance for decision-makers and future researchers in evaluating and managing ICT resources for sustainable competitive advantage.

Keywords: ICT investment, Firm Performance, Time-Lag Effect, Resource-Based View, Dynamic Capabilities Theory

INTRODUCTION

Information and Communication Technology (ICT) has become a pivotal driver of firm competitiveness and innovation in the digital era (Noor & Apadore, 2014). Recent studies underscore that ICT investments enhance operational efficiency, reduce costs, and foster innovation capabilities, thereby strengthening a firm's market position (Yuwono et al., 2024; Noor, 2022). For instance, digital technology innovations have been shown to improve enterprise resilience by minimizing information asymmetry and increasing profitability, hence contributing to sustained competitive advantages (Zhang et al., 2024). Moreover, the integration of digital management practices facilitates the development of innovation capabilities, which in

turn bolster corporate competitiveness (Zhang & Li, 2025). In the context of small and medium-sized enterprises (SMEs), ICT adoption enables access to broader markets and enhances adaptability to market fluctuations, thus leveling the playing field with larger competitors (Yuwono et al., 2024). Empirical evidence also suggests that ICT adoption, coupled with the development of distinctive competencies, significantly improves marketing performance and drives sustainable growth in micro, small, and medium enterprises (MSMEs) (Yuwono et al., 2025). Collectively, these findings highlight the integral role of ICT in driving firm competitiveness and innovation across various organizational contexts.

Despite the growing recognition of the role of ICT in enhancing firm competitiveness and innovation, the outcomes of ICT investments across industries remain inconsistent. While some studies reported positive correlations between ICT spending and firm performance, others found limited or no significant effects. For instance, research on Indian manufacturing MSMEs indicates that ICT investment positively impacts profitability, with optimal investment levels varying by firm size (Joshi et al., 2024). Yang et al. (2025) found that the positive impact of IT system implementation on firm performance diminishes over time, with some indicators shifting from significant to insignificant. Research on Malaysian firms indicated a positive but weak significant impact of ICT investments on firm performance (Alghorbany et al., 2022). Similarly, a study by Alam et al. (2022) revealed mixed evidence regarding the relationship between ICTs and firm performance, therefore suggesting that the effects may vary based on factors such as firm size, industry, and the specific ICT strategies employed. Conversely, a study on Tanzanian manufacturing SMEs found that ICT capabilities did not directly influence financial performance but had significant indirect effects through improved supply chain integration (Rutainurwa et al., 2024).

Empirical studies have highlighted that the benefits of ICT investments often materialize after a time lag, rather than immediately. For instance, a study examining Malaysian technology-based listed companies found that ICT investments improved financial performance only after the first year, attributing the delay to organizational learning processes and market structural adjustments (Noor, 2017; Noor et al., 2017). Moreover, previous literatures highlighted that the measurement of ICT investments may stem from methodological inadequacies such as the use of inappropriate analytical approaches and the failure to account for time-lag effects between ICT expenditure and realized returns which were the factors that collectively contribute to a significant underestimation of ICT true potential (Stiroh, 2002; Weill & Olson, 1989). The inconsistency in findings from prior studies can be attributed to several key factors including the use of heterogeneous measurement approaches for ICT investment, differing frameworks for classifying industries and national development levels (i.e., developed versus developing economies) and a frequent disregard for the temporal lag between ICT investments and their performance outcomes (Noor et al., 2017; Noor, 2017). These limitations collectively underscore the intricate nature of evaluating ICT investment effectiveness but lack in highlighting the necessity for longitudinal research designs that capture delayed impacts of ICT investment on firm performance. Hence, given the complexities and inconsistencies in prior research, particularly the varied measurement methods and lack of attention to time-lag effects, this study aims to propose a conceptual research framework that explains how ICT investment affects firm performance. The framework is designed to address the delayed impact of ICT investments that may influence outcomes. By addressing this research objective, the study seeks to provide a clearer and more structured understanding of the mechanisms that link ICT investment to performance outcomes.

EMPIRICAL STUDIES

Theoretical Foundations

The theoretical foundations underpinning the relationship between ICT investment and firm performance are multifaceted, which are drawn from several established frameworks. These include the Resource-Based View (RBV), the Technology Organization Environment (TOE) framework, and Dynamic Capabilities Theory (DCT). Each offers a unique len through which it examines how ICT investment can influence organizational outcomes. The RBV posits that a firm's sustainable competitive advantage stems from its ability to acquire and manage valuable, rare, inimitable, and non-substitutable resources (Supramono et al.,

2025). In the context of ICT, this perspective suggests that technology assets, when effectively integrated and utilized, can serve as strategic resources that enhance firm performance. Recent studies have reinforced this view, highlighting that ICT capabilities contribute significantly to operational efficiency and innovation capacity. For instance, a meta-analysis by Liang et al. (2010) found that firms leveraging ICT as a strategic resource experienced improved supply chain performance, particularly when these technologies were aligned with organizational processes. This alignment ensures that ICT investments are not just standalone assets but are embedded within the firm's value-creating activities, thereby amplifying their impacts on performance.

Moreover, the RBV emphasizes that the mere possession of ICT is not sufficient; it is the firm's capability to deploy these resources in a coordinated and strategic manner that creates value. Subsequently, firms that embed ICT into their core business strategies and routines are better positioned to respond to market changes and innovate continuously. Hsio (2024) stresses that integrating digital technologies into organizational capabilities is crucial for enhancing firm performance. The study suggests that digital transformation, facilitated by ICT, enables firms to reconfigure their resources and capabilities, which in turn lead to improved adaptability and competitiveness. Moreover, a study by Pashutan et al. (2022) confirms the positive impact of IT resources and strategic alignment on organizational performance, reinforcing the RBV's assertion that the strategic management of ICT resources contributes significantly to a firm's competitive advantage. These finding collectively support the RBV argument that ICT becomes a true strategic asset when it is developed, protected, and exploited in ways that competitors cannot easily replicate. By embedding ICT into core business strategies and routines, firms can enhance their operational efficiency, innovation capacity, and overall performance.

Dynamic Capabilities Theory (DCT) extends the RBV by focusing on a firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments (Supramono et al., 2025). This theory is particularly pertinent when considering the time-lag effects of ICT investments, as it emphasizes the processes through which firms adapt to technological changes over time. Recent empirical research supports the relevance of dynamic capabilities in the ICT context. For example, Nguyen et al. (2024) investigated ICT-SMEs and found that dynamic capabilities significantly mediated the relationship between entrepreneurial orientation and firm performance, therefore highlighting the importance of adaptability in leveraging ICT investments effectively. Similarly, Khalil and Belitski (2020) demonstrated that dynamic capabilities within IT governance frameworks are directly associated with enhanced firm performance, emphasizing the role of strategic management in harnessing ICT resources.

A study by Karadag et al. (2024) analyzed the condition under which dynamic digital capabilities in SMEs could lead to higher performance. The research discovered that configuration of IT utilization, human capital, digital maturity, and digitalization strategy significantly influence organizational performance, highlighting the multifaceted nature of technology adoption. In addition, a study by Al-Moaid and Almarhdi (2024) that examined the significance of dynamic capabilities in digital transformation projects within the telecommunication sector revealed a positive relationship between dynamic capabilities and the successful implementation of digital transformation initiatives. Thus, the role of strategic management in harnessing ICT resources is vital. Furthermore, research by Saeedikiya et al. (2024) indicated the importance of translating firm's intangible assets into responsive capabilities. The study connected the conversion on strategy regarding the RBV to technological advancements, underscoring the need for firms to adapt and utilize internal and external competencies effectively.

The Effects of ICT Investment on Firm Performance

Numerous studies have explored how ICT investment affects financial performance in the banking sector, with largely positive outcomes. Hung et al. (2012) reported improved performance in Taiwanese banks from ATM investments, while Romdhane (2013) found that ICT spending boosted cost efficiency in Tunisian banks. Furthermore, Arabyat (2014) and Makinde (2014) also noted positive links between ICT investments and financial metrics like ROA and ROE in Jordanian and Nigerian banks. In contrast, Francalanci and Galal (1998) established that IT spending negatively impacted productivity in 52 U.S. life insurance companies.

Beccalli (2007) found that while ICT services improved performance in European banks, hardware and software investments had negative effects. Similarly, Safari and Zhen Yu (2014) observed gains in technical efficiency in Iranian banks, but discovered that hardware contributions were minimal. Conversely, Ekata (2011) and Ugwuanyi and Ugwuanyi (2013) found no significant link between ICT spending and financial performance in Nigerian banks, thus reinforcing the ongoing 'ICT paradox' and highlighting uncertainties in firm-level outcomes.

Prior studies have shown both positive and mixed effects of ICT investment on firm performance in the manufacturing sector. Gaith et al. (2008) found a weak but positive link between ICT investments and performance in Malaysian construction companies. Weill (1992) reported that while transactional IT improved outcomes, strategic IT led to negative results, illustrating the productivity paradox. Similarly, Kim (2004) noted that there were gains in productivity and market value in Korean IT companies, but there was little effect on profitability. These mixed results may stem from measurement issues and failure to account for time lags (Weill & Olson, 1989; Stiroh, 2002). Research on ICT investment in the healthcare sector revealed mixed findings. Devaraj and Kohli (2000) observed that IT capital and labor improved financial performance, although IT labor was linked to higher mortality rates. Similarly, Thouin et al. (2008) found that ICT budgets and outsourcing were positively associated with profitability, while they had no effect on IT personnel. Spyros and Euripidis (2014) identified that ICT infrastructure and hospital specific applications are critical to driving product and process innovation, with ICT budgets supporting process innovation, but investments in IT personnel and websites showed limited impact.

In studies across mixed industries, Brynjolfsson and Hitt (1993, 1996) found that ICT investment, particularly in computer capital, significantly boosted firm output, challenging the productivity paradox. Later studies supported these findings, such as the findings by Shin (2006) and Chari et al. (2008), who linked ICT investment to better firm performance, particularly in diversified firms. Conversely, Mahmood and Mann (1993) reported mixed results, attributing them to a potential time lag in ICT benefits. Zehir et al. (2010) observed that varying ICT effects, with IT perception and decision-making, had no significant effect on the performance. Liang et al. (2010) emphasized that the presence of strong organizational capabilities is crucial in translating ICT investments into performance improvements.

The Issue of Time Lag

Brynjolfsson (1993) identified four principal contributors to the IT productivity paradox: measurement error, time lags, redistribution effects, and managerial inefficiencies. Among these, the time-lag effect remains particularly challenging as the benefits of IT investments often materialize only after a significant delay (Brynjolfsson, 1993; Brynjolfsson & Hitt, 1993; Yaylacicegi & Menon, 2004). Empirical studies indicate that firms typically require two to three years to fully realize returns on IT investments (Brynjolfsson, 1993; Brynjolfsson & Hitt, 1993), while Devaraj and Kohli (2002) noted that the timeline can vary from several months to years, depending on the complexity of the technology implemented. Kohli and Devaraj (2003) further argued that this lag effect complicates performance assessment as it is often masked using contemporaneous data (Brynjolfsson, 1993).

The financial theory of capital investments posits that the realization of IT-related benefits may be postponed due to substantial initial adjustment costs (Jorgenson, 2001) while accurately estimating the economic lifespan of ICT assets is critical for properly accounting for their intangible value (Lev, 2003). Empirical findings revealed a considerable variation in the time lag before IT investments translate into measurable performance improvements. For instance, Brynjolfsson et al. (1994) observed a reduction in firm size within one to two years following IT implementation, whereas Francalanci and Galal (1998) reported a doubling of IT impact after a two-year interval. In addition, Devaraj and Kohli (2000) identified a shorter lag of two to three months while Anderson et al. (2003) noted that benefits materialize over a one-to-four-year horizon. Similarly, Brynjolfsson and Hitt (2003) explored lag intervals ranging from one to seven years and Yaylacicegi and Menon (2004) concluded that firms typically experience returns from IT capital expenditures after approximately five years.

Subsequent research has reinforced the critical role of time-lagged effects in evaluating IT investment outcomes. Byrd and Marshall (1997) proposed that firms typically experience a performance lag of two to four years following IT adoption while Beccalli (2007) advocated for a one-year lag model in financial performance assessment. Zhang et al. (2012) observed that Enterprise Resource Planning (ERP) systems exerted minimal influence during the initial three years post-implementation but produced significant gains in firm performance after the fourth year. Similarly, Hung et al. (2012) provided empirical evidence that IT investments positively influenced financial performance under lag-1 and lag-2 models. Therefore, these insights underscore the necessity of incorporating temporal delays when evaluating the strategic value of IT investments.

PROPOSED RESEARCH FRAMEWORK

Conceptual Research Framework

The research framework was formulated in alignment with insights derived from the comprehensive review of existing literature. Figure 1 illustrates the conceptual research framework underpinning this study, highlighting the ICT expenditure variables subject to examination. The framework articulates the linkages between ICT investment and firm performance, positioning ICT spending as the independent variable and firm performance as the dependent variable, thereby encapsulating the influence of technological investment on organizational effectiveness.

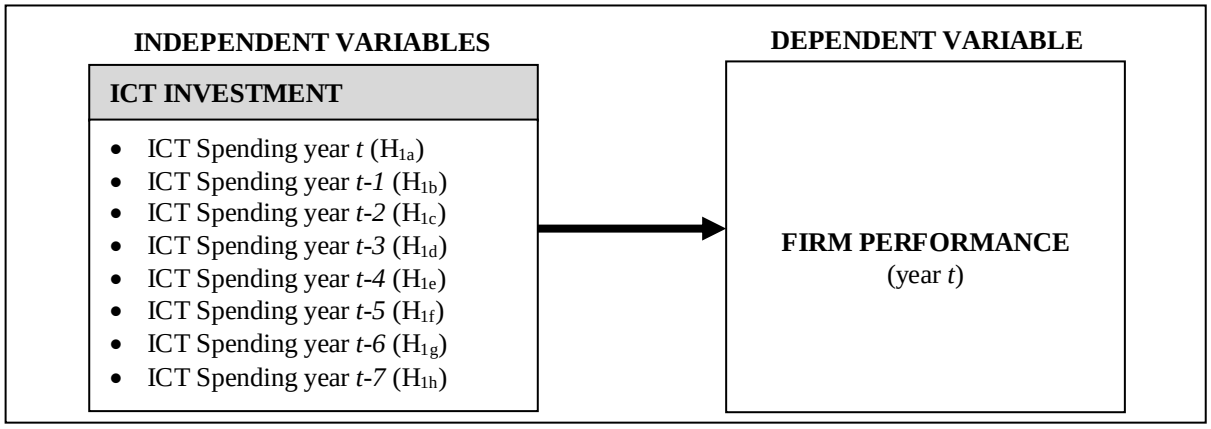

Figure 1: Research Framework

Hypotheses Development

Technology and ICT resources are indispensable strategic assets for firms operating in technology-driven industries which play a pivotal role in achieving sustained high performance (Straub et al., 2006). Investments in both tangible ICT components such as hardware, critical data infrastructure, and networking systems and intangible assets (i.e., software licenses, research and development (R&D), patents and proprietary applications) should be regarded not merely as operational expenditures but as long-term investments. When guided by a well-formulated strategy, these assets can substantially enhance organizational performance. Furthermore, the RDT posits that a firm's survival is contingent upon its capacity to acquire and control essential resources including human capital, information, raw materials, and technological capabilities. Based on these theoretical underpinnings, this study proposes that ICT investment exerts a significant influence on firm performance. Thus, the hypothesis is developed:

H_1: Investment in ICT spending has a significant effect on firm performance.

Previous research has explored the relationship between ICT investment and firm performance from multiple angles that include ICT budgeting, expenditures on hardware and software, training, ICT-related infrastructure, service provision, outsourcing, and the establishment of ICT divisions. The present study

formulates its hypothesis by focusing on ICT expenditure, specifically outlays on hardware, software, and related digital tools as a proxy for ICT investment. Nevertheless, findings across the literature remain inconclusive which are largely due to divergent measurement approaches, variation in industry and national development contexts (e.g., developed versus developing economies) and the frequent omission of time-lag considerations when evaluating ICT's impact on performance. Furthermore, it has been contended that ICT investments may initially suppress profitability, particularly in the year of acquisition, due to the high upfront costs associated with ICT deployment (Ugwuanyi & Ugwuanyi, 2013; Anderson et al., 2003). Even when a positive association is observed in the same period, the magnitude of the effect tends to be modest (Anderson et al., 2003).

This lag in return is largely attributed to the inherent delay between the point of investment and the realization of performance gains, an effect well documented in the literature (Noor, 2017; Yaylacicegi & Menon, 2004, Brynjolfsson & Hitt, 2003; Dedrick et al., 2003; Kohli & Devaraj, 2003; Devaraj & Kohli, 2000; Brynjolfsson, 1993). In alignment with these findings, this study posits that ICT expenditures made in year t are unlikely to yield immediate performance improvements within the same year, Accordingly, the following hypothesis is proposed:

H_{1a}: Investment in ICT spending in year *t* has a negative effect on firm performance in year *t*.

A growing body of research has incorporated the time-lag effect when examining the influence of ICT on firm performance, with many studies reporting positive outcomes. For instance, some findings suggest that optimal returns on ICT investments are realized only after a delay of four (Zhang et., 2012) or even five years (Yaylacicegi & Menon, 2004) following implementation. While certain models incorporating a one-year lag failed to establish a significant relationship (Beccalli, 2007), other investigations have demonstrated positive effects with lag periods ranging from one (Noor, 2017) to two years (Hung et al., 2012; Brynjolfsson, 1989), a two-year lag (Francalanci & Galal, 1998) to four years (Byrd and Marshall, 1997), up to three of four years (Brynjolfsson & Hitt, 2003; 1993; Anderson et al., 2003).

Brynjolfsson and Hitt (2003) explored ICT investment time horizons as long as seven years, noting that the compounding effect of earlier investments can have a delayed but significant impact on firm productivity and value creation. Investments made in year *t-7* may represent the earliest phases of digital transformation, foundational system modernization or the implementation of core enterprise software. Over a seven-year span, these systems do not only stabilize but also evolve to support data-driven decision making and operational excellence. The cumulative learning, process optimization, and human capital development surrounding such ICT assets are essential contributors to long-term performance gains. By taking into consideration all relevant time-lag intervals, starting from year *t-1* to year *t-7*, this study aims to explore the extended temporal impact of ICT investment on firm performance. This approach acknowledges the possibility that the performance benefits of ICT spending may materialize over a prolonged period. Accordingly, the following hypotheses are proposed to examine the cumulative lag effects:

H_{1b}: Investment in ICT spending in year *t-1* has a positive effect on firm performance in year *t*.

H_{1c}: Investment in ICT spending in year *t-2* has a positive effect on firm performance in year *t*.

H_{1d}: Investment in ICT spending in year *t-3* has a positive effect on firm performance in year *t*.

H_{1e}: Investment in ICT spending in year *t-4* has a positive effect on firm performance in year *t*.

H_{1f}: Investment in ICT spending in year *t-5* has a positive effect on firm performance in year *t*.

H_{1g}: Investment in ICT spending in year *t-6* has a positive effect on firm performance in year *t*.

H_{1h}: Investment in ICT spending in year *t-7* has a positive effect on firm performance in year *t*.

CONCLUSION

This study concludes that ICT investment plays a significant role in enhancing firm performance, though its impact may not be immediately realized. The empirical evidence supports the notion that the return on ICT investment often follows a time-lagged pattern, with performance improvements becoming more evident in subsequent years after the initial investment is made. These findings highlight the importance of understanding ICT spending as a long-term strategic initiative rather than a short-term cost. The study confirms that while ICT investment in the current year (year t) may initially produce a negative or negligible impact, positive outcomes can be observed in the years that follow, particularly from year *t-1* to *t-3*, and potentially up to *t-7*. This reinforces the relevance of incorporating the time-lag effect when assessing the value of ICT investments.

In light of these findings, it is recommended that firm leaders, policymakers, and stakeholders adopt a long-term perspective when evaluating the effectiveness of ICT investments. Business executives should integrate ICT initiatives into their strategic planning cycles, with performance assessment models that accommodate delayed returns. Additionally, boards of directors must maintain oversight to ensure that management decisions align with shareholders' interests over an extended period of time. At the policy level, government incentives such as digital transformation grants or phased tax benefits could encourage firms to invest in ICT with the assurance that long-term gains are supported. Future research should expand this study by incorporating firm-specific characteristics (e.g., digital maturity, innovation capability) and sectoral comparisons, using longitudinal data to validate the time-lag effects across different environments. Thus, such efforts would deepen the understanding of ICT strategic values and guide more effective resource allocations in the digital age.

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The study's conception and design were contributed by all authors. Marjan Mohd Noor, Jaya Kumar Shanmugam, Shafawaty Mohamad Shabri, Raja Ade Fitrasari Mochtar and Wan Kamarul Hazim Wan Ya performed material preparation, data collection, analysis, and wrote the first draft of the manuscript. The final manuscript was read and approved by all authors.

CONFLICT OF INTEREST DECLARATION

We confirm that the article is the original work of the Authors and Co-Authors and has not been previously published or considered for publication elsewhere. Additionally, this research/manuscript has not been submitted or published in any form, in whole or in part, elsewhere. We attest that all Authors have made substantial contributions to the work, and the data and its interpretation are valid and legitimate for submission to the journal.

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