The Effects of ICT Investment on Malaysian Technology-Based Firm Performance

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ABSTRACT

This study examines the effects of ICT investment on the performance of Malaysian technology-based firms. While ICT is widely recognized as a driver of competitiveness and productivity, its benefits are often debated due to the persistence of the ICT productivity paradox. Using data from firms listed in the Malaysian technology sector, this study analyzes the impact of ICT spending on firm performance indicators, including return on assets (ROA), return on equity (ROE), and Tobin's Q (TQ). Both Pooled OLS and Panel Fixed Effects models were employed to test the hypotheses. The results reveal that current-year ICT spending negatively affects accounting-based measures of performance (ROA and ROE), but shows a positive and significant relationship with market-based performance (TQ) in lagged periods. These findings suggest that ICT investments may require time to yield measurable benefits, particularly through intangible assets such as software, patents, and innovation-related resources that enhance long-term market value. The study further applies Resource Dependence Theory to explain how ICT serves as a strategic resource for firm survival and growth. By highlighting both the risks and opportunities of ICT investments, this research provides new insights for managers, policymakers, and investors on how ICT spending can be better aligned with long-term firm performance in Malaysia's evolving technology landscape.

Keywords: ICT investment, Firm Performance, Resource Dependence Theory, Return on Asset, Return on Equity, Tobin's Q

INTRODUCTION

The rapid advancement of Information and Communication Technology (ICT) in Malaysia has reshaped the business landscape, creating both opportunities and challenges for firms. Driven by innovations in cloud computing, mobile applications, seamless connectivity, and sophisticated hardware and software, ICT has become a necessity rather than a luxury for firms seeking competitiveness and survival. Recognizing this, the Malaysian government has introduced various incentives to attract ICT investment, positioning the technology sector as a key driver of economic growth. Many organizations invest in ICT not only to improve efficiency and productivity but also to enhance product quality, strengthen communication, and meet growing customer demands in an increasingly competitive and fast-changing environment. This is consistent with evidence from global economies, where ICT investments have been shown to enhance productivity and competitiveness. However, the literature also highlights the ICT productivity paradox, where heavy ICT spending does not always translate into immediate financial gains. Instead, ICT benefits often materialize after a time lag, suggesting that firms need effective resource management and long-term strategies to fully realize value from ICT investments.

In this context, Resource Dependency Theory (RDT) provides a useful lens to understand ICT's role in firm performance. According to RDT, organizations depend on critical resources from their environment to survive

and compete, and ICT can be viewed as one such strategic resource. By investing in ICT, particularly intangible assets such as software, patents, and enterprise systems, firms reduce uncertainty, enhance their control over external dependencies, and strengthen their ability to adapt to industry changes. For Malaysian technology firms, ICT investment not only signals innovation capacity to the market but also provides the resources needed to differentiate products improve operational efficiency and sustain long-term growth. Therefore, ICT should not be seen solely as a cost but as a vital resource that firms must strategically acquire and deploy to secure competitiveness in a dynamic and resource-dependent environment.

Problem Statement

Investments in ICT are often considered vital for improving productivity and enhancing business performance, with many studies showing positive relationships between ICT spending and firm outcomes. ICT is recognized as a key enabler of competitiveness, efficiency and innovation. However, despite its potential, the expected benefits of ICT are not always realized. The persistent issue known as the "ICT paradox" highlights that, while ICT projects can deliver significant advantages, many initiatives have failed to produce the desired results. In Malaysia, several high-profile ICT projects have led to substantial financial losses, and similar failures have been reported globally in advanced ICT-driven economies such as the U.S, U.K., Europe, and Australia, where high rates of ICT project failure have been consistently documented.

Although global literature has examined the link between ICT investment and firm performance extensively, there remains limited evidence in the Malaysian context, particularly within the technology-based sector. Only a few local studies have addressed this issue, with most focusing on other industries such as construction. Given that the technology sector is closely tied to ICT usage and development yet has also been identified as high-risk for ICT project failures, it provides a relevant and timely context to investigate. Thus, this study aims to fill the gap by examining the impact of ICT investment on firm performance within Malaysian technology-based companies, offering insights into both the opportunities and challenges of leveraging ICT as a strategic resource.

Research Questions

This study seeks to address the following research questions:

1. To what extent are ICT investments undertaken in the Malaysian technology-based sector?
2. Do ICT investments influence firm performance in the Malaysian technology-based sector?

Research Objectives

The objectives of this study are as follows:

1. To examine the extent of ICT investment in the Malaysian technology-based sector.
2. To examine the effect of ICT investment on firm performance in the Malaysian technology-based sector.

Research Motivation and Contribution

The advancement of ICT has been widely recognized as a driver of improved business processes and firm performance, enabling efficiency, productivity, and competitiveness in today's knowledge-based economy. While ICT investments are made with the aim of enhancing profitability and efficiency, failures to achieve these goals can lead to wasted resources and poor outcomes. Although many studies have explored the impact of ICT investment on firm performance across sectors such as finance, manufacturing, and mixed industries, limited research has been conducted within the Malaysian context. Only one study has looked at the construction sector, while others in the U.S. have focused on ICT and telecommunications. This gap highlights the need to examine Malaysia's technology-based sector, which is closely linked to ICT activities and has faced notable ICT project failures. Understanding whether ICT investment truly strengthens firm performance in this sector is crucial for addressing these challenges.

Furthermore, since ICT usage varies significantly across industries, studying a sector inherently tied to ICT provides sharper insights into its true impact. The Malaysian technology-based sector is particularly relevant as it represents one of the country's ICT core industries and heavily relies on ICT equipment and innovations. By narrowing the scope to this sector, this study contributes by offering a more focused and in-depth analysis of the relationship between ICT investment and firm performance in Malaysia. Grounded in Resource Dependence Theory, the research emphasizes how acquiring ICT resources is not only a strategy for improved performance but also a mechanism for firm survival and growth in a competitive and dynamic business environment.

LITERATURE REVIEW

The Concept of Firm Performance and ICT Investment

The concept of firm performance has been extensively explored, yet a universally accepted definition remains elusive. Early scholars like Venkatraman and Ramanujam (1986) associated firm performance with organizational effectiveness, encompassing both financial and operational indicators such as new product introductions, product quality, and marketing effectiveness. Stannack (1996) expanded this view by proposing a multi-dimensional measurement framework, including transactional, input, and output efficiencies. Bourguignon (1998) further refined the concept by distinguishing between performance results (the comparison of outcomes to set objectives), performance actions (the commitment to achieving these outcomes), and performance success. These foundational perspectives underscore the complexity and multifaceted nature of firm performance, highlighting the interplay between various operational and strategic dimensions.

Over time, the concept of firm performance has evolved into a more comprehensive framework, integrating strategic initiatives aimed at fostering growth (Neely, 2007). In contemporary research, firm performance is often regarded as an overarching organizational outcome or a dependent variable, measurable through various dimensions. These dimensions encompass financial and market-based indicators, as well as broader social performance metrics that reflect a company's impact on stakeholders and society (Orlitzky et al., 2003). Traditional financial indicators, such as profit margins and return on assets (ROA), have been widely used to assess performance, but their limitations in capturing long-term sustainability and operational effectiveness have been highlighted. Recent studies emphasize the need for a multidimensional approach, incorporating both financial and non-financial measures. Non-financial indicators, including innovation, employee engagement, and corporate social responsibility, provide a more comprehensive assessment of a firm's long-term success (Gupta & Sharma, 2023). Furthermore, the integration of sustainability reporting into firm performance evaluation has gained traction. These developments underscore the transition from purely financial assessments to a more balanced framework that considers operational and strategic dimensions.

A vast body of scholarly literature has extensively explored the multifaceted determinants influencing firm performance, underscoring its prominence as a critical inquiry within strategic management studies. This subject has garnered substantial attention from researchers due to its far-reaching implications for business sustainability and competitiveness. The rigorous analysis of firm performance determinants is particularly crucial for all stakeholders, especially investors, as well-performing firm inherently enhances shareholder value and ensures favorable returns on investment. Furthermore, chronological assessments of existing literature have uncovered widely divergent findings regarding the impact of key factors on firm performance. These include firm-specific attributes such as age and size (Hatem, 2014; Almajali et al., 2012), capital intensity (Shiamwama et al., 2014; Mirza & Javed, 2013) and technological advancements (Shiamwama et al., 2014) to further shape firm performance, demonstrating the complex and often contradictory nature of its determinants.

Technological advancements, particularly in Information and Communication Technology (ICT), play a crucial role in driving firm performance by improving operational efficiency, customer engagement, and market competitiveness. Studies have shown that digital transformation enhances financial performance by streamlining processes, reducing operational costs, and facilitating data-driven decision making (Mikalef et al.,

2021). The integration of artificial intelligence (AI), big data analytics, and cloud computing has further strengthened firm's ability to respond to market dynamics and improve customer experience (Liu et al., 2023).

ICT encompasses a range of technologies, including computers, software, and internet connectivity, that facilitate information processing and communication (Statistic Canada, 2008). Investment, on the other hand, plays a crucial role in wealth creation and economic growth, particularly when directed toward physical assets like buildings, machinery, and technological tools. Over the year, ICT has emerged as one of the most dynamic investment components, covering both hardware and software that contribute to long-term business efficiency. Strategic ICT investments enable firms to enhance productivity, streamline operations, and ultimately financial performance (Noor & Apadore, 2014). As businesses increasingly rely on digital transformation, ICT investments are no longer optional but essential for sustained growth and superior firm performance.

Trends of ICT Investment in Developed and Developing Countries

In developed countries, ICT investment has played a crucial role in driving economic growth, productivity, and innovation. The United States, in particular, has experienced significant technological advancements due to large-scale ICT investments, especially in software, hardware, and telecommunications (Oliner et al., 2007; Jorgenson et al., 2005). Failing costs of ICT components, such as semiconductors, have led to capital deepening allowing firms to enhance efficiency and labour productivity (O'Sullivan & Sheffrin, 2003). The United Kingdom, while benefiting from ICT investments, has faced challenges due to lower ICT production capabilities (Oultan, 2002). Overall, developed nations have consistently prioritized ICT investments as a means of sustaining economic competitiveness and technological leadership.

In contrast, ICT investment trends in developing countries have been more uneven. While some nations, such as Malaysia, Thailand, and South Korea, have successfully leveraged ICT production for economic growth, others continue to struggle with infrastructure limitations and financial constraints. Many developing economies recognize ICT as a catalyst for modernization, yet their investments remain lower than those of developed nations. The increasing affordability of ICT equipment has helped bridge this gap, enabling developing countries to adopt digital technologies in key sectors such as education, healthcare and financial services.

Malaysia, in particular, has emerged as a leader in ICT investment among developing nations. The Malaysian Department of Statistics indicated that Malaysia's population stood at approximately 30.27 million, with projections estimating an expansion to 38.5 million by the year 2040. With a growing population and rising digital demand, ICT has become the fastest-growing contributor to the country's Gross Domestic Products (GDP) (Puspitaningdyah, 2012). The Malaysian government has actively promoted ICT development through strategic initiatives aimed at transforming the nation into a knowledge-based economy. These efforts include investments in digital infrastructure, e-commerce, and smart technology to enhance business efficiency and global competitiveness. As ICT to evolve, both developed and developing nations must adapt their investment strategies to harness its full potential for economic growth.

Factors that Influence ICT Investment

Firms invest in ICT to boost efficiency, productivity, and competitiveness (Miller & Atkinson, 2014) by streamlining operations, reducing costs, and driving profitability. Internal factors such as strong management commitment, a skilled workforce (Oyetade et al., 2024), robust ICT infrastructure (Irefin et al., 2012), and technological capabilities play a pivotal role in influencing ICT adoption. Externally, market competition (Iyanda & Ojo, 2008), regulatory policies, economic conditions, and government support (Pan & Jang, 2008) encourage firms to embrace digital transformation. Competitive pressures push businesses to adopt advanced technologies to maintain their market position, while incentives, financial aid, and supportive ICT policies accelerate adoption. As technology rapidly evolves, continuous ICT upgrades become essential for firms to remain relevant, innovative, and competitive in a dynamic business environment.

In Malaysia, the government has actively promoted ICT investment through strategic policies, tax incentives, and infrastructure development. According to Saifubahrim Salleh, CEO of PIKOM, and Ramachandran Ramasamy, Head of Policy at PIKOM, ICT investment plays a crucial role in driving economic growth and enhancing firm performance (PIKOM, 2013). The 2014 Budget provided significant opportunities for companies investing in ICT, including eligibility for the Accelerated Capital Allowance (ACA), which offers a 20% initial allowance and a 40% annual allowance until the year of accounting (YA) 2016. Initiatives such as the Accelerated Capital Allowance (ACA), the Multimedia Super Corridor (MSC), and nationwide broadband programs under the 10th and 11th Malaysian Plans have positioned ICT as a key enabler of economic growth. The push toward Green ICT has further encouraged eco-friendly technology adoption to improve energy efficiency and sustainability. By expanding communication networks, enhancing ICT education, and fostering digital commerce, Malaysia continues to strengthen its digital ecosystem, enabling businesses to leverage ICT for long-term growth, innovation and global competitiveness.

The Effect of ICT Investment on Firm Performance

In recent decades, the rapid advancement of ICT has prompted nations, industries, and enterprises to make substantial investments in digital infrastructure. Despite the extensive proliferation of ICT investments, scholars continue to debate the extent to which these expenditures generate tangible value for business entities. Consequently, ICT has been widely advocated for its transformative potential in reshaping organizational structures, enhancing operational capabilities, and serving as a critical enabler for optimizing business planning processes.

Several studies have examined the impact of ICT investment on financial performance across different banking sectors. Hung et al. (2012) found that Taiwanese domestic banks experienced improved financial performance despite their investments in ATM technology. Similarly, Romdhane (2013) highlighted that ICT investments in software, hardware, and services significantly enhanced cost efficiency in Tunisian banks. Arabyat (2014) and Makinde (2014) reported a positive correlation between ICT investments and financial performance in Jordanian and Nigerian banks, respectively, using ROA and ROE as key indicators. However, contradictory findings were observed in Francalanci and Galal's (1998) study on 52 U.S. life insurance companies, where IT expenses and workforce composition had a negative impact on productivity.

Past studies have also explored the relationship between ICT investment and financial performance with mixed results. Beccalli (2007) found that ICT services, such as consulting and training positively impacted European banks, while hardware and software investments had a negative effect. Similarly, Safari and Zhen Yu (2014) concluded that ICT investments improved technical efficiency in Iranian banks, though hardware investments were insignificant. Conversely, Ekata (2011) found no correlation between IT spending and financial performance in Nigerian banks, highlighting the persistent 'ICT paradox.' Supporting this, Ugwuanyi and Ugwuanyi (2013) reported that ICT expenditures did not significantly enhance ROA in Nigerian banks, suggesting that while ICT investment may benefit industries overall, its direct impact on firm-level profitability remains uncertain.

Past studies have highlighted both positive and mixed effects of ICT investment on firm performance, particularly in the manufacturing sector. Gaith et al. (2008) found that while ICT investments such as communication, R&D, and training positively influenced Malaysian construction firms, the relationship remained weak. Weill (1992) reported mixed results among manufacturing firms, where transactional IT investments improved performance, but strategic IT investments had a negative impact, revealing a productivity paradox. Similarly, Kim (2004) discovered that ICT investment in Korean IT manufacturing firms had positive effects on productivity and market valuation but did not significantly impact profitability. The literature also suggests that mismeasurement issues, such as improper methodologies and neglecting time lags, may underestimate ICT's true potential (Weill & Olson, 1989; Stiroh, 2002).

Studies on ICT investment in the healthcare industry have shown mixed results. Devaraj and Kohli (2000) found that IT labor and capital positively influenced financial performance, though IT labor negatively affected mortality rates. Similarly, Thouin et al. (2008) reported a positive correlation between ICT budget, outsourcing, and profitability but found no impact from IT personnel. Spyros and Euripidis (2014) highlighted

ICT infrastructure and hospital-specific applications as key drivers of product and process innovation, while ICT budgets positively affected process innovation. However, IT personnel and website investments showed no significant impact.

In mixed industries, Brynjolfsson and Hitt (1993, 1996) found that ICT investment significantly contributed to firm output, especially through computer capital spending, contradicting the productivity paradox. Later studies supported these findings, such as Shin (2006) and Chari et al. (2008), who linked ICT investment to better firm performance, particularly in diversified firms. However, Mahmood and Mann (1993) reported mixed results, suggesting a time lag in ICT benefits. Zehir et al. (2010) found varying ICT effects, with IT perception and decision-making having no significant impact, while IT investment positively correlated with future orientation. Liang et al. (2010) further argued that organizational capabilities immediate ICT's impact on performance.

Additional research has produced inconsistent findings. Byrd and Marshall (1997) observed that IT accessibility improved labor productivity, but supercomputers and IT staff spending negatively affected capital productivity. Jun (2008) examined Korean security firms and found that capital budget ratios positively influenced ROA and profitability, while computer capital budgets had the strongest impact on profitability. These mixed results suggest that ICT investment effects vary based on industry, investment type, and measurement methods, reinforcing the importance of paper management and strategic alignment for maximizing ICT benefits.

The Issue of Time Lag

Brynjolfsson (1993) identified four factors contributing to the IT productivity paradox measurement error, lags, redistribution, and mismanagement. The time-lag effect, where firms experience delayed benefits from IT investments, has been a key challenge in measuring its impact (Brynjolfsson, 1993; Brynjolfsson & Hitt, 1993; Yaylacicegi & Menon, 2004). Studies suggest that firms may take 2 to 3 years to realize IT investment benefits (Brynjolfsson, 1993; Brynjolfsson & Hitt, 1993), while Devaraj and Kohli (2002) argued that outcomes may take months or years, depending on IT complexity. Kohli and Devaraj (2003) further emphasized that the lagged effect complicates ICT investment measurement due to factors like contemporaneous data use (Brynjolfsson, 1993) and the delayed financial impact of IT accumulation (Bharadwaj et al., 1999; Dierickx & Cool, 1989).

The financial theory of capital investments suggests that initial adjustment costs may delay IT benefits (Jorgenson, 2001), while estimating ICT economic life is crucial for intangible asset accounting (Lev, 2003). Studies have shown varied lag periods before IT investments yield performance gains. Brynjolfsson et al. (1994) observed a decline in firm size 1 to 2 years post-IT investment, whereas Francalanci and Galal (1998) found IT effects doubling after two years. Devaraj and Kohli (2000) noted a 2 to-3-month lag, while Anderson et al. (2003) reported benefits appearing between 1 to 4 years. Meanwhile, Brynjolfsson and Hitt (2003) tested lag periods from 1 to 7 years, while Yaylacicegi and Menon (2004) found a 5-year lag before firms saw returns from IT capital spending.

Further research confirmed the significance of time-lagged effects in IT investment. Byrd and Marshall (1997) suggested a 2 to 4-year lag, while Beccalli (2007) introduced a 1-year lag model. Zhang et al. (2012) found that Enterprise Resource Planning (ERP) implementation had an insignificant effect in the first three years but showed significant performance improvements after four years. Similarly, Hung et al. (2012) demonstrated that IT investment positively impacted financial performance based on lag-1 and lag-2 models. These findings highlight the importance of considering time-lag when assessing IT investment outcomes.

METHODOLOGY

Research Framework

Figure 1 presents a conceptual diagram of the research framework explored in this study, outlining the ICT spending variables under investigation. The framework delineates the relationship between ICT investment

and firm performance, where ICT spending serves as the independent variable, while firm performance functions as the dependent variable, capturing the impact of technological investment on organizational outcomes.

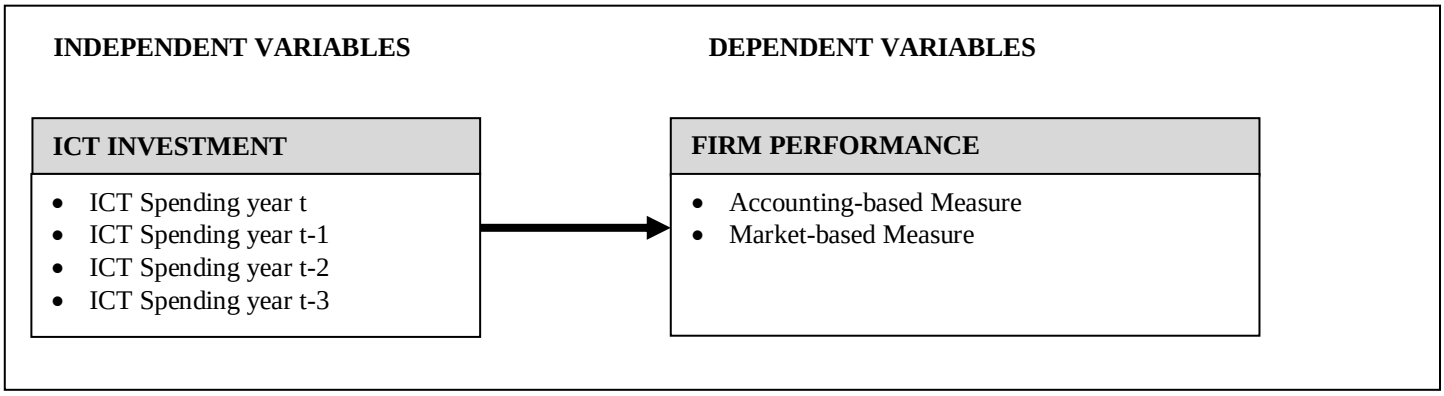


Figure 1: Research Framework

Hypotheses Development

ICT Investment and Firm Performance in the Malaysian Technology-Based Sector

ICT resources are vital for sustaining high performance in technology-driven sectors (Straub et al., 2006). The Malaysian technology sector was chosen for this study due to its strong reliance on ICT components (Noor & Apadore, 2014; PIKOM, 2014; 2013; 2012). ICT spending, encompassing both tangible (hardware, key data and networks) and intangible assets (licenses, R&D, patents and software), should be viewed as an investment rather than a cost (Haskel & Wallis, 2010). With a strategic approach, these assets can significantly enhance firm performance. Rooted in Resource Dependence Theory (RDT), this study posits that a firm's survival depends on its ability to acquire and manage critical resources, including technology. Therefore, the following hypothesis is proposed:

H_1: Investment in ICT spending has a significant effect on firm performance in the Malaysian technology-based sector.

Past research has examined the impact of ICT investment on firm performance through various factors, including ICT budgets, spending on hardware, software, training, services, outsourcing, and ICT branches. This study specifically evaluates ICT spending on equipment such as hardware and software. However, prior findings remain inconsistent due to differences in measurement approaches, industry segmentation, national development levels (developing vs. developed economies), and failure to account for time-lag effects. Moreover, firms initially experience profit declines due to high upfront ICT investment costs (Ugwuanyi & Ugwuanyi, 2013; Anderson et al., 2003). Although ICT spending in the initial period (t) may positively impact firm performance, the effect remains marginal (Anderson et al., 2003). This is because ICT investment generally involves a delay between expenditure and financial returns (Yaylacicegi & Menon, 2004; Brynjolfsson & Hitt, 2003; Dedrick, Gurbaxani, & Kraemer, 2003; Kohli & Devaraj, 2003; Devaraj & Kohli, 2000; Brynjolfsson & Hitt, 1993; Brynjolfsson, 1993; Brynjolfsson et al., 1989). Given these insights, this study proposes that ICT investment in year t does not immediately yield positive effects on firm performance in the same year, reinforcing the following hypothesis:

H_{1a}: Investment in ICT spending in year *t* has a negative effect on firm performance in year *t* in the Malaysian technology-based sector.

Research on the time-lag effect of ICT investment on firm performance has yielded positive findings. Some studies indicate that firms achieve the best returns from ICT investments after a lag of four (Zhang et al., 2012) or five years (Yaylacicegi & Menon, 2004). While a one-year lag model failed to show significant impact (Beccalli, 2007), other studies found positive effects with lags of 1 to 2 years (Hung et al., 2012; Brynjolfsson et al., 1989), 2 years (Francalanci & Galal, 1998), 2 to 3 years (Brynjolfsson & Hitt, 2003; 1993), and even 4

years (Anderson et al., 2003). Considering these findings and theoretical perspectives, this study suggests that ICT investments made in previous years (t-1, t-2 and t-3) positively influence firm performance in year *t* within the Malaysian technology-based sector. Although prior research highlights benefits emerging after 4 to 5 years, this study focuses on shorter lags of up to three years, considering the financial and tax policies governing ICT investments in Malaysia. According to the Malaysian Ministry of Finance (2014), the Accelerated Capital Allowance (ACA) allows companies to fully write off investments in computers and ICT assets within two years. Additionally, for tax purposes, the useful life of ICT assets is typically recognized in three years. To reinforce H_1, the following hypotheses are proposed:

H_{1b}: Investment in ICT in year *t-1* has a positive effect on firm performance in year *t* in the Malaysian technology-based sector.

H_{1c}: Investment in ICT in year *t-2* has a positive effect on firm performance in year *t* in the Malaysian technology-based sector.

H_{1d}: Investment in ICT in year *t-3* has a positive effect on firm performance in year *t* in the Malaysian technology-based sector.

Sample and Data Collection

This study explored how Malaysia Public Listed Companies (MPLCs) reported their ICT investments between 2010 and 2014, using annual reports as the main source of data. Although the accounting rule IAS38 on Intangible Assets had been introduced back in 1998, it was only after the adoption of international standards in 2006 that companies in Malaysia were required to follow stricter reporting under FRS116 (Property, Plant and Equipment (PPE)) and FRS138 (Intangible Assets), which affected how ICT assets were classified. In practice, however, not all firms were consistent, some voluntarily provided clearer ICT disclosures, but only 37 out of 74 technology-based companies had reported detailed enough to be included in this study. The government also pushed ICT development during this period through initiatives like 9th and 10th Malaysia Plans, offering tax incentives under the ACA (2009 – 2016) and enforcing ISO/IEC 27001 information security standards from 2010. To capture a broad perspective, the study began with 777 MPLCs across industries such as technology, construction, finance, and consumer products, covering both large, established firms on the Main Market and fast-growing companies on the ACE Market.

Table 1 Data Sample of the Malaysian Technology-Based Sector from 2010 to 2014

Particulars	**Main Market**	**ACE Market**	**Total of Companies**	**Total of Observations**
Companies in the Malaysian technology sector from the financial year end 2010 to 2014	35	68	103	515
Companies in the Malaysian technology sector with **incomplete annual reports** from the financial year end 2010 to 2014	8	21	29	145
Companies in the Malaysian technology sector with **complete annual reports** from the financial year end 2010 to 2014	27	47	74	370
Companies with **improper ICT records** from the financial year end 2010 to 2014	13	24	37	185

Companies with **proper ICT records** from the financial year end 2010 to 2014	14	23	37	185
Total companies discarded (outliers)	1	3	4	20
Final sample of the Malaysian technology-based sector	13	20	33	165

Note: MPLC refers to the Malaysian Public Listed Companies and total observations refer to the number of companies multiplied with 5 periods of annual reports).

Since Bursa Malaysia does not have a specific ICT sector, this study focused on the broader technology sector, which includes firms in electronics, semiconductors, communications equipment, software, hardware, and ICT-related services. Table 1 showed that, from 2010 to 2014, 103 technology companies were identified (35 in the Main Market and 68 in the ACE Market), but after excluding 29 with incomplete reports, only 74 were retained, producing 370 observations. Among these, 37 companies (185 observations) provided sufficient ICT disclosures, while the other 37 (180 observations) were excluded for weak reporting of ICT assets under PPE and Intangibles. To improve accuracy, four companies considered outliers were removed along with 20 observations, leaving a balanced panel dataset of 33 companies with 165 observations. This balanced dataset accounted for both firm-level and time dimensions, while also reflecting key developments such as IFRS adoption in 2006, ICT-focused initiatives under the 9th and 10th Malaysia Plans, and the mandatory ISO/ IEC 27001 compliance introduced in 2010, ensuring a more reliable analysis of ICT investments.

Dependent Variable: Firm Financial Performance

This study measures firm performance from both management and investor perspectives using accounting-based and market-based indicators (Black, Love, & Rachinsky, 2006). Return on Assets (ROA) reflects how efficiently a company uses its assets to generate earnings (Gral, 2013), calculated as earnings before interest and taxes (EBIT) divided by average total assets (Marshall et al., 2014), with higher values showing stronger profitability and management efficiency (Ibrahim & Abdul Samad, 2011; Haniffa & Hudaib, 2006). Return on Equity (ROE), on the other hand, measures profitability from shareholders' capital by dividing after-tax earnings by average equity (EAIT) (Marshall et al., 2014), with higher ROE indicating good governance and investor confidence (Haider et al., 2015; Johl et al., 2015; Yusoff et al., 2015; Wahba, 2015; Aggarwal, 2013a; Aggarwal, 2013b; Wan Yusoff & Alhaji, 2012; Ibrahim & Abdul Samad, 2011; Sami et al., 2011). Both ROA and ROE are widely applied in ICT investment studies as they revealed how effectively firms utilize resources and equity to enhance financial outcomes (Noor et al, 2017).

However, accounting measures alone may not capture the full value of ICT (Lubatkin & Shrieves, 1986), particularly its intangible benefits and long-term impact. For this reason, Tobin's Q (TQ), a market-based measure, is also used to reflect investor perceptions of firm performance. TQ incorporates factors such as innovation, customer service, and improved processes (Zhang et al., 2012; Lin, 2007; Shin, 2006) that accounting figures often miss, calculated as (Market Value + Preferred Stock + Debt) divided by Total Assets. ICT adoption has been shown to improve efficiency, cost control, and responsiveness, which positively influences both accounting outcomes and market valuations (Zhang et al., 2012; Strassman, 1997). By combining ROA, ROE, and TQ, this study offers a more complete understanding of how ICT investments shape firm performance among Malaysian technology-based companies between 2010 and 2014.

ICT Spending as Independent Variable

This study focuses on ICT spending as a proxy for ICT investment, excluding other proxies like ICT training costs and staff expenditures due to data limitations (Ugwuanyi & Ugwuanyi, 2013; Ekata, 2011; Liang et al., 2010; Lim et al., 2004; Anderson et al., 2003; Byrd & Marshall, 1997). ICT spending (ICTSPE) is measured as the logarithm of Net Cash for IT Investing Activities (logNCITIA). Which includes tangible assets like hardware and intangible assets like software and R&D costs (Noor & Apadore, 2014; Safari & Zhen Yu, 2014; Spyros & Euripidis, 2014; Romdhane, 2013; Ekata, 2011; Beccalli, 2007). Non-ICT assets such as office

equipment are excluded. Given the time-lag effect, ICT investment does not yield immediate returns, so ICT spending is measured in *t*, *t-1*, *t-2*, and *t-3* (Kavida & Sivakoumar, 2011; Sundac & Krmpotic, 2009; OECD, 2008; Dvenport & Prusak, 1998). ICT spending incurred in year *t* refers to $ICTSPE_t$, $ICTSPE_{t-1}$ refers to ICT spending incurred in year *t-1*, $ICTSPE_{t-2}$ refers to ICT spending incurred in year *t-2*, and $ICTSPE_{t-3}$ refers to ICT spending incurred in year *t-3*. While ICT is part of intellectual capital (IC), Malaysia lacks a mandatory accounting standard for reporting ICT investments (Rahim et al., 2011). Thus, ICT spending data is extracted from financial statement under PPE, as well as intangible assets, aligning with IFRS adoption in Malaysia from January 1, 2006.

Panel Data

This study utilized panel data analysis to examine the effect of ICT investment on firm performance, as panel data accounts for both observed and unobserved variables, controls for heterogeneity, reduces multicollinearity, and provides more efficient and dynamic data (Jager, 2008; Baltagi, 2005). Panel data can be balanced (complete observations over time) or unbalanced (missing data for certain years), with financial and economic data often being unbalanced due to firms dropping out over time (Baum, 2006). Since Malaysia has no mandatory ICT disclosure requirement, unbalanced panel data was initially considered. However, this study ultimately used balanced panel data to align with key regulatory changes, including the IFRS implementation in 2006, the 9th and 10th Malaysia Plans, and the mandatory ISO/ IEC 27001 compliance in 2010. Additionally, some firms were excluded due to missing or improperly recorded ICT investment data in their financial reports, particularly when ICT spending was not separately disclosed from office equipment in PPE and Intangible Assets.

Model Specification

There is no single standard model for predicting the effect of ICT investment on firm performance, and the IT paradox persists despite substantial ICT investments (Beccalli, 2007). One key factor contributing to this paradox is the time-lag effect, which many prior studies have overlooked (Devaraj & Kohli, 2002; Brynjolfsson, 1993). Due to the lack of empirical models examining the lagged effect of ICT investment on firm performance, this study incorporated similar treatments from other research areas. For example, Brynjolfsson et al. (1994) analyzed IT investments over multiple lag periods (e.g., IT_{t-1}, IT_{t-2}, IT_{t-3}, and IT_{t-4}), finding that firm size declined more significantly one to two years after IT investments. Likewise, previous studies demonstrated positive effects of ICT investments on firm performance after lag periods of one to two years (Hung et al., 2012; Brynjolfsson et al., 1989), two years (Francalanci & Galal, 1998), and two to three years (Brynjolfsson & Hitt, 2003; Brynjolfsson et al., 1994; Brynjolfsson & Hitt, 1993).

Furthermore, Anderson et al. (2003) suggested that ICT spending in year *t* is informative for future firm performance if it reflects new information not captured by past performance trends. This study, therefore, estimated a positive correlation between ICT spending and firm performance in subsequent years. Considering the Malaysian context, factors such as Accelerated Capital Allowance (ACA) allow ICT assets to be written off over two years, while a three-year useful life for ICT assets is standard for tax purposes (Malaysian Ministry of Finance, 2014). Therefore, this study included three lagged variables ($ICTSPE_{j,\,t-1}$, $ICTSPE_{j,\,t-2}$, and $ICTSPE_{j,\,t-3}$) to account for the delayed effect of ICT investment on firm performance.

The developed regression model is given in the following:

$$Y_{j,\,t} = \alpha + (\beta_1\, ICTSPE_{j,\,t}) + (\beta_2\, ICTSPE_{j,\,t-1}) + (\beta_3\, ICTSPE_{j,\,t-2}) + (\beta_4\, ICTSPE_{j,\,t-3}) + \eta_j + \varepsilon_{j,\,t} \quad \text{Equation (1)}$$

$$\varepsilon_{j,\,t} = v_j + u_{j,t} \quad \text{Equation (2)}$$

where the description of each variable is as follows:

$Y_{j,t}$	: represents either annual accounting performance ratios (ROA and ROE) or market ratio (TQ) of the Malaysian technology firms *j* at time *t*.
$ICTSPE_{j,t}$	: represents the logarithm of ICT spending firms *j* at time *t*.
$ICTSPE_{j,t-1}$	: represents the logarithm of ICT spending firms *j* at time *t - 1*.
$ICTSPE_{j,t-2}$	: represents the logarithm of ICT spending firms *j* at time *t - 2*.
$ICTSPE_{j,t-3}$	: represents the logarithm of ICT spending firms *j* at time *t - 3*.
η_j	: represents unobserved firm fixed-effect.
$\varepsilon_{j,t}$	: represents as an error term that includes time invariant effect v_j and random error term $u_{j,t}$.

RESULTS AND DISCUSSION

Descriptive Statistics

Table 2 provides descriptive statistics for all variables used to analyse the impact of ICT investment on firm performance in Malaysia's technology sector from 2010 to 2014. These statistics give an overview of the data by summarizing the characteristics of dependent, independent, control variables, without testing hypotheses. The table includes measures such as mean, median, standard deviation, maximum, minimum, skewness, and kurtosis, offering a clear understanding of the dataset and its distribution within the sector.

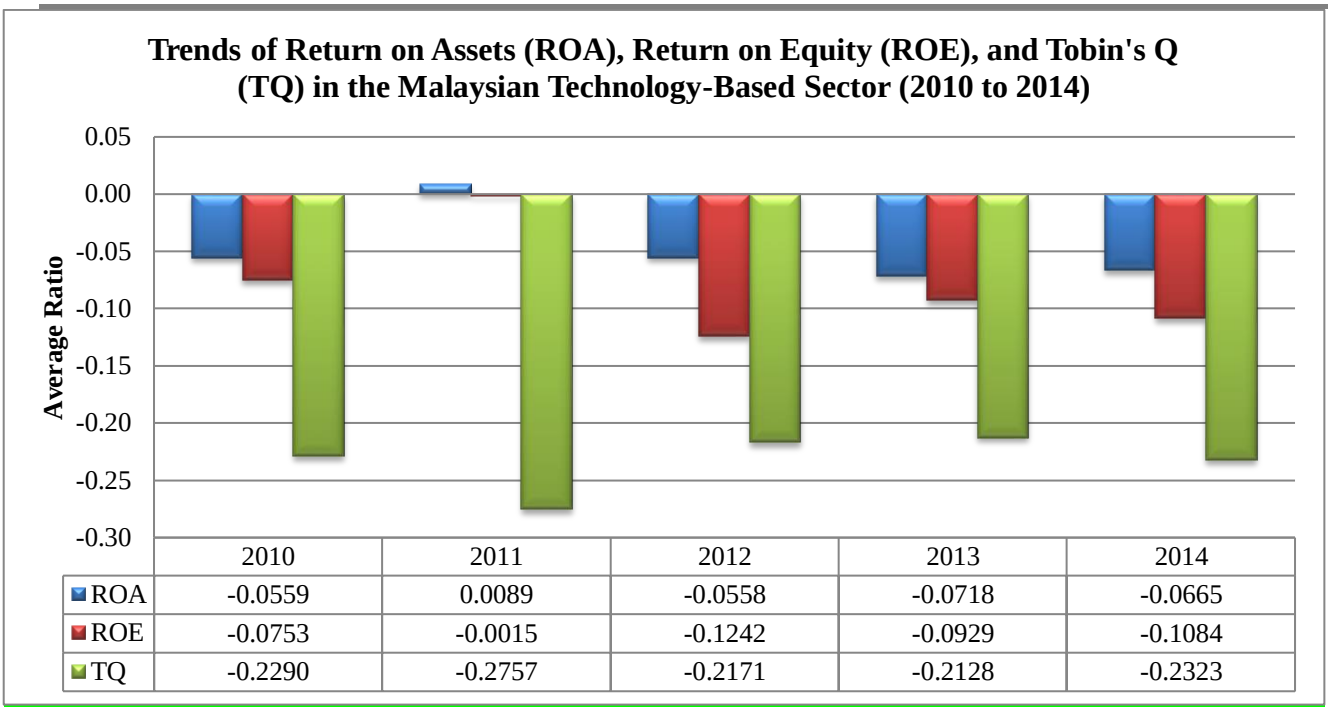
Table 2 Descriptive Statistics of Variables

Variables	Obs	Mean	Median	Standard Deviation	Minimum	Maximum
ROA	165	-0.0482	-0.0078	0.2876	-1.6158	0.8784
ROE	165	-0.0805	-0.0078	0.4140	-2.7251	0.9188
TQ	165	-0.2334	-0.2628	0.3848	-0.9220	1.4314
$ICTSPE_t$	165	9.1659	10.634	5.1696	0.0000	16.226
$ICTSPE_{t-1}$	165	9.3478	10.748	4.9835	0.0000	16.226
$ICTSPE_{t-2}$	165	9.6553	11.095	5.0069	0.0000	16.646
$ICTSPE_{t-3}$	165	10.0701	11.493	4.8268	0.0000	16.646

Note: ROA is return on assets; ROE is return on equity; TQ is Tobin's Q; ROA_{t-1} is return on assets at time t-1; ROE_{t-1} is return on equity at time t-1; TQ_{t-1} is Tobin's Q at time t-1; ICTSPE is logarithm ICT spending at time t; $ICTSPE_{t-1}$ is ICT spending at time t-1; $ICTSPE_{t-2}$ is ICT spending at time t-2; $ICTSPE_{t-3}$ is ICT spending at time t-3.

Dependent Variables

The descriptive results showed that Malaysian technology-based companies recorded negative average values for ROA (-0.0482), ROE (-0.0805), and Tobin's Q (-0.2334) from 2010 to 2014, indicating weak profitability, poor equity returns, and undervalued stock performance during the period. These results suggested that many firms struggled to generate returns from assets and shareholder capital, partly due to the lingering effects of the 2007 – 2009 global financial crisis, which left the sector in a transitional recovery phase. Although performance was generally weak, yearly averages revealed gradual improvement: ROA rose in 2011, dropped efficiency in asset utilization. To strengthen the analysis, lagged variables of ROA, ROE, and TQ were also included in the regression model, helping to capture the persistence of financial performance over time.



	2010	2011	2012	2013	2014
ROA	-0.0559	0.0089	-0.0558	-0.0718	-0.0665
ROE	-0.0753	-0.0015	-0.1242	-0.0929	-0.1084
TQ	-0.2290	-0.2757	-0.2171	-0.2128	-0.2323

Figure 2: Trends of ROA, ROE and TQ in the Malaysian Technology-Based Sector (2010 to 2014).

Figure 2 further showing the fluctuating trends of ROA and ROE over the period, highlighting both the challenges faced and the cautious recovery efforts within the sector. The results showed that the performance of Malaysia technology companies between 2010 and 2014 was unstable, particularly for ROE, which fluctuated over the five-year period. ROA recorded an increase in 2011, reflecting improved efficiency in asset utilization that helped enhance company value and provide returns to shareholders. However, ROE declined sharply in 2012, rose slightly in 2013, and dropped again in 2014, indicating inconsistent profitability. Although a steady increase in ROE would normally signal better efficiency and profitability, this was not sustainable due to slow and volatile trends, as well as the lingering effects of the global financial crisis. As a result, companies became more cautious in planning their business strategies to minimize the crisis' impact on profits while maintaining shareholder confidence.

The descriptive results indicated that the performance of TQ in the Malaysian technology sector showed mixed trends between 2010 and 2014. In the first two years, TQ declined slightly from -0.2290 to -0.2757, reflecting a small downturn in stock market performance. However, signs of recovery appeared in 2012 and 2013, with values improving from -0.2171 to -0.2128, suggesting gradual growth. Despite this, the market slipped again in2014 to -0.2323. overall, the consistently negative average TQ values highlighted that the stock market for technology companies was undervalued throughout the period, signaling persistent challenges in gaining fair market recognition.

Independent Variables

ICT Investment

The descriptive statistics of ICT investment, as shown in Table 5.3, not only examined ICT spending in the current year ($ICTSPE_t$) but also include lagged spending over three earlier periods: $ICTSPE_{t-1}$, $ICTSPE_{t-2}$, and $ICTSPE_{t-3}$. The results showed that the mean value of ICT spending in year *t* was 9.1659 with a median value of 10.634, ranging from 0.0000 (indicating no investment) to a maximum of 16.226. For the lagged periods, the mean values recorded were 9.3478 in year *t-1*, 9.6553 in year *t-2*, and 10.0701 in year *t-3*, showing a gradual increase across the years. These variations highlighted that some companies did not invest in ICT at all, while others allocated significantly higher spending to strengthen their technological capabilities. To provide a clearer view of this trend, Figure 3 presents the yearly average logarithm of ICT investment from 2010 to 2014. The bar chart indicated fluctuations in ICT spending but also reflects a continuous effort by Malaysian technology-based companies to enhance their ICT capacity. Despite the effects of the 2008 – 2009

global financial crisis, these companies remained committed to advancing technology for short-term sustainability while mitigating crisis-related impacts.

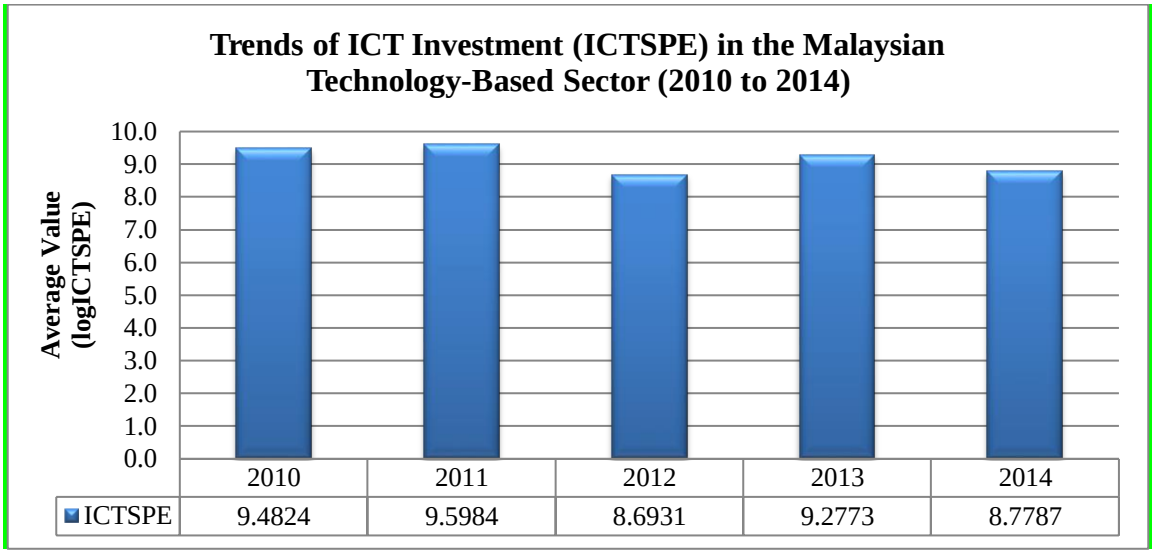


Figure 3: Trends of ICT Investment in the Malaysian Technology-Based Sector (2010 to 2014).

Note: ICTSPE refers to ICT spending, a proxy of ICT Investment.

Univariate Analysis

This study applied the t-test and pairwise correlation matrix on all sampled companies in the Malaysian technology-based sector to examine the key variables.

***T*-test for All Sampled Companies in the Malaysian Technology Sector**

The first objective of this study is to evaluate the level of ICT investment among firms in Malaysia's technology-based sector. To achieve this, inferential analysis was carried out using the t-test, which compared ICT investment across different groups based on mean ICT spending (ICTSPE). Specifically, the Independent Sample Test for Equality of Means was applied to examine differences in mean ICT spending between groups, such as (1) inter-ICT components and (2) inter-Bursa markets. For the inter-ICT components, comparisons were made using the total frequency of firms investing during the study period. The results of these tests are presented in Tables 5.6 to 5.12, which showed the outcomes for all variables tested using both dichotomous and continuous measures, coded with dummy values (1,0).

Inter-ICT Components

To examine differences in ICT investment, three group categories were established based on specific indicators. For the first group, a test of group statistics was conducted to compare firms that invested in ICT with those that did not, using ICT spending (ICTSPE) as the measurement. Table 3 presents the results of this analysis. The findings indicated that 131 firms (79%) invested in ICT, while 34 firms (21%) chose not to.

Further analysis showed that out of the 131 firms that invested in ICT, approximately 76 were from the ACE Market, while only 55 were from the Main Market. This suggests that ACE Market firms were more active in ICT investment compared to their Main Market counterparts. Such difference may be explained by the fact that ACE Market firms, often smaller and growth-oriented. In contrast, Main Market firms may adopt a more cautious approach, possibly due to larger scale operations, higher costs, or risk management strategies.

Overall, the findings highlighted that the majority of technology-based firms in Malaysia actively invested in ICT between 2010 and 2014, with ACE Market firms demonstrating stronger commitment to ICT adoption. This reflects the critical role of ICT in driving growth, innovation, and long-term sustainability in the sector.

Table 3 Inter-ICT Components: Analysis of Group Statistics

Group Statistics					
Test Variables	**Dummy Codes**	**MM (Fq.)**	**ACE (Fq.)**	**TFq**	**%**
ICTSPE	1 Invested	55	76	131	79
	0 Not invested	10	24	34	21
	Total	**65**	**85**	**165**	**100**
ICTTA	1 Invested	48	70	118	72
	0 Not invested	17	30	47	28
	Total	**65**	**85**	**165**	**100**
ICTTN	1 Invested	30	37	67	41
	0 Not invested	35	63	98	59
	Total	**65**	**85**	**165**	**100**

Note: ICTSPE refers to ICT spending which is the measurement of ICT investment; ICTTA refers to ICT tangible assets; ICTTN refers to ICT intangible assets; MM refers to Main Market; ACE refers to the ACE Market; Fq. refers to the frequencies; and TFq. refers to the total frequencies.

To examine the level of ICT investment in the Malaysian technology sector, companies were grouped into two categories: ICT tangible assets (ICTTA) and ICT intangible assets (ICTTN). For ICTTA, results showed that 118 firms (72%) invested, while 47 firms (28%) did not. Of those investing in ICTTA, 70 were form the ACE Market and 48 from the Main Market, indicating higher participation among ACE firms. For ICTTN, however, only 67 firms (41%) invested, while 98 firms (59%) did not. Among the 67 investors, 37 came from the ACE Market and 30 from the Main Market. These results highlighted that while most firms were active in ICTTA, ICTTN investment was less common overall. Despite lower participation in ICTTN, the financial commitment was much greater. Between 2010 and 2014, companies invested RM31.5 million (28%) in ICTTA, compared to RM79.7 million (72%) in ICTTN, giving a total ICT investment of RM111.3 million. Main Market companies contributed the most, with RM71.8 million, while ACE Market companies accounted for RM39.5 million. Overall, the sector invested more heavily in ICTTN, showing that firms prioritized intangible assets such as software, systems, and digital capabilities over physical infrastructure.

Table 4 Total of ICT Investment in the Malaysian Technology-based Sector (2010 to 2014)

Types of ICT Investment	**MM (RM)**	**Total (%)**	**ACE (RM)**	**Total (%)**	**Total of ICT investment in the Bursa Markets (RM)**	**Total (%)**
• Investment amount of ICTTA	21,647,259	30	9,865,801	25	31,513,060	28
• Investment amount of ICTTN	50,110,133	70	29,634,398	75	79,744,531	72
Total Amount of ICT Investment	71,757,392	100	39,500,199	100	111,257,591	100

Note: ICTTA refers to ICT tangible assets; ICTTN refers to ICT intangible assets; MM refers to Main Market; and ACE refers to the ACE Market.

Inter-Bursa Markets

In the Malaysian technology-based sector, ICT investment (ICTSPE) was compared between two Bursa Markets, namely the Main Market and the ACE Market, to assess differences in investment levels from 2010 to 2014. Since the Main Market consists of larger and financially stronger companies, while the ACE Market is made up of smaller and emerging firms, it was expected that the Main Market would invest more heavily in ICT. The results, as shown in Table 5, confirmed this expectation, revealing that although the difference in ICT investment between the two markets was relatively small, the mean investment value was higher in the Main Market (9.98) compared to the ACE Market (8.63). The null hypothesis was rejected at the 10% significance level, suggesting that the stronger financial capacity of the Main Market companies enabled them to allocate slightly more resources toward ICT investment than their ACE Market counterparts.

Table 5 Inter-Bursa Markets: Analysis of Group Statistics and T-Test

Group Statistics **Test Variable: ICTSPE**					**t-test**	
Grouping Variable	**Dummy Codes**	**TFq**	**%**	**Mean**	***t***	***p***
MKTYPE	1 MM	65	39	9.98	1.67	0.097*
	0 ACE	100	61	8.63		
	Total	**165**	**100**			

Note: MKTYPE refers to Market Type; MM refers to Main Market; ACE refers to the ACE Market; and TFq. refers to the total frequencies. *, ** and *** represent significance at 10%, 5% and 1% levels respectively.

Pairwise Correlation Matrix

The Pairwise Pearson's correlation matrix was employed to test for multicollinearity among the independent variables, and the results in Table 6 showed that the Tobin's Q_{t-1} had the highest coefficient value at 0.6445. Overall, all correlation coefficients were below the 0.9 threshold suggested by Tabachnick & Fidell (2007) and Hair et al. (2006), indicating nor serious multicollinearity problem; thus, all variables were retained for regression analysis. In cases of inconsistent findings, any potential multicollinearity issues were addressed using the panel data analysis method.

Testing for Panel Data

In this study, lagged dependent variables were included in the equation model (refer to Equation (3)), and the estimation results of Pooled OLS and panel fixed effect (FE) were also considered, while diagnostic tests such as multicollinearity, heteroscedasticity, autocorrelation, and the F-test were conducted to ensure the data satisfied the necessary statistical assumptions.

Results of Multicollinearity

The Variance Inflation Factors (VIFs) were analyzed for all models to check for multicollinearity, and the results in Table 7 showed that the ROA model had VIF values between 1.21 and 2.56, the ROE model also ranged from 1.21 to 2.56, and the TQ model ranged from 1.21 to 2.57. Since all values fall well below the threshold of 10 (Hair et al., 2006, Ho, 2006; Gujerati, 2003), the findings confirmed that multicollinearity is not a concern, meaning the regression analysis can be reliably interpreted.

Table 7 Results of Variance Inflation Factor (VIF)

Variables	**ROA**		**ROE**		**TQ**	
	VIF	**1/VIF**	**VIF**	**1/VIF**	**VIF**	**1/VIF**
ROA_{t-1}	1.28	0.781752				

ROE_{t-1}			1.29	0.773783		
TQ_{-1}					1.60	0.624819
$ICTSPE_{t}$	1.43	0.701008	1.44	0.695150	1.42	0.704125
$ICTSPE_{t-1}$	1.82	0.548832	1.84	0.544468	1.82	0.548798
$ICTSPE_{t-2}$	2.43	0.411206	2.42	0.413594	2.36	0.422994
$ICTSPE_{t-3}$	1.80	0.556758	1.80	0.555590	1.76	0.569482
Mean VIF	**1.67**		**1.67**		**1.70**	

Note: ROA is return on assets; ROE is return on equity; TQ is Tobin's Q; ROA_{t-1} is return on assets at time t-1; ROE_{t-1} is return on equity at time t-1; TQ_{t-1} is Tobin's Q at time t-1; ICTSPE is ICT spending at time t; $ICTSPE_{t-1}$ is ICT spending at time t-1; $ICTSPE_{t-2}$ is ICT spending at time t-2; $ICTSPE_{t-3}$ is ICT spending at time t-3.

Regression Analysis

This section examines the effect of ICT investment on firm performance, where OLS regression results were calculated using robust standard errors clustered by firm-specific effects, while FE estimations controlled for firm-specific factors. To strengthen the robustness of the findings, both Pooled OLS and panel fixed effect (FE) results were also included in the regression tables. Accordingly, the regression outcomes for OLS and FE are presented in Table 8 showing the results for ROE and TQ models.

The Effects of ICT Investment on Firm Performance (H_1, H_{1a} to H_{1d})

This sub-section discusses the effects of ICT investment on firm performance within the Malaysian technology-based sector. To test this relationship, several hypotheses were developed under H_1, focusing on the effect of ICT spending at different time lags: current year ($ICTSPE_t$, H_{1a}), one year prior ($ICTSPE_{t-1}$, H_{1b}), two years prior ($ICTSPE_{t-2}$, H_{1c}), and three years prior ($ICTSPE_{t-3}$, H_{1d}) on firm performance, measured by ROA, ROE, and TQ. Collectively, the findings from H_{1a} to H_{1d} explained the overall outcome of H_1. The regression analyses were conducted using two estimation methods: Pooled OLS and Fixed Effect (FE). For H_{1a}, it was anticipated that current-year ICT spending ($ICTSPE_t$) would negatively influence firm performance. The results confirmed this expectation, showing that $ICTSPE_t$ had a significant negative effect on ROA under both Pooled OLS (10% significance level) and FE (5% significance level). It also showed a significant negative effect on ROE, with significance at the 10% level under Pooled OLS and at a stronger 1% level under FE. Interestingly, $ICTSPE_t$ demonstrated a significant positive effect on TQ at the 10% level under the FE estimation. This suggests a contrasting impact when firm performance is assessed through market valuation. The technology sector, however, was considered high risk if heavy ICT investments were continued during these periods, since the returns on such investments did not immediately translate into improved firm performance.

In the initial hypotheses, ICT spending lagged by one ($ICTSPE_{t-1}$, H_{1b}), two ($ICTSPE_{t-2}$, H_{1c}), and three years ($ICTSPE_{t-3}$, H_{1d}) was expected to positively effect firm performance. However, the Pooled OLS and FE results showed that $ICTSPE_{t-1}$ had no significant effect on ROA, ROE, or TQ. Similarly, $ICTSPE_{t-2}$ and $ICTSPE_{t-3}$ did not display any significant effect on ROA and ROE across both estimation methods. For TQ, $ICTSPE_{t-3}$ also showed no significant effect under any estimation method. The continued weak performance of ROA and ROE can be attributed to the 2009 economic downturn, which caused unstable growth in Malaysia's technology sector, largely due to declining demand for ICT products.

Table 6 Pairwise Correlation Matrix

Variables	**ROA**	**ROA_{t-1}**	**ROE**	**ROE_{t-1}**	**TQ**	**TQ_{t-1}**	**$ICTSPE_{t}$**	**$ICTSPE_{t-1}$**	**$ICTSPE_{t-2}$**	**$ICTSPE_{t-3}$**
ROA	1.000									

	0									
ROA_{t-1}	0.1190	1.0000								
ROE			1.0000							
ROE_{t-1}			0.0824	1.0000						
TQ					1.0000					
TQ_{t-1}					0.6445***	1.0000				
$ICTSPE_{t}$	-0.0227	0.1045	-0.0452	0.1155	-0.0727	-0.1551**	1.0000			
$ICTSPE_{t-1}$	0.0478	-0.0575	0.0075	-0.0829	-0.0122	-0.2145***	0.4134***	1.0000		
$ICTSPE_{t-2}$	-0.0496	0.0105	-0.0542	-0.0254	0.0204	-0.1122	0.1931**	0.5754***	1.0000	
$ICTSPE_{t-3}$	-0.0505	-0.0921	-0.0233	-0.1161	0.0213	-0.0572	0.1219	0.3315***	0.6330***	1.0000

Note: ROA is return on assets; ROE is return on equity; TQ is Tobin's Q; ROA_{t-1} is return on assets at time t-1; ROE_{t-1} is return on equity at time t-1; TQ_{t-1} is Tobin's Q at time t-1; ICTSPE is ICT spending at time t; $ICTSPE_{t-1}$ is ICT spending at time t-1; $ICTSPE_{t-2}$ is ICT spending at time t-2; $ICTSPE_{t-3}$ is ICT spending at time t-3. *, ** and *** represent significance at 10%, 5% and 1% levels respectively.

Table 8 Regression Results of ROA, ROE and TQ

Variables	**ROA**		**ROE**		**TQ**	
	Pooled OLS (OLS)	**Fixed Effect (FE)**	**Pooled OLS (OLS)**	**Fixed Effect (FE)**	**Pooled OLS (OLS)**	**Fixed Effect (FE)**
Constant	-1.2169*** 0.4441	-3.5994*** 0.9091	-1.8103*** 0.6372	-4.6607*** 1.3659	-0.9159** 0.4061	-2.2834** 0.9216
$ICTSPE_{t}$	-0.0089* 0.0048	-0.0134** 0.0055	-0.0121* 0.0069	-0.0219*** 0.0083	-0.0002 0.0044	0.0096* 0.0057
$ICTSPE_{t-1}$	0.0048 0.0047	-0.0008 0.0041	0.0017 0.0069	-0.0067 0.0061	0.0062 0.0044	0.0066 0.0042

$ICTSPE_{t-2}$	-0.0020	-0.0029	-0.0027	-0.0052	0.0008	0.0025
	0.0053	0.0044	0.0076	0.0066	0.0048	0.0045
$ICTSPE_{t-3}$	-0.0002	-0.0003	0.0022	0.0033	0.0032	0.0020
	0.0049	0.0044	0.0071	0.0066	0.0045	0.0045
No. of obs	165	165	165	165	165	165
R-Sq	0.2467	0.6276	0.2510	0.5941	0.6479	0.7820
Adj. R-Sq	0.1421	0.4547	0.1469	0.4056	0.5990	0.6808

Note: ROA is return on assets; ROA_{t-1} refers to ROA in year t-1; ROE is return on equity; ROE_{t-1} refers to ROE in year t-1; TQ is Tobin's Q; TQ_{t-1} refers to TQ in year t-1; ICTSPE is ICT spending at time t; $ICTSPE_{t-1}$ is ICT spending at time t-1; $ICTSPE_{t-2}$ is ICT spending at time t-2; $ICTSPE_{t-3}$ is ICT spending at time t-3. Robust standard errors are in parentheses. *, ** and *** represent significance at 10%, 5% and 1% levels respectively.

As demand for ICT products and services declined, the slow recovery from the 2009 financial crisis further destabilized ICT investments, ultimately reducing firm performance. Moreover, the trend of ICT investment in the Malaysian technology sector showed a steady decline from 2010 to 2014, as illustrated in Figure 5.5. Since the technology sector heavily depends on new ICT equipment, this slowdown in investment reduced the adoption of technological innovations, which in turn worsened firm performance. The significantly positive effect of ICT spending in the previous year ($ICTSPE_{t-1}$) on TQ, with a coefficient of 0.0070, indicated that a one-unit increase in $ICTSPE_{t-1}$ led to a 0.0070 unit rise in TQ. This positive effect was also reflected in the trend of TQ, which increased from 2011 to 2013, although there was a slight decline in 2014. As shown in Table 4, ICT investment in the Malaysian technology sector was mainly directed towards ICT intangible assets (ICTTN) rather than ICT tangible assets (ICTTA). The pattern of ICT investment also shifted during this period due to the impact of the 2008 to 2009 financial crisis. A substantial focus on ICT intangibles sent a strong signal to the stock market, showing that returns could be realized not only in the same year of investment but also in the following year.

To keep up with technological development, firms needed innovation and creativity to deliver high-quality products, even under challenging post-crisis conditions. Experts have noted that investment in ICT intangible assets recovered more quickly and grew faster after the recession compared to tangible investments (Goodridge al., 2014). In the long run, intangible investments are considered vital for supporting continuous development. For example, Davenport (1998) highlighted that investment in Enterprise Resource Planning (ERP) software, when properly implemented, could improve productivity.

From the perspective of signaling theory, ICT intangible investments such as patents were also seen as signals of technological strength that helped firms build market differentiation and gain competitive advantage. In this study, technology signals were not only associated with patents but also with other resources such as the development of unique software and hardware components. These innovations enabled firms to strengthen their product differentiation strategies, stay competitive, and improve business performance.

Some researchers have also argued that market-based measures like Tobin's Q are better suited to capture the lagged effects of ICT investment on firm performance. For instance, Zhang et al. (2012) found that ICT investment had no significant effect on TQ within three years of ERP implementation, but the effect became significant after four years. Consistent with this, the findings of this study revealed that ICT investment had a significant positive effect on TQ, not only for ICT spending in the previous year (*t-1*) but also for current-year spending (*t*).

CONCLUSION AND RECOMMENDATIONS

The overall results of this study showed that ICT investment has both short-term costs and long-term benefits for firm in the Malaysian technology sector. Specifically, current-year ICT spending ($ICTSPE_t$) had a negative effect on accounting-based performance indicators such as ROA and ROE. This reflects the reality that ICT

adoption often requires high upfront costs, which can reduce profitability in the short run. At the same time, the sector was particularly vulnerable during and after the 2009 economic downturn, when market instability and weak demand for ICT products further limited the immediate financial returns from ICT investments. This finding highlighted the risk for firms that allocated significant resources to ICT without expecting quick returns.

However, when firm performance was measured using Tobin's Q, a different picture emerged. Both year and lagged ICT spending showed significantly positive effects on market-based performance, implying that the stock market views ICT investment as a valuable signal of growth, competitiveness, and innovation potential. In particular, investments in ICT intangible assets such as software, ERP systems, and patents were found to contribute strongly to market value by enabling firms to differentiate their products and improve long-term productivity. This suggests that while accounting measures reflected the short-term financial burden of ICT adoption, market valuation recognized the strategic importance of ICT for sustaining future growth.

From a practical standpoint, these findings imply that technology-based firms should not view ICT investment purely as a cost but as a long-term strategic asset. Managers need to balance their financial planning by anticipating initial performance declines while ensuring that ICT resources are effectively leveraged for innovation and competitive differentiation. In particular, greater emphasis should be placed on intangible ICT investments, which signal technological capability to the market and contribute to sustainable firm performance. For policymakers, the results underscored the importance of supporting ICT adoption through incentives, training, and infrastructure development, especially in times of economic uncertainty. By doing so, firms in the Malaysian technology sector can strengthen their resilience and maximize the long-term value of ICT investments.

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