UNVEILING THE DYNAMICS OF INFORMATION TECHNOLOGY INVESTMENTS: THE MODERATING ROLE OF ENVIRONMENTAL UNCERTAINTY ON FIRM PERFORMANCE

BY:

ANKIT DEO

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Supervising Committee:

Dr. Sridhar Nerur

Dr. Mahmut Yasar

Dr. Riyaz Sikora

ABSTRACT

UNVEILING THE DYNAMICS OF INFORMATION TECHNOLOGY INVESTMENTS: THE MODERATING ROLE OF ENVIRONMENTAL UNCERTAINTY

Ankit Deo, Ph.D. (Information Systems)

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Supervising Professor(s): Dr. Sridhar Nerur and Dr. Mahmut Yasar

The proficient administration of information technology (IT) investments is essential for organizations aiming to attain a competitive edge in the current dynamic business landscape. Nevertheless, the correlation between investments in information technology (IT) and the performance of an organization is dependent on several contextual factors. The primary objective of this dissertation is to elucidate the intricacies of investments in information technology (IT) by examining the moderating influence of environmental uncertainty on this association.

This study presents a comprehensive research framework that integrates IT investments, environmental uncertainty, and organizational performance. The study utilizes a mixed-methods methodology, integrating quantitative analysis of secondary data with primary data collection through the administration of surveys and conducting interviews.

The quantitative analysis encompasses the comprehensive examination of extensive datasets across various industries, intending to investigate the correlation between investments in information technology, environmental uncertainty, and organizational performance. The qualitative inquiry offers a more comprehensive understanding of the fundamental mechanisms and processes by conducting interviews with key stakeholders.

This study's results are anticipated to contribute to theoretical understanding and practical applications significantly. This study contributes to the theoretical framework by providing insights into the dynamic nature of IT investments and the significant moderating influence of environmental uncertainty. This study offers significant perspectives on the contextual variables that influence the efficacy of information technology investments within various environmental settings. The research findings provide practical insights for organizations to enhance their IT investment strategies per the current environmental circumstances.

This dissertation aims to enhance organizational decision-making regarding IT investments and navigate the complexities of the digital era by examining the dynamics of IT investments and the moderating influence of environmental uncertainty. The research presented in this study has significant implications for scholars and practitioners in IT management. It adds to the existing body of knowledge on the strategic utilization of IT resources and emphasizes the crucial role of aligning IT investments with the ever-changing business environment.

Keywords: IT Investments, Software and Hardware Budget, Fixed-Effects Analysis, Environmental Dynamism, Environmental Munificence

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1. INTRODUCTION

The constantly evolving and dynamic nature of contemporary business requires a continuous striving for excellence, and the impact of information technology (IT) on business outcomes remains a captivating topic that consistently garners attention (Hitt & Brynjolfsson, 1997; Bharadwaj et al., 1999; Aral & Weill, 2007; Mithas et al., 2012; Ma et al., 2021). Is there a direct impact of IT on organizational performance? Have organizations seen the anticipated financial returns on their information technology (IT) investments? What factors contribute to the link between IT and business value? During the process of addressing these inquiries, the scholarly literature regarding the value of information technology (IT) has encountered a lack of consensus. Some researchers argue that IT directly affects business performance (Bharadwaj, 2000; Dehning & Richardson, 2002; Wade & Hulland, 2004), whereas another school of thought proactively follows the claim that a company's capacity to use IT to its advantage translates into a meaningful competitive advantage (Clemons & Row, 1991; Carr, 2003; Chae et al., 2014). Furthermore, information systems are so standard and uniform these days that their strategic importance is fading (Carr, 2003). Correspondingly, the mechanism(s) through which IT competence affects organizational performance needs more clarification (Yan & Sengupta, 2011). Despite widespread agreement that strong IT capabilities are essential to success, empirical research on the positive relationship between IT strength and business outcomes still needs to be accomplished. This work explores a contextually underlying mechanisms that affect the association between IT investments and firms' financial performance.

Considering that investment is a strategic decision, one must account for the internal and external fluctuations relative to a firm (Huy et al., 2021; Wong et al., 2011). Environmental uncertainty pertains to a lack of predictability and complexity in the external business environment

in which organizations function (Downey et al., 1975). Uncertainty highlights enterprises' obstacles and complexities in comprehending and predicting alterations in various elements, including market circumstances, technological progressions, competitive forces, consumer inclinations, regulatory framework, and socio-political aspects (Duncan, 1972; Terreberry, 1968; Lawrence & Lorsch, 1969). Amidst an environment marked by unpredictability, organizations may encounter potential challenges in making strategic decisions with a significant degree of assurance (Duncan,1972; McMullen & Decastro, 2000). The presence of uncertainty can result in ambiguity and a dearth of lucid information, thereby rendering the identification of optimal strategies a challenging task (Santoso et al., 2005). Organizations may be required to modify their decision-making procedures, exhibiting greater flexibility and adaptability to accommodate evolving circumstances (McMullen & Decastro, 2000; Santoso et al., 2005). If organizations are unable to maneuver through uncertain circumstances proficiently, it can lead to the implementation of suboptimal strategies that have the potential to affect their overall performance adversely (Li & Simmerly, 1998; Drnevich et al., 2011; Chung et al., 2019). This study takes a deeper dive to fetch details about how IT investments, and environmental uncertainty interplay to increase corporate success.

1.1 Research Questions

1.1.1 IT Investments and Firm Performance

The first section of this study centers on the connection between business performance and investments in IT infrastructure. As stated previously, the relationship between IT infrastructure and performance has been controversial throughout the course of investigation (Brynjolfsson, 1993; Bharadwaj, 2000; Wade & Hulland, 2004; Carr, 2003; Chae et al., 2014). From a

Table 1: IT Investment Operationalization

Measure of IT investments	Study
Computer ownership Number of Standard application areas computerized Types of application areas computerized	Cron and sobol (1983)
Ratio of information-processing expense to total operating expense.	Bender (1986)
Raw material expenditures Costs for real non-IT purchased services Real total labor compensation Real IT capital Real non-IT capital	Loveman (1988)
Ratio of ITI : premium income Ratio of ITI : total operating expense	Harris and Katz, (1989)
CEO, CIO, and Managers Questionnaire	Weill, (1988)
Time deposits Labor Capital ITI	Alpar and Kim, (1990)
IT budget as a percentage of revenue (BUDBYREV) Value of organization's IT as a percentage of revenue (ITVALBYREV) Percentage of IT budget spent on staff (BUDBYSTA) Percentage of IT budget spent on training of IT staff (BUDBYTRA) Number of PCs and terminals as a percentage of total employees (PCSEMP)	Mahmood and Mann (1993)
Percentage of sales (ITB/S), averaged over a period of tie.	Mitra and Chaya (1996)
Total value of IT Total central processing power Number of PCs Number of LANs Workplace computerization survey	Hitt & Brynjolfsson (1997)
Total installed base of computer hardware, software, peripherals, and services	Dewan et al. (1998)
Book value (bv) Net income (adj)	Hendersen et al. (2010)
Total IT intensity IT intensity by asset class IT asset X organizational ITC	Aral and Weill (2007)
Context-driven IT budget	Kobelsky et al. 2008
Total IT Investment	Kim et al. (2009); Dewan and Ren (2011); Ray et al. (2013); Mithas & Lee (2014
Flexible IT infrastructure IT Assimilation	Liu et al. 2013
ITI ratio Maintenance cost ratio	Hung et al. 2014
Basic infrastructure, wireless, collaboration, security, and data center	Lee at al. 2016
Eleven categories of investments: IT, software, communications, services, server, pc, storage, other hardware, terminal, printer, hardware	**Current Study**

methodological perspective, a majority of these discrepancies are caused by the operationalization of IT spending. (Weill, 1992; Mahmood & Mann, 1993). Table 1 lists a variety of subjective and objective metrics to operationalize IT investments employed by most of the studies.

A significant amount of the research on the relationship between IT and business value considers IT investments as a monolithic entity and relied on CEO questionnaires and surveys to build measures of IT (Bharadwaj, 2000; Hendersen et al., 2010; Ray et al., 2013; Aral & Weill, 2007; Morales & Rojas, 2013). Weil (1992) pointed out that investments aligned with specific managerial objectives affect various organizational outcomes, rejecting the idea of IT investment as a homogeneous entity. They stressed that transactional IT investments impact an organization's profitability and labor productivity. In contrast, strategic and informational IT investments drive an organization's growth and profitability, building on the categorization established by Turner & Lucas (1985). Similarly, Bharadwaj et al. (1999) maintained that not all businesses reap the same rewards from their IT spending. For instance, businesses perform differently from investing in innovative versus noninnovative IT (Santos et al., 1993), and investment in IT about process control and coordination (Francalanci & Magiolini, 2002) differs from the investments made in IT about customer satisfaction and relationship management (Maklan & Knox, 2009). Despite the advancements achieved in classifying IT investments, there continues to be a need for more clarity regarding the precise mapping of individual components of the IT budget to specific categories.

Within IT investments, two primary components stand out: hardware and software. Hardware investments encompass the tangible physical assets of an organization's IT infrastructure, including computers, servers, networking equipment, and storage devices (Chen et al., 2016). These components provide the necessary computing power and resources for

information processing and data storage (Capra et al.,2019). On the other hand, software investments refer to the intangible programs, applications, and operating systems that run on the hardware and enable specific functionalities and tasks, and they classify as nonhardware IT (Ray et al., 2013).

Understanding the impact of IT investments on firm performance is crucial for organizations aiming to make informed decisions regarding their IT spending. While previous research has recognized the importance of IT investments in enhancing firms' performance, it is necessary to explicitly examine the specific contributions of hardware and software investments individually. Motivated by this gap in the literature, our research seeks to explore the significance of both hardware and software investments in improving firm performance. To this point, our first research question is as follows:

RQ1: What is the relationship between investments in IT infrastructure and the performance of firms?

1.1.2 Environmental Uncertainty and Firm Performance

The third part of the study aims at unraveling the role of environmental dynamism in the relationship between IT investments and firm performance. Contemporary businesses encounter many obstacles and ambiguities from diverse sources, such as market dynamics, technological progress, competitive pressures, and alterations in regulatory frameworks (Duncan, 1972; Tushman & Anderson, 1986; DeSarbo et al., 2005). Amid complex business environments, organizations have acknowledged the strategic significance of allocating resources toward Information Technology (IT) to augment their operational efficiency, attain a competitive edge, and bolster their overall performance (Parsons, 1956; Katz & Kahn, 1966; Byrd et al., 2006). The

influence of information technology (IT) investments on a company's performance is contingent on the investments per se and the environmental factors surrounding the firm (Simerly & Li, 2000; Garg et al., 2003). Environmental uncertainty is a significant contextual factor that pertains to the absence of predictability and intricacy in the external business environment (Richard et al., 2019). Comprehending the dynamic relationship between environmental unpredictability, information technology investments, and organizational performance holds significance for academic researchers and industry professionals. There is a myriad of investigations examining the contextual role of environmental uncertainty on organizational performance. For instance, Goll & Rasheed (1997) investigated the role of environmental uncertainty in process rationality's effect on organizational performance. Similarly, Sabherwal et al. (2019) investigated the moderating role of environmental uncertainty in the strategic alignment of IT resources. Nevertheless, the way environmental uncertainty impacts the relationship between IT investments and the financial performance of firms remains ambiguous, which directs us to the study's third research question.

RQ2: What is the function of environmental uncertainty in the relationship between investments in information technology and companys' performance?

1.2 Motivation for the Study

1.2.1 IT Investments: Software and Hardware

The current study employs segmented parts of businesses' IT expenditures, emphasizing the measurement errors leading to contradictory results on the association between IT expenditure and firm performance (Weill, 1992; Mahmood & Mann, 1993). Mahmood and Mann (1993) were the first to point out that it took much work to create relevant and acceptable measures to operationalize IT spending. To address this issue, we employed eleven different types of IT

expenditures: *terminal budget, storage budget, software budget, services budget, server budget, printer budget, pc budge, hardware budget, IT budget, other hardware budget, and communication budget*, and categorized them into software and hardware budgets. The details of these eleven investments are provided in Table 2, and the allocation of specific IT resources to software and hardware categories are provided in Table 3.

Table 2: Budget Categories

Expenditure Category	Definition
IT Spend	The amount of investment in IT
Software Spend	The amount of investment in software and applications
Communications Spend	The amount of investment in communication technologies
Services Spend	The amount of investment in services provided by company
Server Spend	The amount of investment in server installations
PC Spend	The amount of investment in personal computers
Storage Spend	The amount of investment in storage
Other Hardware Spend	The amount of investment in hardware other than computer hardware
Terminal Spend	The amount of investment in number of different terminals installed
Printer spend	The amount of investment in printers
Hardware Spend	The amount of investment in computer hardware

Table 3: Software and Hardware Categories

Category	Resources
Software Spend	IT, Software, Communications, Services
Hardware Spend	Server, PC, Storage, Other hardware, Terminal, Printer, Hardware

Acknowledging that allocating funds towards information technology is not a homogeneous entity is imperative (Weill, 1992; Mahmood & Mann 1993). IT investments have witnessed numerous categorizations proposed by researchers over the years. Weill (1992) put forth one of the early categorization frameworks, which classified investments as strategic, informational, and transactional. Another categorization approach was proposed by Santos et al. (1993) to distinguish between innovative and non-innovative IT spending. Furthermore, IT investments for process control and coordination investments (Francalanci & Mangiolini, 2002)

and IT investments for customer satisfaction and relationship management (Maklan & Knox, 2009) have also been explored in the literature. However, despite the progress made in categorizing IT investments, more specific IT resources must be mapped to these categories.

To address this academic void and provide a more focused investigation, our research centers on the two primary components of information systems: hardware and software. By focusing on these fundamental building blocks, we aim to examine the distinct contributions and implications of hardware and software investments on firm performance. This approach allows us to understand better how these specific components influence organizational outcomes.

By exploring the relationship between hardware and software investments and firm performance, we can bridge the gap between the categorization frameworks proposed in previous research and the fundamental components that constitute IT investments. This research fills a crucial void in the existing literature by providing a comprehensive analysis of the impact of these primary components on organizational performance.

Through our research, we strive to shed light on the specific roles played by hardware and software investments in improving firm performance. By analyzing these components individually, we can uncover their unique effects, enabling organizations to make informed decisions when allocating their IT budgets. This research will contribute to a more nuanced understanding of the relationship between IT investments and firm performance, ultimately guiding organizations in their strategic investment decisions.

Drawing upon the categorization proposals of multiple scholars and recognizing the absence of a precise mapping of specific IT resources into categories, our study focuses on the core components of information systems—hardware and software. By addressing this academic gap, we aim to enhance the understanding of how investments in these primary components drive

organizational performance and provide valuable insights for practitioners and decision-makers in their IT investment strategies.

1.2.2 Environmental Uncertainty

The rationale for investigating the moderating impact of environmental uncertainty on the relationship between IT investments and firm performance arises from acknowledging that the business landscape exhibits diverse uncertainty and unpredictability (Li & Simmerly, 1998; Garg et al., 2003; Karna et al., 2016). Organizations function in dynamic markets characterized by ongoing technological advancements, evolving customer demands, regulatory modifications, and competitive pressures, continuously reshaping the business environment (Duncan, 1972; Terreberry, 1968; Lawrence & Lorsch, 1969). Competitive advantage is prominently provided by innovation. Patel et al. (2014) stressed entrepreneurial orientation as a strategic posture to increase competitiveness by developing radically innovative products. Firms seek to improve business performance by acquiring, assimilating, transforming, and applying external knowledge. Investments in IT infrastructure are undoubtedly a precursor to this realization (Kim, 1995), and turbulence in the environment adds to the contextuality of this phenomenon. In the given context, it is imperative to comprehend how environmental uncertainty and IT investments interact, as this knowledge is vital for strategic decision-making and achieving sustainable performance.

First, it is essential to acknowledge that environmental uncertainty presents both challenges and opportunities that have the potential to exert a substantial influence on the outcomes of investments in information technology (Sabherwal et al., 2019). The presence of significant uncertainty can impede the efficacy of investments in information technology (IT) by introducing various complexities, risks, and obstacles that hinder the successful implementation and utilization

of technological solutions (Simerly & Li, 2000). On the other hand, under specific conditions, the presence of environmental uncertainty can give rise to prospects for organizations to strategically utilize IT investments strategically, thereby facilitating their ability to adjust, innovate, and attain a competitive advantage within a dynamic marketplace (Turulja & Bajgoric, 2019). Investigating the moderating influence of environmental uncertainty offers valuable insights into the strategies organizations can employ to effectively navigate uncertain conditions and maximize the benefits derived from their investments in information technology.

Second, in contexts characterized by significant technological uncertainty, investments in information technology (IT) could yield a more pronounced positive effect on organizational performance because companies allocate resources towards adopting state-of-the-art technologies to maintain a competitive edge (Carr, 2003; Chae et al., 2014). However, during periods of market instability, the correlation between investments in information technology (IT) and the performance of a firm may become more intricate, as uncertainties have the potential to impact market demand and competitive dynamics. Gaining a comprehensive understanding of these intricacies enables organizations to customize their IT investment strategies according to their environmental uncertainties.

Finally, it is imperative to consider the external context when examining the correlation between IT investments and firm performance. Environmental uncertainty plays a significant role in influencing the outcomes of IT investments as it interacts with these investments within a given context (Sabherwal et al., 2001; Sabherwal et al., 2019). Organizations must carefully evaluate the alignment between their IT investments and the current level of environmental uncertainty to optimize the value derived from these investments (Sabherwal & Chan, 2001). By examining the moderating influence of environmental uncertainty, scholars and professionals can enhance their

comprehension of the circumstances in which investments in information technology (IT) result in enhanced organizational performance. Furthermore, this analysis enables the identification of approaches to alleviating the adverse consequences of uncertainty.

Considering the gap in the literature, the objectives of this study are as follows: to determine the impact of investments in IT on the financial performance of firms; to investigate the moderating role of environmental uncertainty in the relationship between IT investments and firm performance. Our study is based on a sample of 2000 US public firms listed in Compustat, which also provides the financial measures of firms.

1.3 Contributions

Our research makes two major contributions to the literature on IT infrastructure and business performance. First, this study resolves the inconsistencies in the findings of the current IT-value research body by analyzing the influence of the primary components of IT investments- *hardware and software expenditures*- on firm financial performance. As far as current understanding permits, this investigation is the first to represent the initial attempt to introduce explicit delineations for the dual of IT investment. Detailed analysis and applying quantitative approaches aim to provide empirical data and insights into the relationship between IT investments and financial consequences. This study's findings can influence decision-making processes and resource allocation techniques, allowing firms to optimize their IT investment decisions and improve their financial performance. It adds to the body of knowledge on the worth and effectiveness of IT investments by explaining how IT resources can deliver verifiable financial advantages for businesses.

And second, this study illuminates the contextual factors that determine the impact of IT investments on firm performance by considering the moderating influence of environmental uncertainty. This perspective transcends the traditional notion of a linear correlation between investments in information technology and organizational performance and recognizes the significance of factoring in the external context. The impact of IT investments on firm performance can be analyzed through the context-specific lens of environmental uncertainty. The statement acknowledges that the efficacy and consequences of information technology investments may fluctuate based on the degree of unpredictability in the surrounding milieu. It also underscores the significance of strategic congruence between IT investments and the external milieu.

The rest of the paper is organized as follows. The second chapter consists of a thorough literature review summarizing the studies. The third chapter is dedicated to theory and hypotheses development. The fourth chapter explains data and analysis. The fifth chapter presents the discussions and conclusions of this study. Finally, the sixth chapter provides recommendations for future studies.

2. LITERATURE REVIEW

This section provides a comprehensive literature review conducted in two streams of literature. We draw upon the arguments from the resource-based view (RBV) of a firm (Barney, 1991) and the interpretations provided by Amit and Shoemaker (1993) that firms create value by using their capabilities to leverage their resources and firms' environmental *and internal or external* conditions affect its ability to do so (Wade & Hulland, 2004). Against this backdrop, we express how IT investments and environmental uncertainty fit together in the context of RBV. Specifically, our focus is to explicate the role environmental uncertainty as the *environmental condition* in transforming IT investments into organizational outcomes. A list of detailed investigations on the performance impact of IT investments and environmental uncertainty are presented in the table A.1 and A.2 in the Appendix.

2.1 IT Investments and Firm Performance

The relationship between IT expenditure and firm performance has been a topic of interest for researchers and practitioners for many years. While some studies have found a positive relationship between IT spending and firm performance, others have found no significant or negative relationship. This literature review aims to provide a chronological overview of the state of research on the relationship between IT expenditure and firm performance and highlight key findings and research gaps in the field.

Theoretical frameworks that have been used to explain the relationship between IT expenditure and firm performance include the resource-based view (Armstrong & Shimizu, 2007; Lockett et al., 2009; Lin & Wu, 2014), the contingency theory (Yang & Jiang, 2023; Otley, 2016; Deng & Smyth, 2013), and the information processing theory (Hsu et al., 2013; Qrunfleh &

Tarafdar, 2014). The resource-based view suggests that IT investments can lead to sustained competitive advantage by providing valuable and rare resources that are difficult to imitate (Wernerfelt, 1984). The contingency theory suggests that the effectiveness of IT investments depends on the fit between IT and organizational context, including factors such as size, strategy, and environment (Tosi & Slocum, 1984). The information processing theory suggests that IT investments can improve firm performance by enabling better information processing and decision-making (Grant, 1996).

2.1.1 Early stage of IT-value research

Empirical studies have provided mixed results on the relationship between IT expenditure and firm performance. A study conducted by Bender (1986) found that 15% to 25% of total costs should be invested in information processing at the optimal level. The insurance businesses whose organizational performance improved the greatest (operating expenses to premium income) devoted a much higher proportion of their noninterest operating expenses to IT, according to a study based on four years of historical data (Harris and Katz 1988, 1991). Another study by Melville et al. (2004) found that IT investments were positively associated with firm performance in the banking industry.

However, other studies have found a complex, insignificant, or negative relationship between IT expenditure and firm performance. For example, in a study of warehousing companies, Cron and Sobol (1983) found that firms with extensive computer users were either very strong or weak financial performers. This finding supports the strategy literature section that emphasizes the significance of strategic position (PIMS 1984, Strassmann 1985). A study by Brynjolfsson (1993) found no significant relationship between IT spending and productivity in the US economy, while

a study by Loh and Venkatraman (1992) found a negative relationship between IT spending and profitability in the US manufacturing industry. Other research did not find a correlation. In a study of 58 banks, Turner stated that "unexpectedly, there is no correlation between organizational effectiveness and the share of resources committed to data processing" (Turner, 1985). In a study of 165 branches of a California bank, Lucas (1975a) discovered that the use of the information system "did not explain a significant amount of performance variation." In a second study of a manufacturer of ready-to-wear garments, Lucas (1975b) showed a "poor correlation" between performance and the use of computer systems.

The issue's essence is whether IT investment yields a return (Lucas, 1975; Turner, 1985). The solution relies on the strategy and linked sector, rivals, environmental instability and market structure, technological qualities of a company, the degree of diversity and vertical integration, and, of course, one's personal preferences. The foundational question posed in their case study was whether IT investment could have a unique effect on the firm performance and whether this effect's pronunciation varies across industries. The commonly used measures of the levels of investment in IT included the MIS budget, a percentage of revenues, total staff, and a ratio of hardware expenditures to personnel costs. Substitute measures used in the prior studies included computer ownership, the number of common application areas computerized, and the type of application areas computerized. Bender (1986) divided IT investment into multiple components: people, hardware, and environment, and found a significant relationship between performance, but no significant relationship was found between the latter and software expenditures. Relevant studies like the one conducted by Cron and Sobol (1983) investigated the impact of IT expenditures on the performance of the housing industry, and the results found were aligned with strategic planning. Another four-year study by Harris and Katz (1988) revealed that the most profitable

firms are likelier to spend a higher proportion of their noninterest operating expenses on IT. Both studies needed to establish causality between expenditures and performance due to the inability to generalize their results beyond a particular industry, the methods of measuring investment and performance, and the units of analysis. A further weakness was generated from the fact that no distinction was made among the different types of IT investments made by these firms, which could influence different aspects of firm performance.

As a result of their study, they coined IT investment in three different dimensions: strategic, informational, and transactional IT investment. Strategic IT alters a company's product or competitiveness over time. Informational IT provides the organization's communication and information infrastructure, while transactional IT facilitates operational management with a short-term ROI and the processing of repetitive transactions. Each sort of IT investment has a distinct aim and period. This research focuses primarily on informational IT investments.

Mahmood and Mann (1993) discussed in their study a list of investigations that enquired about the relationship between IT expenditure and organizational performance. The rationale of their study was based on two significant areas for improvement of the previous research. First, the studies needed a conceptual framework to research this association. And second, they needed to identify relevant and accurate measures to operationalize the participating constructs. They proposed five measures to operationalize IT investment: ratio of IT budget as a percentage of revenue, value of organization's IT as a percentage of revenue, percentage of IT budget spent on staff, percentage of IT budget spent on the training of IT staff, and the number of PCs and terminals as a percentage of total employees. To operationalize firms' performance, they employed return on investment (ROI), return on sales (ROS), growth in revenue (GINR), sales by total assets (SBYTA), and market-to-book value (MVTOBV). The results of their study suggested a weak

correlation between IT investment measures and organizations' strategic and economic performance. However, they emphasized that the relationship could be improved if different IT measures were combined.

Mahmood (1994) conducted a follow-up study extending on the claim by Brynjolfsson (1993) about firms failing to shrink the gap between IT investments and expected returns. They stated that a rise in IT spending, even during the economic turndown, resulted in an increasing number of senior executives requesting that IT play a more prominent role in determining their company's success by assisting them in achieving better organizational efficiencies and, potentially, competitive advantage. On the other hand, existing information systems literature on IT investment and strategic organizational success was limited to top executives making IT investment decisions. He employed data envelopment analysis to provide more substantial evidence linking IT investment to organizational strategic and economic performance using eight IT investment metrics and ten strategic and economic performance ratios. They concluded their study by differentiating firms into efficient and inefficient groups. The firms in the efficient group received a significantly higher return on their information technology investment than those in the inefficient group. Furthermore, the DEA results identify an inefficient company's inputs and poor outputs, allowing a top manager to take corrective action. Furthermore, the DEA results pinpoint an inefficient firm's inefficient inputs and deficient outputs, allowing a senior manager to take corrective actions to compensate for the situation.

Extending on the claim by Bynjolfsson (1993), Mitra and Chhaya 1996 investigated the cost factors that are affected by IT investments. They found that higher investments in information technology were associated with lower average production costs, lower average total costs, and higher average overhead costs. They also found that larger companies spent more on information

technology as a percentage of their sales than smaller companies. However, they did not link information technology investments and lower labor costs. The analysis results of their study are deprived of causality.

The Hitt and Brynjolfsson (1997) study diverged from the standard research examining how IT investments affected businesses' economic and strategic performance. Instead, they conducted an exploratory study to evaluate the relationship between organizational structure and information technology usage. They emphasized a set of organizational procedures businesses use due to considerable information technology utilization. Decentralization of decision-making authority (designated as decision rights (DR)), a focus on subjective incentives (designated as incentives (IN)), and a more extensive reliance on human capital (designated as knowledge work and inputs (KW)) are some of these approaches. They reasoned that the marginal benefit of adopting one set of practices grows when more practices are adopted. It is generally associated with a functioning system with decentralized authority, incentives based on decreasing observability, and the increasing relevance of knowledge workers.

2.1.2 Operationalization of the Variables

Bharadwaj et al. (1999) identified a flaw in how earlier studies measured businesses' financial performance. They developed theories and analytical justifications for the ambiguity in the relationship between IT investment and corporate business performance. The unexpected results were primarily attributable to the characteristics of the sample used, measurement difficulties, and omission of other industry- and business-specific factors (Weill, 1992; Ahituv & Giladi, 1993; Brynjolfsson & Hitt, 1996). The discussion of methodological concerns revolves around the question of what measurements should be employed to assess a company's profitability. Although

there have been various rate-of-return indicators used in IT-business value studies, they have primarily been based on historical accounting measures like Return on Assets (ROA), Return on Equity (ROE), and Return on Sales (ROS). As a result, they switched from using an accounting-based metric to a market-based measure, *Tobin's q,* to operationalize business performance, and forecasts a company's upcoming investments. In their research, they found that three categories of variables—(a) information technology capabilities, (b) firm-specific factors unrelated to IT, and (c) industry structure variables—all contribute to a firm's q ratio and that the IT ratio was positively related to q ratio for all the years that were included in their study.

Based on visible anecdotal evidence, several studies were conducted to validate the positive association between IT spending and a firm's performance. For instance, Stolarick (1999) emphasized the economic significance of IT expenditure on firms' financial performances. Specifically, he questioned the magnitude of this relationship, which in many ways, is not what it is expected to be. He investigated plant-level productivity as a function of spending on IT, and he found that although there is support for the idea that lower productivity plants spend more on IT in order to compensate for their productivity shortcomings, management skill is as much crucial if not more, of a contributor to improve plant-level productivity. Sircar et al. (2000) introduced a framework that shows the relationship between firm performance and IT and corporate investments. They established better statistical validation by improving the quality and quantity of the dataset used. Consistent with the previous literature, they used seven measures of firm performance related to sales, assets, and market value and computed them as a function of seven IT and corporate investment measures. They concluded their study by describing a solid connection between these investments and the financial performance of firms, and determining that spending on staff training, both IS and non-IS, has a stronger positive correlation with the

performance. Teo et al. (2000) extended Weill (1990) to address the question, "Do computers payoff?". They categorized IT investment into four management objectives: transactional, strategic, informational, and threshold, and attempted to understand their role in traditional, evolving, and strategic firms. They found that the firms adopting a traditional role favor investment in transactional IT as an investment in this dimension of IT improved internal efficiency due to cost-cutting.

Bharadwaj (2000) addressed the bidirectional relationship between IT investments and firm performance by taking a resource-based view of the firm and proposing a theoretical explanation for this correlation. The first empirical study, the resource-based theory of the corporation, claims that organizations compete based on "unique" corporate resources that are prized, scarce, difficult to reproduce, and incomparable to other resources (Barney, 1991; Schulze, 1992). While creating, selecting, and executing strategies, it considers that firms' resources are not evenly distributed and that firm variances do not vary with time (Barney, 1991). Researchers have identified some IT-related resources as potential sources of competitive advantage. Management IT abilities, for example, are unusual and firm-specific, according to Mata et al. (1995), making them likely to be sources of long-term competitive advantage. According to Ross et al. (1996), reusable technology (a technical asset) and strong cooperation between information technology and business unit management influence a firm's ability to utilize information technology for strategic goals (a relational asset).

Hendersen et al. (2010) departed from the conventional IT-value investigation and considered whether IT investments' economic implications merit separate disclosure within financial statements. They provided evidence that disclosing information about IT expenditures has a strong predictive power over organizational performance in the form of its market value.

Including accounting measures, the downturn in equity markets, and skepticism about the potential for IT investments to continue to add to firm value diminished the IT's role in firm success. However, the proportion of investments in IT over sales increased gradually over the years.

2.2 Environmental Uncertainty

The notion of environmental uncertainty has received considerable interest within strategic management and organizational research disciplines, including information systems (Pavlou et al., 2007; Richard et al., 2019), marketing (Ashill & Jobber, 1999), and management (Waldman et al., 2017; DeSarbo et al., 2005). The term pertains to the complexity, and the lack of predictability in the surrounding environment, characterized by rapid changes, fluctuating market dynamics, technological progressions, regulatory modifications, and competitive constraints (Duncan, 1972). Comprehending environmental uncertainty is paramount for organizations as it influences their strategies, decision-making procedures, resource allocation, and overall performance (Koberg & Ungson, 1987; Vecchiato, 2012; Koberg, 2017).

Scholars have posited various conceptualizations of environmental uncertainty. Lawrence and Lorsch's (1967) classification of environmental uncertainty is utilized to understand the phenomenon, and a significant amount of work has been put into these three dimensions: complexity, dynamism, and munificence (McArthur & Nystrom, 1991; Goll & Rasheed, 2004; Chen et al., 2017). According to these studies, complexity pertains to the number of constituents and interrelationships within a given setting; dynamism denotes the pace of change in said environment; and munificence pertains to the abundance of resources accessible within the context. Duncan's (1972) framework is frequently employed and differentiates between environmental complexity and instability. The concept of complexity pertains to the presence of a

wide range of heterogeneous and diverse environmental factors, whereas instability pertains to the volatility and unpredictability of the environment (Goll & Rasheed, 1997).

2.2.1 Theoretical Perspective of environmental uncertainty

The Contingency Theory offers a robust conceptual framework for comprehending the correlation between environmental unpredictability and the consequences for organizations. The theory posits that the efficacy of management methodologies and frameworks is contingent upon the congruity between the surrounding environment and the distinctive attributes of the organization (Lawrence & Lorsch, 1967; Tosi et al., 1973). The contingency theory emphasizes the importance of organizational adaptation of strategies, structures, and processes to correspond with the particular uncertainties encountered (Tosi et al., 1973). Organizations may benefit from implementing mechanistic structures and standardized processes in stable environments. Conversely, in situations characterized by high levels of uncertainty, organic structures and decentralized decision-making may be more appropriate (Duncan, 1973; Gordon & Narayanan, 1984; Koberg, 1987).

2.2.2 Drivers of Environmental Uncertainty

Environmental uncertainty can manifest from diverse origins and sources, such as technological advancements, market dynamics, consumer behavior, regulatory policies, and competitive strategies (Lawrence & Lorsch, 1967; Chawla et al., 2012; Yayla, 2008; Udenio et al., 2018). The advent of technological progressions, such as digital disruption, can have a substantial influence on various industries, leading to a state of unpredictability by modifying pre-existing business models and competitive environments (Bstieler, 2005). Moreover, globalization and geopolitical

considerations may engender ambiguity as enterprises encounter obstacles associated with global markets, commercial regulations, and governmental instability (Darvishmotevali, 2020).

2.2.3 Impact of Environmental Uncertainty

Organizations are significantly impacted by environmental uncertainty. According to existing research, heightened levels of uncertainty can disturb established routines, amplify risk and ambiguity, and pose obstacles to the process of making strategic decisions (Duncan, 1973; Koberg, 1987; Garg et al., 2003). Organizations that operate in ambiguous environments encounter challenges in precisely forecasting customer requirements, recognizing market trends, and harmonizing their approaches with constantly changing circumstances. Nevertheless, environmental uncertainty can offer innovation, expansion, and competitive edge prospects to organizations that can adjust and take advantage of alterations (Ye & Zhang, 2023). Following are the contradictory findings about how environmental uncertainty affects business performance.

According to Simerly & Li (2000), environmental dynamism affects performance in a way that competitive environments weaken the impact of capital structure on organizational performance while considering leveraging the intensity of the firm. Conversely, the same authors in 1998 concluded that for the firms in the industry experiencing environmental dynamism to a substantial extent, the ownership structure of the top management team improves the business performance. Organizational reconfiguration is yet another consequence of perceived turbulent environments. For instance, Girod & Whittington (2017) concluded in their study that while the more pervasive restructuring is associated with positive performance outcomes, and the more limited reconfiguration is associated with adverse performance outcomes, environmental dynamism flips the impact of reconfiguration and restructuring on the organizational outcomes.

Conversely, Turulja and Bajgoric (2019) investigated the impact of environmental turbulence on product and process innovations, and their findings showed that a turbulent environment does not moderate the relationship between innovation and business performance. However, they found a clear role of environmental turbulence in boosting innovation instead of moderating the relationship, otherwise.

2.2.4 Response to the Uncertainty

Organizations utilize diverse tactics to manage and address environmental ambiguity. Scholarly investigations have identified several strategic responses, such as flexibility, diversification, strategic alliances, information acquisition, and organizational learning (Krishnan et al., 2014; Yu et al., 2023; Patel, 2011; Yap et al., 2013; Richard et al., 2019). Flexibility confers the ability to swiftly modify strategies and operations to organizations, whereas diversification mitigates reliance on a solitary market or product (Krishnan et al., 2014). The formation of strategic alliances enables organizations to distribute risks and resources effectively (Patel, 2011). Additionally, the acquisition of information and the process of organizational learning facilitate the collection and utilization of pertinent information, which is crucial for making well-informed decisions in ambiguous and unpredictable settings (Richard et al., 2019; Chang et al., 2022). Based on the extensive body of literature that emphasizes the significance of a sustained impact of environmental uncertainty on organizational performance, we contend that the association between investments in information technology (IT) and organizational performance is subject to the influence of uncertainty.

3. HYPOTHESES

3.1 IT and Firm Performance

The resource-based view of the firm, which characterizes the business entity as a collection of resources, is founded on Penrose's (1959) work. Penrose believes that a company's expansion is both constrained and aided by its management's efforts to maximize returns on investment. Barney (1991) offers a clear and formalized explanation of this point of view. According to a resource-based view of the firm, its resources and capabilities are the primary drivers of its competitive advantage (Wernerfelt, 1984). These viewpoints contend that firms can use their different resources and capabilities to create value and gain a competitive advantage.

IT investments have been shown to improve firm performance through various methods and channels. First, IT investments boost operational productivity and efficiency (Rosen et al., 2021). Advanced information systems and technology improve workflow management by streamlining corporate processes, automating repetitive tasks, and streamlining business processes (Sabherwal et al., 2019), which leads to enhanced efficiency, lower costs, and more production, allowing organizations to manage resources better, and optimize their operations. Furthermore, IT expenditures enable better data management and analysis, which aids in informed decision-making and strategic planning (Ghasemaghaei, 2019). Managers can make data-driven decisions, spot market trends, and respond rapidly to altering customer expectations and competitive landscapes using real-time and precise information.

Second, IT investments promote innovation and competitiveness. Technology is critical in promoting creativity in organizations. Businesses that invest in R&D can develop unique goods, services, and business models that set them apart from their competitors (Choi et al., 2021). IT investments help organizations to embark on digital transformation efforts, discover new

development opportunities, and enter emerging markets (Sadeghi et al., 2021). Furthermore, IT investments promote employee collaboration and knowledge exchange, which fosters an innovative and creative culture.

Finally, investments in information technology boost customer pleasure and experience. Consumers increasingly want consistent and tailored experiences across all touchpoints in the digital era. Investments in information technology allow organizations to better customer relationship management, launch focused marketing initiatives, and provide more excellent customer service (Otto et al., 2019). Customer-centric information technology solutions, including CRM systems and e-commerce platforms, improve customer experience, promote customer loyalty, and stimulate revenue growth. Businesses that effectively leverage technology may optimize their processes, stimulate innovation, and maintain a competitive edge in ever-changing markets. However, effective IT investment implementation and integration necessitate strategic planning, change management, and alignment with overall business objectives. So, we hypothesize:

H1: (a) Total, (b) Software, and (c) Hardware budgets are positively associated with firm performance, ceteris paribus.

3.2 The Effect of Environmental Uncertainty

Environmental uncertainty has received a good amount of attention across multiple disciplines like information systems (Pavlou et al., 2007; Richard et al., 2019), marketing (Ashill & Jobber, 1999), and management (Waldman et al., 2017; DeSarbo et al., 2005). Consistent with the prior literature (Chen et al., 2015; Goll & Rasheed, 2004), we visualize uncertainty in terms of dynamism, complexity, and munificence. Just like a well-established body of literature on IT-value link, previous investigations on understanding the role of environmental uncertainty in organizational

performance have yielded mixed results (Yayla & Hu, 2012; Chang et al., 2008; Choe, 2003; Kears & Lederer, 2001; Turulja & Bajgoric, 2019). We argue that uncertainty moderates the relationship between investments in IT and firm performance. Precisely, a turbulent environment composed of increased dynamism and complexity and decreased munificence should pronounce the impact of IT investments on financial performance for the following reasons.

First, Adaptability to Changing Environment: Environmental uncertainty refers to the unpredictability and complexity of the external business environment, including market dynamics, technological advancements, competitive landscape, and regulatory changes (Cullen et al., 2014). In highly uncertain environments, IT investments can enable firms to enhance their ability to adapt and respond to changes quickly (Ramamurthy, 2011). IT systems, such as flexible software platforms, data analytics tools, or cloud infrastructure, can help organizations quickly gather and analyze information, make informed decisions, and adjust their strategies accordingly (Hashem et al., 2015). Thus, in the face of environmental uncertainty, IT investments can positively impact firm performance by enabling greater adaptability and agility.

Second, Competitive Advantage: IT investments can provide a competitive edge by improving operational efficiency, supporting innovation, enabling superior customer experiences, or facilitating new business models (Hayes, 2006; Fichman, 2004; Ray et al., 2005). However, the impact of IT investments on firm performance can vary depending on the level of environmental uncertainty. In stable and predictable environments, IT investments may contribute to incremental improvements in performance (Garg et al., 2003). However, IT investments can be precious in highly uncertain environments as they can help firms navigate and capitalize on emerging opportunities or mitigate risks associated with environmental changes (Sabherwal et al., 2019).

Leveraging IT investments effectively in uncertain environments can lead to a more decisive competitive advantage and improved firm performance.

Third, Resource Allocation and Risk Management: Environmental uncertainty can influence the allocation of resources, including financial resources, human capital, and managerial attention (York & Venkataraman, 2010; Skaggs & Youndt, 2004). In uncertain environments, firms may face competing resource demands, and allocating resources to IT investments becomes a strategic decision. Organizations need to carefully assess the risks and potential benefits associated with IT investments in the context of environmental uncertainty. For example, in turbulent environments, firms may prioritize investments that enhance flexibility (Vecchiato, 2015), scalability (Kipley & Lewis, 2009), or risk mitigation capabilities (Trkman & Cormack, 2009). The alignment of IT investments with the specific needs and challenges posed by environmental uncertainty is crucial for optimizing resource allocation and mitigating risks affecting firm performance outcomes.

Finally, *Industry and Market Factors:* The impact of environmental uncertainty on the relationship between IT investments and firm performance can also depend on industry-specific factors. Different industries face varying levels of environmental uncertainty, regulatory requirements, technological disruptions, or market dynamics (Buganza & Verganti, 2006; Narasimha, 2001). IT investments can be particularly influential in industries where rapid technological advancements or digital transformation are critical drivers of competitive advantage. In such industries, firms that effectively leverage IT investments to navigate uncertainty and capitalize on emerging opportunities tend to outperform their peers. The consequences mentioned above apply to all the three dimensions of environmental uncertainty- dynamism, munificence, and complexity.

3.2.1 Dynamism

The notion of environmental dynamism is centered on the notion that the level of stability or instability in an organization's external environment can have significant consequences for its operational and decision-making procedures. According to Pfeffer (1974) and Jurkovich (1974), turnover, absence of patterns, and unpredictability are significant indicators of environmental instability. They define *dynamism* as encompassing unpredictable changes that intensify the degree of uncertainty. As the level of task uncertainty escalates, decision-makers are required to engage in more extensive information processing to attain the desired performance levels. Galbraith (1973) emphasizes the importance of information processing and adaptive strategies in addressing increased levels of task uncertainty.

Similarly, Aldrich (1979) posits that the presence of environmental turbulence, which is marked by externally instigated changes, may pose difficulties for administrators in terms of both comprehension and strategic planning. Emery & Trist (1965) and Terryberry (1968) have argued that the introduction of changes from the external environment of the residual organization presents considerable obstacles in planning and adaptation. The authors contend that as industrial economies progress, there is a growing level of interconnectedness within an organization's residual environment. Consequently, this heightened interconnectedness poses challenges in effectively anticipating and responding to changes.

In general, the notion of environmental dynamism emphasizes the significance of acknowledging and adjusting to unforeseen and externally induced fluctuations in an organization's surroundings. Organizations can enhance their resilience and long-term success by comprehending and effectively managing the intricacies of a dynamic environment, thereby equipping themselves to tackle uncertainties and challenges (Guan et al., 2023). Hence, we

hypothesize that investments towards information technology enhances an organization's resilience and capabilities to stand shocks.

H2a: Dynamic environment will positively moderate the relationship between IT investments and firm performance. Specifically, IT investments will be associated with improved productivity in dynamic environments.

3.2.2 Munificence

The notion of environmental munificence pertains to the degree to which an organization's external environment can facilitate long-term growth and stability (Dess & Beard, 1984). Organizations proactively pursue environments that offer expansion prospects, enabling them to generate extra resources (Cyert & March 1963) used to fulfill multiple functions, including preserving organizational coalitions, facilitating innovation, and resolving conflicts within the organization, as observed by Bourgeois.

The significance of the product-evolution cycle, as identified by Hofer (1975), is paramount in determining a suitable business strategy. The sales growth rate is the principal variable in this cycle, influencing market growth and allowing organizations to enhance their competitive position or broaden their scope. The relationship between industry profitability and organizational performance has been substantiated by empirical research. For instance, Beard and Dess (1981) conducted a study that revealed that the influence of the industry's return on equity on the firm's return on equity was more significant than other factors, including firm size, capital expenditure, and leverage.

In general, environmental munificence underscores the importance of pursuing environments that promote growth and stability. Organizations can strategically leverage opportunities in such environments to amass surplus resources and strategically position themselves to succeed. Organizations must comprehend the correlation between environmental abundance, industry profitability, and organizational performance to develop effective strategies and prosper in ever-changing business environments. Hence, we hypothesize the following:

H2b: Munificent environment will positively moderate the relationship between IT investments and firm performance. Specifically, IT investments will be associated with enhanced organizational performance in munificent environment.

4. DATA AND ANALYSIS

4.1 Data Collection and Sampling

The study was conducted using data from two sources: Compustat and Aberdeen Group LLC. First, Standard & Poor's COMPUSTAT is a reliable source of firms' financial data and has been consistently used in various research studies (Mithas et al., 2012; Bharadwaj, 2000; Hitt & Brynjolfsson, 2017). The specific variables employed by Compustat include net sales, cost of fixed assets, number of employees, R&D expenditures, and advertising expenditures.

Table 4 specifies the ten industry divisions and their distribution across the dataset.

Table 4: Industry Divisions

Division	Industry	Frequency
A	Agriculture, Forestry, And Fishing	22
B	Mining	522
C	Construction	95
D	Manufacturing	3458
E	Transportation, Communications, Electric, Gas, And Sanitary Services	641
F	Wholesale Trade	247
G	Retail Trade	508
H	Finance, Insurance, And Real Estate	509
I	Services	1754
J	Public Administration	22

There are ten industry classifications in the dataset, and there can be three interpretations from it. First, there are two industries, (i) agriculture, forestry, and fishing, and (ii) public administration, with slightest appearance in the dataset. Second, firms belonging to manufacturing industries appear the highest in the dataset. Third, firms belonging to the rest of the industry sectors are equally distributed on frequency.

Finally, Aberdeen Group, which operates under Crunchbase, assists B2B technology firms to expand and accelerate their sales and marketing processes by offering content, expertise, data, and applications. As a prominent provider of solutions based on behavioral analysis, Aberdeen helps businesses enhance revenue growth by identifying, prioritizing, and engaging potential customers. Their solutions utilize a combination of buyer intent information, data science, and analyst insights to ensure that clients address ethical concerns at the appropriate stage of the buying journey. For our study, we obtained permission to access the Aberdeen database. Aberdeen provided us with a research dataset consisting of multiple interconnected tables that can be linked using unique identifiers.

4.1.1 Data Preprocessing

First, we combined IT Spend and Site Level Enterprise tables to generate the IT expenditure dataset for businesses used in our analysis. We were given a sample for the years 2016-2020. The format for the data was consistent from 2016 to 2019. However, the data for 2020 followed a different pattern, so it was not included in the analysis.

Second, the businesses in the dataset are from different nations and were geographically located in four different ways: standalone, branch, headquarters, and ultimate headquarter. First, we limited our search to businesses in the United States to limit our sample to the firms in the United States. Second, we removed standalone firms from the dataset because they did not represent a company. Each company's location, including its branches, headquarters, and ultimate headquarters, was assigned a unique site id. We used the site id, the primary key in both tables, to merge the site-level data with the ITSpend dataset. Finally, based on the business names in the dataset, the various budgets mentioned for companies were summed up.

Third, the processed dataset needs to be combined with the Compustat dataset. The Aberdeen and Compustat datasets' lack of a shared attribute made their merging. As a result, we used a method suggested by Pian Shu (2019) to clean the company names in both datasets and convert them into a consistent format. The cleaning process was applied to both datasets. The two datasets were merged, yielding a final dataset with a unique company identifier, gvkey, associated with each company. The final dataset we obtained contained 7,140 firm-year observations.

4.2 Variables

4.2.1 IT Investment

IT investments are crucial in shaping organizational performance and competitiveness in today's digital age. Organizations across various industries invest substantially in information technology to enhance operational efficiency, innovate processes, and gain a competitive edge (Brynjolfsson & Hitt, 1998; Melville et al., 2004). IT investments encompass a wide range of expenditures, including hardware, software, infrastructure, and human resources, aimed at leveraging technology to drive organizational success.

The present investigation involves the categorization of IT investments into hardware and software budgets. These categories were established by aggregating the individual expenditures that constitute each category, as outlined in Table 3 in Appendix, and we employed deflated investments to operationalize the IT investment construct. *Investment deflation* is a measure used to adjust investment data for the effects of inflation. It helps to isolate changes in investment spending by removing the impact of changing price levels over time. Investment deflation is applied to investment expenditures to reflect actual, inflation-adjusted terms changes. By deflating investment data, economists can assess the valid changes in investment levels and determine

whether there has been an increase or decrease in investment activity independent of inflationary effects. The investment deflator is calculated by dividing the current value of investment expenditures by the value of investment expenditures in a base year and multiplying by 100 to express the result as a percentage, resulting in a measure of the change in investment after adjusting for changes in the general price level. An investment deflator is a vital tool in economic analysis as it allows for comparisons of investment activity over time and across different periods, accounting for the impact of inflation. It helps economists and policymakers to understand investment trends better, make informed decisions, and analyze the dynamics of investment in the economy.

4.2.2 Productivity

Measuring and analyzing firm productivity have long been a subject of great interest for researchers, policymakers, and practitioners in various fields, including economics, management, and industrial organization (Topalova & Khandelwal, 2011; Cassiman et al., 2010; Konrad & Mangel, 2000). Firm productivity is a vital indicator of an organization's efficiency, competitiveness, and overall market performance (Xu et al., 2021; Chen & Guariglia, 2013). Understanding the determinants and drivers of firm productivity is crucial for making informed business decisions, developing effective strategies, and fostering economic growth (Bartel & Shaw, 2007; Brynjolfsson & Hitt, 2003).

This study selects firm productivity as the dependent variable of interest. Productivity represents a firm's capacity to convert inputs, such as labor, capital, and technology, into valuable outputs, reflecting its efficiency in resource utilization for generating goods or services (Chen & Guariglia, 2013; Brynjolfsson & Hitt, 2003). By examining the factors influencing firm

productivity, researchers can shed light on the mechanisms contributing to superior performance and identify areas for improvement (Bartel & Shaw, 2007; Chen & Guariglia, 2013).

Analyzing firm productivity provides valuable insights into the effectiveness of diverse management practices, technological advancements, industry dynamics, and policy interventions (Topalova & Khandelwal, 2011; Konrad & Mangel, 2000). It enables organizations to benchmark their performance against industry peers and identify best practices that can be adopted to enhance productivity. Moreover, policymakers can utilize findings on firm productivity to design targeted policies to foster economic growth and improve competitiveness (Hayakawa et al., 2010).

For this study, we operationalized productivity based on a method used in economics to adjust sales data for changes in inflation. The GDP deflator reflects the average price level of all goods and services produced in an economy relative to a base year. We divide the sales value by the GDP deflator to adjust sales data for changes in the general price level. This measure removes the effects of inflation, providing a measure of sales in real, inflation-adjusted terms. By dividing sales by the GDP deflator, the resulting value represents the sales volume or quantity of goods and services adjusted for price changes over time.

Finally, the deflated sales were divided by the number of employees to measure the average sales per employee, indicating the level of productivity each worker achieved in generating sales. By measuring labor productivity, economists and analysts can assess the efficiency and effectiveness of the workforce in generating revenue or output. It provides insights into the output level that can be attributed to each employee, highlighting the productivity contribution of labor within the organization. Measuring labor productivity can help evaluate the efficiency of labor utilization, identify performance differences across firms or industries, and monitor productivity changes over time.

4.2.3 Environmental Uncertainty

The dimensions of environmental uncertainty are assessed by utilizing existing measures and COMPUSTAT data. Following previous scholarly works (Keats & Hitt, 1988; Xue et al., 2011), environmental dynamism is measured by assessing the level of volatility in industry sales. In this study, we conduct regression analyses on the logarithm of aggregate sales for each firm within a specific three-digit SIC industry code. The regression model includes a time index variable spanning four years (t, t-3). Next, the antilogarithm of the standard error of the regression coefficient is employed to quantify sales volatility, indicating a company's environmental dynamism.

Environmental munificence is assessed by examining the industry's sales increase, as indicated by previous studies conducted by Keats and Hitt (1988) and Xue et al. (2011). To accomplish this, we employ a regression analysis where the dependent variable is the natural logarithm of the total sales of the specific industry code, consisting of three digits, to which the firm is affiliated. This variable is regressed against an index representing the years spanning four years [t, t-3]. The antilogarithm of the regression coefficient is subsequently employed to quantify munificence.

4.2.4 Control Variables

Following the literature, we controlled for several variables to rule out alternative explanations and enhance the accuracy with which the relationships of interest are examined (Bharadwaj et al., 1999; David et al., 2008). *Capital intensity* represents the property, plant, and equipment level per employee. This ratio reflects the extent of capital investment relative to the workforce size. It has been asserted that corporations will only assume the risks of sunk investments when the potential

for corporate performance is significant (Bettis, 1981) and exit barriers are reflected in capital intensity. The finding that capital intensity and performance are positively correlated in Robins and Wiersema's (1995), we expect to have a positive correlation, too.

Capital structure refers to the degree of debt employed by a firm. It measures the proportion of a company's assets financed by debt, providing insights into the level of financial risk and the ability to meet debt obligations, and helps assess a company's financial health and risk profile. Following the prior work (Hitt et al., 1997), we expect that a firm's capital structure harms firm performance.

Firmage refers to the length of time a company has been operational, including it in the equation controls for the potential impact of a company's maturity on the dependent variable. It enhances the robustness of our findings by accounting for additional factors that may confound the relationship between the primary independent and dependent variables. Prior studies have shown that as they age, firms learn about their abilities and about how to do things better (Rossi, 2014). Hence, we expect the firm to be positively correlated with the performance.

Sale, or revenue, represents the total money a company generates through business activities. Employing sales as a control variable allows us to account for the potential impact of a firm's size or scale of operations. Positive sales growth is frequently regarded favorably by investors and stakeholders since it indicates that the company is gaining clients and creating income, which can result in increased investor trust, higher stock prices, and easier access to funds for future developments. Hence, we expect to see a positive correlation between sales and performance.

Industry concentration refers to the extent to which a small number of firms dominates a market or industry. Two theories link industry concentration and company performance. The concentration provides market power, which improves performance, according to the structure-

conduct-performance paradigm (Domowitz et al., 1986; Martin, 1983; Weiss, 1974). According to the efficient-structure hypothesis (Demsetz, 1973; McGee, 1974; Smirlock et al., 1984), higher performance is due to efficiency rather than market dominance. Montgomery and Wernerfelt (1988) note that concentration predictions depend on one's ideas about the structure-conduct-performance paradigm against the efficient-structure theory. We expect concentration's influence on performance may be negative following Montgomery and Wernerfelt (1988).

4.3 Data Description

Table 5 and Table 6 depict the operationalization and summary statistics of the key variable in this study, respectively. The correlation matrix of these variables is presented in the Table 7. The correlational matrix shows that Budget, SwBudget, and HwBudget have a 30% correlation in common. Given that both the hardware and software budgets are calculated using Budget, we anticipate that there will be a correlation. So, for the estimation, we examine these three budgets separately.

Table 5: Operationalization of the key variables

Variable	Operationalization	Source
Productivity	The natural logarithm of the ratio of deflated sales to the number of employees.	COMPUSTAT
Budget	The natural logarithm of the ratio of deflated summation of the overall expenditures made by a firm in eleven different categories to the number of employees.	Aberdeen
SwBudget	The natural logarithm of the ratio of deflated summation of software, IT, communication, and services budgets to the number of employees.	Aberdeen
HwBudget	The natural logarithm of the ratio of deflated summation of storage, server, terminal, printers, other hardware, pc, and hardware budgets to the number of employees.	Aberdeen
Dynamism	Variability in the value of shipments operationalized as the standard error of the regression slope coefficient if the shipments value divided by industry mean.	COMPUSTAT
Munificence	The growth rate in the value of shipments operationalized as the regression slope coefficient of the value of shipments.	COMPUSTAT
CapInt	The ratio of deflated property, plant, and equipment, gross to the number of employees to assess the level of investment in fixed assets.	COMPUSTAT
Leverage	The ratio of the summation of long-term debt and long-term debt current to the total assets	COMPUSTAT
FirmAge	The natural logarithm of the number of years a firm has been operational	COMPUSTAT
Sale	Logarithm of the deflated revenue generated by a company from its primary business operations	COMPUSTAT
HHI	Herfindahl-Hirschman Index to measure the degree of competition within an industry	COMPUSTAT

Table 6: Summary statistics of the variables

Variable	Obs	Mean	Std. Dev.
Productivity	7140	1.053	1.188
Budget	7120	9.747	2.026
SwBudget	7120	5.022	2.023
HwBudget	7095	2.725	2.003
Dynamism	7786	.024	.027
Growth	7786	.017	.082
HHI	7808	.158	.175
CapInt	6933	.387	1.728
Leverage	7655	.635	10.789
FirmAge	7644	2.682	.978
Sale	7699	1.025	2.756

Table 7: Correlation matrix of the key variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Productivity	1.000										
(2) Budget	0.342	1.000									
(3) SwBudget	0.343	1.000	1.000								
(4) HwBudget	0.341	0.996	0.995	1.000							
(5) Dynamism	0.233	0.082	0.082	0.086	1.000						
(6) Growth	-0.101	0.002	0.002	-0.008	-0.101	1.000					
(7) HHI	0.057	-0.031	-0.030	-0.038	0.124	-0.018	1.000				
(8) CapInt	0.540	0.180	0.180	0.183	0.331	-0.282	-0.072	1.000			
(9) Leverage	-0.089	0.009	0.009	0.009	0.008	-0.011	-0.029	-0.012	1.000		
(10) FirmAge	0.139	0.059	0.060	0.055	0.015	-0.085	0.145	0.180	-0.019	1.000	
(11) Sale	0.455	0.004	0.005	0.001	0.030	-0.049	0.170	0.200	-0.126	0.389	1.000

4.4 Empirical Analysis

We estimate the effect of IT Budget, on labor productivity according to the following specification:

$$(1) \qquad Y_{it} = \beta_0 + \beta_1\, Budget_{it} + \beta_2 CapInt_{it} + \beta_3 Leverage_{it} + \beta_4 FirmAge_{it} + \beta_5 Sale_{it} + \beta_6 HHI_{it} + a_i + a_t + u_{it}$$

where Y represents the productivity of firm *i* at time *t*; $Budget_{it}$ represents the IT expenditures of a firm *i* in year *t*, $CapInt_{it}$ represents the capital intensity of a firm *i* in time *t*, $Leverage_{it}$ represents the capital structure of a firm *i* in time *t*, $FirmAge_{it}$ represents the age of the firm *i* at

time t, $Sale_{it}$ represents the revenue generated by the firm i in time t, HHI_{it} represents the industry concentration for a firm i at time t, a_i represents a vector of firm FEs, a_t represents a vector of year FEs, and ϵ_{it} represents the idiosyncratic error term. In this study, β_1 is the main parameter of interest.

We also include firm fixed effects to control for unobservable factors that vary from firm to firm but constant over time, a_i, such as managerial quality, and we control the year dummies to control for the unobservable factors that vary from time to time but are constant across firms, a_t, such as business cycles. Accordingly, we specify our empirical models for testing our arguments about IT investments and environmental uncertainty as follows:

4.4.1 Analysis and Results

4.4.1.1 IT Investments and Productivity

To answer the first research question, we conducted fixed effects regression on productivity and investments. Table 8 - 11 present the results for testing the first hypothesis that investigates the correlation between IT investments and firm performance.

Table 8, 9, and 10 specify the models' results of OLS regression and industry fixed-effects estimation for total budget, software budget, and hardware budget, respectively. It is evident from the estimation results that IT expenditures are positively associated with productivity across all the models providing support for our first hypothesis. We added robust standard errors to account for potential violations of the assumption of homoscedasticity in the error terms. The details of the model specifications are discussed below.

Table 8 presents the results of OLS regression to estimate the relationship between productivity and total IT budget.

Table 8: OLS regression of performance and total budget

	Productivity			
Budget	0.154***	0.155***	0.125***	0.125***
	(0.00643)	(0.00655)	(0.00649)	(0.00660)
CapInt	0.286***	0.286***	0.234***	0.236***
	(0.00683)	(0.00683)	(0.0135)	(0.0135)
Leverage	-0.0231	-0.0231	-0.0225	-0.0223
	(0.0138)	(0.0139)	(0.0147)	(0.0147)
FirmAge	-0.147***	-0.147***	-0.110***	-0.109***
	(0.0113)	(0.0113)	(0.0119)	(0.0119)
Sale	0.173***	0.173***	0.183***	0.183***
	(0.00637)	(0.00637)	(0.00743)	(0.00742)
HHI	0.296***	0.298***	-0.0699	-0.0247
	(0.0546)	(0.0546)	(0.335)	(0.339)
cons	0.639***	0.664***	0.688***	0.691***
	(0.0383)	(0.0397)	(0.0662)	(0.0661)
Time FE	*No*	*Yes*	*No*	*Yes*
Industry FE	*No*	*No*	*Yes*	*Yes*
N	6865	6865	6856	6856
R^2	0.504	0.505	0.636	0.637

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Regression results of productivity and software budget are presented in Table 9, and those of productivity and hardware budget are presented in Table 10. We include year dummies (2nd and 4th column) to isolate the impact of potentially confounding variables over the years on productivity.

Table 9: OLS regression of software budget and productivity

	Productivity			
SwBudget	0.154***	0.156***	0.125***	0.125***
	(0.00643)	(0.00656)	(0.00649)	(0.00660)
CapInt	0.286***	0.286***	0.234***	0.236***
	(0.00683)	(0.00683)	(0.0135)	(0.0135)
Leverage	-0.0231	-0.0231	-0.0225	-0.0223
	(0.0138)	(0.0139)	(0.0147)	(0.0148)
FirmAge	-0.147***	-0.147***	-0.110***	-0.109***
	(0.0113)	(0.0113)	(0.0119)	(0.0119)
Sale	0.173***	0.173***	0.183***	0.183***
	(0.00637)	(0.00637)	(0.00743)	(0.00743)
HHI	0.295***	0.297***	-0.0686	-0.0249
	(0.0546)	(0.0546)	(0.335)	(0.339)
cons	1.369***	1.399***	1.278***	1.283***
	(0.0353)	(0.0393)	(0.0663)	(0.0668)
Time FE	*No*	*Yes*	*No*	*Yes*
Industry FE	*No*	*No*	*Yes*	*Yes*
N	6865	6865	6856	6856
R^2	0.504	0.505	0.636	0.637

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 10: OLS regression of hardware budget and productivity

	Productivity			
HwBudget	0.152***	0.152***	0.123***	0.123***
	(0.00647)	(0.00651)	(0.00646)	(0.00649)
CapInt	0.286***	0.287***	0.236***	0.238***
	(0.00686)	(0.00684)	(0.0135)	(0.0135)
Leverage	-0.0243	-0.0242	-0.0231	-0.0229
	(0.0138)	(0.0138)	(0.0148)	(0.0148)
FirmAge	-0.143***	-0.143***	-0.106***	-0.105***
	(0.0113)	(0.0113)	(0.0119)	(0.0119)
Sale	0.171***	0.171***	0.179***	0.179***
	(0.00646)	(0.00646)	(0.00753)	(0.00753)
HHI	0.304***	0.304***	0.00646	-0.00457
	(0.0547)	(0.0547)	(0.336)	(0.339)
cons	1.708***	1.718***	1.543***	1.541***
	(0.0423)	(0.0463)	(0.0709)	(0.0714)
Time FE	*No*	*Yes*	*No*	*Yes*
Industry FE	*No*	*No*	*Yes*	*Yes*
N	6845	6845	6836	6836
R^2	0.498	0.499	0.634	0.635

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

We ran high-dimensional fixed-effects models controlling for the industry fixed effects (3rd and 4th column). Industry fixed effects are frequently used because they eliminate all between-industry variation and produce an estimate of a variable's average effect within industries over time when they are thought to differ systematically from one another in unobserved ways that affect the outcome of interest (Allison Reference Allison2009; Wooldridge 2010).

OLS assumes that the independent variables are not highly correlated. To test this assumption,

we conducted a series of tests suggested by Hair et al. (1998) and Belsley et al. (1980) to determine whether multicollinearity impacts our findings. We specifically examined the tolerance values and variance inflation factors (VIFs). The tolerance values were well above the suggested threshold of 0.10, which is indicative of multicollinearity (Belsley et al., 1980; Hair et al., 1998) (our tolerance values were 0.80, or greater, for total budget, software budget and hardware budget), and the VIFs were well below the threshold value of 10 or greater, which is indicative of multicollinearity (none of our VIFs were above 1.25). Table 11 shows the results of these tests.

Table 11: VIFs for total, software, and hardware budgets

Variable	Total		Software		Hardware	
	VIF	1/VIF	VIF	1/VIF	VIF	1/VIF
Budget	1.05	0.949936	1.05	0.950038	1.04	0.958825
CapInt	1.11	0.904637	1.11	0.904734	1.11	0.904253
Leverage	1.02	0.980771	1.02	0.980768	1.02	0.982442
FirmAge	1.21	0.828912	1.21	0.828884	1.21	0.827108
Sale	1.25	0.802181	1.25	0.802179	1.25	0.800351
HHI	1.05	0.950765	1.05	0.950791	1.05	0.950531
Mean VIF	1.22		1.22		1.21	

Table 12 presents firm fixed-effects regression between productivity and expenditures. The results provide support for our first hypothesis ($\beta1=0.034^{***}$ for total budget, $\beta1=0.034^{***}$ for software budget, and $\beta1=0.033^{***}$ for hardware budget). Specifically, a 9.7% increase in total, 5.02% in software, and 2.76% hardware budget is associated with approximately a 0.32%, 0.14%, and 0.1% increase in productivity, respectively, ceteris paribus.

Table 12: Regression Results

	Productivity		
Budget	0.034***		
	(0.00622)		
SwBudget		0.034***	
		(0.00623)	
HwBudget			0.033***
			(0.00634)
CapInt	0.199***	0.199***	0.201***
	(0.0283)	(0.0283)	(0.0286)
Leverage	0.0173	0.0173	0.0159
	(0.00967)	(0.00966)	(0.00967)
FirmAge	-0.386***	-0.386***	-0.384***
	(0.0417)	(0.0417)	(0.0420)
Sale	0.786***	0.786***	0.784***
	(0.0209)	(0.0209)	(0.0213)
HHI	0.0529	0.0529	0.0603
	(0.0812)	(0.0812)	(0.0810)
cons	0.744***	0.901***	0.963***
	(0.114)	(0.107)	(0.108)
Time FE	*Yes*	*Yes*	*Yes*
Firm FE	*Yes*	*Yes*	*Yes*
N	6249	6249	6230
Within-R^2	0. 7354	0.7354	0.7334

Standard errors in parenthese
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4.4.1.2 IT Expenditures and Environmental Uncertainty

The effect of IT budget in dynamic and munificent environments can be estimated by the following specifications below.

(2) $Productivity_{it}$

$$= \beta_0 + \beta 1 Budget_{it} + \beta_2 Dynamism_{it} + \beta_3 Munificence_{it}$$
$$+ \beta_4 Concentration_{it} + \beta_5 Bud * Dyn_{it} + \beta_6 Cap\ Int_{it} + \beta_7 Leverage_{it}$$
$$+ \beta_8 Firm\ Age_{it} + \beta_9 Sale_{it} + a_i + a_t + u_{it}$$

(3) $Productivity_{it}$

$$= \beta_0 + \beta 1 Budget_{it} + \beta_2 Dynamism_{it} + \beta_3 Munificence_{it}$$
$$+ \beta_4 Concentration_{it} + \beta_5 Bud * Mun_{it} + \beta_6 Cap\ Int_{it} + \beta_7 Leverage_{it}$$
$$+ \beta_8 Firm\ Age_{it} + \beta_9 Sale_{it} + a_i + a_t + u_{it}$$

where $Budget_{it}$ represents three expenditures: total, software and hardware, $Dynamism_{it}$, and $Munificence_{it}$ represent the proxies for environmental uncertainty. Table 13 and table 14 represent the results of the model with firm fixed-effects and industry-fixed effects, respectively.

Environmental uncertainty has proven to have a significant association with performance (Goll & Rasheed, 1997; Garg et al., 2003). Although, examining the direct impact of uncertainty on performance is out of the scope of this study, the results show that environmental dynamism has a negative insignificant, environmental munificence has a positive significant, and concentration has a positive insignificant correlation with productivity. To provide support for the fourth hypothesis, we must find the coefficient β5 and β6 significant and positive. From the results presented in table 13 and 14, it can be observed that the interaction coefficient on both, dynamism, and munificence, are significant and positive, and provides support for the second hypothesis. The results are presented in the following table.

Table 13: Effect of Budget and Dynamism

	(1)	(2)	(3)	(4)	(5)	(6)
	Total		**Software**		**Hardware**	
Budget	0.0335***	0.126***	0.0335***	0.125***	0.0334***	0.123***
	(0.00612)	(0.0226)	(0.00612)	(0.0226)	(0.00626)	(0.0213)
Dynamism	-0.107	-0.406	-0.107	-0.406	-0.121	-0.437
	(0.170)	(0.543)	(0.170)	(0.544)	(0.169)	(0.523)
Bud*Dyn	0.274**	-0.208	0.273**	-0.206	0.219*	-0.190
	(0.0927)	(0.538)	(0.0926)	(0.539)	(0.0855)	(0.489)
Munificence	0.198**	0.580	0.199**	0.580	0.192**	0.579
	(0.0652)	(0.308)	(0.0651)	(0.309)	(0.0652)	(0.307)
Concentration	0.112	0.0427	0.111	0.0429	0.113	0.0636
	(0.0876)	(0.299)	(0.0876)	(0.299)	(0.0872)	(0.296)
lnki	0.200***	0.237***	0.200***	0.237***	0.202***	0.239***
	(0.0284)	(0.0561)	(0.0284)	(0.0561)	(0.0287)	(0.0560)
leverage2	0.0177	-0.0220	0.0177	-0.0220	0.0165	-0.0226
	(0.00972)	(0.0223)	(0.00971)	(0.0223)	(0.00973)	(0.0220)
lnfirmage	-0.389***	-0.110***	-0.389***	-0.110***	-0.387***	-0.106***
	(0.0417)	(0.0213)	(0.0417)	(0.0213)	(0.0420)	(0.0219)
lnsale2	0.785***	0.183***	0.785***	0.183***	0.783***	0.180***
	(0.0211)	(0.0531)	(0.0211)	(0.0532)	(0.0214)	(0.0522)
_cons	1.069***	1.039***	1.068***	1.038***	1.054***	1.017***
	(0.110)	(0.0953)	(0.110)	(0.0954)	(0.110)	(0.0998)
Firm FE	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*
Industry FE	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*
N	6231	6837	6231	6837	6212	6817
Within-R^2	0.7364	0.3936	0.7364	0.3935	0.7342	0.3873

Standard errors in parenthese
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Before performing the moderated regression, we centered the variables Centering the interacting variables provides two obvious benefits. First, *reduced multicollinearity*: When two variables are multiplied to form an interaction term, the resulting product can correlate highly with the original variables. The presence of multicollinearity in regression analysis can result in challenges when attempting to interpret the subjective effects of variables. By centering the

variables prior to generating the interaction term, the correlation between the variables is diminished, alleviating the multicollinearity issue.

Table 14: Effect of Budget and Munificence

	(1)	(2)	(3)	(4)	(5)	(6)
	Total		**Software**		**Hardware**	
Budget	0.0326***	0.127***	0.0327***	0.127***	0.0326***	0.125***
	(0.00616)	(0.0227)	(0.00617)	(0.0227)	(0.00629)	(0.0214)
Munificence	0.166**	0.558*	0.166**	0.560**	0.162**	0.544**
	(0.0620)	(0.237)	(0.0620)	(0.237)	(0.0616)	(0.238)
Bud*Mun	0.0635*	0.173*	0.0634*	0.173*	0.0711*	0.183*
	(0.0306)	(0.102)	(0.0305)	(0.102)	(0.0301)	(0.102)
Dynamism	-0.139	-0.0642	-0.138	-0.0605	-0.130	-0.133
	(0.154)	(0.448)	(0.154)	(0.448)	(0.152)	(0.431)
Concentration	0.0832	0.0704	0.0832	0.0704	0.0912	0.0853
	(0.0869)	(0.287)	(0.0868)	(0.287)	(0.0866)	(0.286)
lnki	0.199***	0.236***	0.199***	0.236***	0.201***	0.237***
	(0.0283)	(0.0560)	(0.0283)	(0.0560)	(0.0286)	(0.0559)
leverage2	0.0175	-0.0219	0.0176	-0.0220	0.0162	-0.0226
	(0.00968)	(0.0223)	(0.00968)	(0.0224)	(0.00969)	(0.0221)
lnfirmage	-0.387***	-0.111***	-0.387***	-0.111***	-0.385***	-0.107***
	(0.0418)	(0.0212)	(0.0418)	(0.0212)	(0.0420)	(0.0218)
lnsale2	0.785***	0.183***	0.785***	0.183***	0.783***	0.180***
	(0.0211)	(0.0529)	(0.0211)	(0.0530)	(0.0215)	(0.0520)
_cons	1.076***	1.048***	1.076***	1.048***	1.060***	1.030***
	(0.110)	(0.106)	(0.110)	(0.106)	(0.111)	(0.109)
Firm FE	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*
Industry FE	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*
N	6231	6837	6231	6837	6212	6817
Within-R^2	0.7361	0.3943	0.7361	0.3941	0.7342	0.388

Standard errors in parenthese
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

And second, *facilitating interpretation*: The process of centering variables in interaction terms enhances the interpretability of the interaction effect, rendering it more meaningful. In the context

of centered variables, the interaction term denotes the alteration in the dependent variable when both variables deviate from their means by a single unit. This approach facilitates the interpretation of the interaction effect and mitigates the potential confounding influence of the main effects of the variables.

According to Wooldridge (2015), we must apply the first derivative to interpret the coefficient of an interaction effect. Precisely, we must differentiate equation (2) and (3) with respect to total, software and hardware budget to interpret its partial effect on productivity. Results show that environmental uncertainty positively moderates the relationship between IT expenditures and firm performance providing support for H2a and H2b.

4.4.1.3 Results with interactions between budgets and dynamism

The main effect of dynamism on labor productivity is $\beta 2 = -0.107$. Given the results in column 1 of Table 13, the impact of dynamism on productivity is -0.107 + 0.274 * *Budget.* For example, if the level of budget is 9.747*,* the effect of the dynamism on productivity is -0.107 + 0.274 * 9.747 = 2.564%*.* This shows that the dynamism effect on productivity is negative, but it becomes positive with the higher levels of IT expenditures, showing that IT expenditures make the firms more resilient to dynamic environments. Thus, we find support for the hypothesis H2a.

We have also separately analyzed the role of software and hardware expenditures in the relationship between productivity and dynamism. As shown in table 13 column 3 & 5, we found that software investments make the firm relatively more resilient to uncertainty as compared to hardware. Specifically, the coefficient on the interaction term between dynamism and software budget is larger than that on the interaction between dynamism and hardware budget.

The findings suggest that in a dynamic context, software investments have a more pronounced effect on augmenting labor productivity than hardware investments, which implies that in a dynamic and technology-oriented environment, the integration and application of software solutions are crucial for enhancing productivity. Although hardware investments are undeniably significant, the results indicate that software solutions have a greater impact on fully utilizing the workforce's potential due to their adaptability and efficiency. The findings of this study underscore the importance of making strategic investments in software to optimize labor productivity and maintain competitiveness in rapidly changing business landscapes.

4.4.1.4 Results with interactions between budgets and munificence

The main effect of munificence on productivity is $\beta 3 = 0.166$. Given the level results in column 1 of table 14, the impact of munificence on productivity is 0.166 + 0.165 * *Budget*. For example, if the level of budget is 9.747, the impact of munificence on productivity is 0.166 + 0.165 * 9.747 = 1.78%. The results show that in munificent environments, expenditures in IT improve productivity. Thus, we find support for hypothesis H2b.

The results indicate that within a generous setting, there is no substantial disparity in the effects of software and hardware investments on improving labor productivity. This implies that in a setting characterized by abundant resources, investments in both software and hardware play a relatively equitable role in enhancing workforce productivity. Organizations operating within such contexts have the potential to attain significant improvements in productivity by prioritizing the optimization of their software systems and hardware infrastructure. The findings of this study emphasize the significance of adopting a well-rounded strategy when allocating resources to

technology in prosperous settings. It is crucial to capitalize on the benefits of both software and hardware to improve overall workforce efficiency.

5. DISCUSSION AND CONTRIBUTION

5.1 Interpretation of the results

The objective of this research is to unravel the interplay between IT investments and firm performance in presence of environmental uncertainty. Specifically, this study surrounds to serve two objectives: (i) to examine the relationship between IT investments and firm performance, and (ii) to investigate the moderating role of environmental uncertainty in the relationship between IT investments and firm performance. As hypothesized, our expectations were as follows: (i) We expect the investments in IT to positively associate with firms' performance, and (ii) We expect that environmental uncertainty will positively moderate the relationship between IT investments and firms' performance. We performed fixed-effects regression to investigate the stated hypotheses.

The first objective was to find the association between IT expenditures and productivity. Organizations participate in constant endeavors to capitalize on the investments they make, and still contemplate how these investments might yield them the desired results (Hitt & Brynjolfsson, 1997; Bharadwaj et al., 1999). A very well-established body of literature suggests that this association is questionable at several levels. Our thorough literature covers some of the most cited studies that investigated this relationship and found equivocal results (Bharadwaj, 2000; Wade & Hulland, 2004; Carr,2003; Chae et al., 2014). The findings of this study are aligned with the previous research and suggest that investments in information technology and firm performance are positively linked. (1) Investing in IT paves the way for automation and process optimization, contributing to greater productivity. Organizations can save time and effort by automating mundane and repetitive processes using information technology systems and technologies. These results are aligned with the findings suggested by Hasan et al. (2003), where they found the

evidence of a positive effect of automation on the productivity of stock exchange. This enables workers to devote more time to tasks that require their talents, thereby raising productivity as workers achieve more in the same period. (2) This research findings align with the findings of Lee & Kim (2021) that investments in IT increase people's ability to access data and insights. Information systems allow workers to quickly and conveniently access, share, and work together on projects. Because of this, it is easier to collaborate, share information, and make sound and timely judgments, reducing the likelihood of bottlenecks that slow down operations and reduce output. (3) Investments in information technology facilitate efficient internal communication and teamwork. Thanks to modern communication and project management tools and collaboration software, employees can work together effectively, notwithstanding their location (Benitez et al., 2023), which in turn facilitates cooperation, information sharing, and practical task completion. When teams can effectively communicate with one another (Bauer, 2010), they make fewer mistakes and complete their projects faster. (4) The money spent on IT is used to train and educate workers. By investing in IT training programs, businesses can provide their staff with the expertise they need to make the most of technology, which enables workers to make the most of available IT resources, allowing them to accomplish their jobs more efficiently (Phillips, 2003). Additionally, user-friendly interfaces and intuitive applications are frequently included in IT expenditures, making it more straightforward for workers to embrace and operate technology (Hu et al., 2015). (5) Investing in IT lays the way for telecommuting and other forms of workplace flexibility. Technology has made it so that workers no longer need to be physically present in the office to access company systems and complete their assignments. Improved productivity may result from the good effects of more work-life balance, and happier employees (Freeman & Shaw, 2009).

5.2 Methodological Contribution

The previous scholarly discourse has identified two primary reasons for the conclusive inconsistencies regarding the association between IT investments and firm performance. From a methodological standpoint, the IT construct has consistently been regarded as a singular entity in previous studies (Weill, 1992; Mahmood & Mann, 1993). Additionally, there exists a secondary source of data that relies on managerial surveys, which are publicly accessible, considering IT investment as a subjective measure, according to articles by Ray et al. (2013), Aral and Weill (2007), and Morales and Rojas (2013). The current research relies on the proprietary data obtained directly by Aberdeen, enabling us to present the analysis findings with enhanced rigor.

The availability of granular data has facilitated an in-depth exploration of the classification of IT investments, primarily within software and hardware budgets. The categorization has yielded a more profound comprehension of the correlation between investments in information technology (IT) and productivity, thereby emphasizing the importance of these elements in examining the relationship between IT and productivity. Our research provides a methodological contribution by introducing a categorization approach, thereby enhancing the existing body of literature with a new dimension.

By classifying IT investments into different software and hardware budgets, we could discern and analyze each component's contributions to enhancing productivity. The correlation between these investments and productivity underscores their significance in facilitating organizational performance. This discovery is consistent with prior studies that have emphasized the significance of IT investments as primary catalysts for enhancing productivity and performance (Aral & Weill, 2007; Mithas & Rust, 2016).

Furthermore, our study makes a methodological contribution by systematically categorizing IT investments according to software and hardware budgets, and this categorization provides a more underlying viewpoint regarding the various classifications of information technology investments and their unique impacts on productivity. The argument presented aligns with Weill's (1992) argument for classifying IT investments into strategic, informational, and transactional categories, based on the understanding that each type of investment has a distinct impact on various aspects of firm performance. Bharadwaj (2000) supported this perspective by asserting that investment returns vary dimensionally. Researchers and practitioners can acquire valuable insights regarding software and hardware investments' relative contributions and effects by categorizing IT investments into these domains.

The contribution of our study extends beyond its theoretical implications. The classification of IT investments into software and hardware budgets has practical implications for decision-makers and IT managers, allowing individuals to allocate resources strategically, considering each category's distinct advantages and consequences. Comprehending the unique impacts of software and hardware investments enables organizations to make well-informed choices regarding resource allocation (Aral & Weill, 2007), prioritize investments (Masli et al., 2014), and optimize their IT portfolio (Dickinson et al., 2001).

Our finding suggests that hardware and software investments are crucial in enhancing productivity. First, consistent with the prior literature, it is observed that there exists a positive correlation between investments in software and hardware resources and labor productivity (Hu & Quan, 2005), indicating that an increase in such investments tends to lead to higher levels of productivity in the workforce , suggesting that organizations that invest resources in the acquisition

and implementation of software solutions and hardware infrastructure are more likely to observe enhanced efficiency, effectiveness, and productivity among their employees.

Second, the observed correlation suggests that the association between investments in software and hardware and labor productivity is not a result of chance but a meaningful and consistent pattern. The results indicate that allocating resources toward software and hardware can significantly enhance labor productivity, thus highlighting their significance as crucial determinants of organizational performance.

The implications encompass both strategic and operational dimensions. From a strategic standpoint, organizations must acknowledge the significance of allocating resources toward software and hardware investments to boost labor productivity, which may entail allocating resources towards acquiring sophisticated software systems that optimize organizational workflows, enhance data governance, and facilitate expedited and informed decision-making. Similarly, allocating resources towards contemporary hardware infrastructure, encompassing powerful computers, servers, and networking apparatus, can furnish employees with the essential instruments and resources to enhance the efficiency of their tasks.

At the operational level, organizations must prioritize continuous investments in software and hardware to ensure that their workforce is adequately equipped with the most up-to-date technology and tools. To optimize the advantages obtained from these investments, engaging in consistent upgrades, maintenance, and training is imperative. Organizations can sustain their competitive advantage, accommodate evolving market demands, and enhance labor productivity through consistent investments in software and hardware.

5.3 Managerial Implications

Exploring the correlation between investments in information technology and a company's performance holds numerous managerial implications. First, resource allocation is a critical aspect of executive decision-making (Sabherwal & Chan, 2001; Sabherwal et al., 2019), and understanding the impact of information technology (IT) investments on firm performance can aid managers in effectively allocating resources (Vecchiato, 2012; Koberg, 2017). The ability to make informed decisions regarding investment in particular technologies or systems can significantly improve productivity, efficiency, and overall performance. Second, strategic planning involves analyzing the correlation between IT investment and organizational performance, enabling managers to devise strategic plans integrating technology as a crucial element (Hitt & Brynjolfsson, 1997; Bharadwaj et al., 1999). Organizations possess the capability to recognize domains where technology can be utilized to attain a superior edge, enhance customer encounters, and stimulate novelty (Hayes, 2006; Byrd et al., 2006; Ma et al., 2013). Finally, investigating the correlation between IT investment and firm performance in performance measurement enables managers to establish significant performance metrics like return on assets (Dong et al., 2021), profitability (Mithas & Rust, 2016), and innovation (Guo et al., 2022). Organizations can monitor the return on investment (ROI) of their information technology (IT) initiatives, assess the influence of technology on diverse business outcomes, and utilize data-driven approaches to enhance future IT investments (Provost & Fawcett, 2013; Brynjolfsson & McElheran, 2016).

5.4 Environmental Uncertainty

The investigation of how environmental uncertainty serves as a moderator in the association between IT investments and firm performance has significant implications for both scholarly and

managerial practices. Our research has provided insights into the significance of software and hardware investments within various environmental contexts, explicitly focusing on their implications for environmental uncertainty. Our study's results indicate that companies tend to modify their investment strategies in response to the stability and availability of resources in their respective environments. Our study analyzed the investment allocation patterns between software and hardware in unstable environments and abundant resources.

In environments marked by unpredictability and dynamism, accompanied by significant levels of uncertainty, our findings indicate that organizations tended to prioritize the augmentation of their software expenditures. As mentioned above, the discovery suggests that organizations operating within such contexts acknowledge the necessity of employing agile and adaptable software solutions to navigate the obstacles presented by uncertainty effectively. By allocating additional resources to software development, companies can capitalize on technological advancements, integrate adaptable systems, and enhance their capacity to adapt promptly to evolving market dynamics. Software investments provide:

- organizations with the benefit of improving their agility,
- facilitating prompt decision-making, and
- enabling the customization and scalability of their processes and operations.

In contrast, within warm environments characterized by ample resources and stability, we have observed a comparatively lesser disparity in the allocation of funds between investments in software and hardware, implying that organizations functioning in highly productive environments may not encounter an equivalent degree of immediacy or necessity for software-based adaptability. Alternatively, organizations may prioritize allocating resources toward enhancing their hardware infrastructure to streamline operational processes and optimize the utilization of available

resources. In this context, hardware investments encompass the procurement of sophisticated machinery, equipment, and tangible infrastructure to facilitate production processes, enhance operational effectiveness, and leverage existing resources.

6. LIMITATIONS

The research must acknowledge several limitations concerning the moderating role of environmental uncertainty on firm performance. The limitations of this study arise from multiple facets of the study design and data analysis, potentially influencing the credibility and applicability of the results. The research limitations are derived from the given premises.

The categorization of the IT budget into hardware and software needs a robust theoretical underpinning. The current categorization may not effectively capture the multifaceted and ever-changing nature of information technology expenditures within organizations. Consequently, the study's findings about the moderating influence of environmental uncertainty on firm performance may be compromised, given that the selected categorization may need to capture the intricacies of IT investments sufficiently.

Evaluating the immediate performance impact of IT investments conducted within the same fiscal year may yield a partial comprehension of the correlation between IT investments and organizational performance. According to existing research, it has been found that the impact of investments in information technology (IT) on performance may take time and effort and, instead, may require a considerable amount of time, typically a year or more, to become apparent. The study's exclusive focus on the immediate effects within the same year may result in the omission of long-term consequences and potentially lead to an underestimation of the actual correlation.

The lack of lagged effects of information technology (IT) investments on firm performance observed in the data prompts inquiries regarding the precision and comprehensiveness of the findings. Although the available data does not indicate a lagged effect, this finding contradicts the existing body of literature that suggests a temporal delay between investments in information technology and the resulting performance outcomes. The absence of observed effects in the present

study could be attributed to constraints in the duration of data collection, the methodologies employed for measurement, or the particular circumstances being examined.

The study's findings may have restricted applicability to organizations functioning in dissimilar sectors or geographical areas characterized by distinct levels of environmental uncertainty. The current study may not have fully considered industry-specific factors, or regulatory environments that could influence the moderating role of environmental uncertainty on firm performance.

The study's primary emphasis on environmental uncertainty and IT investments as determinants may need to consider the potential impact of additional variables that could affect organizational performance. The analysis did not explicitly consider factors such as organizational culture, leadership, competitive strategies, or macroeconomic conditions, which may have substantial influence.

The study does not investigate potential mediating factors that could elucidate the link between environmental uncertainty, IT investments, and firm performance. Variables such as organizational learning, innovation, or strategic alignment have the potential to act as mediators in this relationship, offering a more comprehensive understanding of the fundamental dynamics at play.

To further advance the comprehension of how environmental uncertainty influences the association between IT investments and firm performance, it is recommended that future research endeavors focus on addressing these limitations. More comprehensive and refined insights can be obtained, benefiting both theoretical understanding and practical applications.

7. FUTURE DIRECTIONS

The research model that investigates the moderating influence of environmental uncertainty on the association between IT investments and firm performance offers numerous prospects for further investigation. By exploring IT investments' intricacies within diverse environmental contexts, this study enhances our comprehension of how organizations can adeptly navigate the complexities inherent in the digital realm. Based on the empirical findings and inherent constraints of the present study, it is recommended that future research endeavors explore the following avenues:

Examining context-specific factors involves exploring environmental uncertainty, which comprises multiple dimensions such as technological turbulence, market volatility, and regulatory complexity. Subsequent investigations may be conducted to examine further the distinct dimensions mentioned above and their respective impacts on the relationship between IT investment and firm performance. Gaining insight into the impact of each dimension on the moderating effect of environmental uncertainty can enhance our comprehension of the intricate relationship between IT investments, environmental factors, and performance outcomes.

This study investigates the potential variations in the relationship between environmental uncertainty, IT investments, and firm performance across diverse sectors and organizational types. Future research has the potential to investigate the effects specific to different sectors by conducting comparisons between industries that possess distinct characteristics, such as technology-intensive sectors, in contrast to traditional industries. Furthermore, examining the moderating influence of environmental uncertainty within distinct organizational contexts, such as small and medium-sized enterprises, compared to large corporations, can yield valuable insights regarding the variations in IT investment dynamics contingent upon organizational size and structure.

To further elucidate the mediating mechanisms by which environmental uncertainty moderates the relationship between IT investment and firm performance, future research endeavors may examine mediating variables. For instance, examining the mediating function of organizational agility or absorptive capacity can provide insights into how organizations adjust and utilize their investments in information technology in uncertain environmental conditions. Identifying these mediating mechanisms can offer a more comprehensive comprehension of the causal pathways and processes by which environmental uncertainty impacts the efficacy of IT investments.

Comparative studies encompassing various countries or regions can provide significant insights into the influence of environmental factors, regulatory frameworks, and cultural contexts on the interplay between IT investments, environmental uncertainty, and firm performance. Comparative analyses offer a more comprehensive viewpoint and facilitate identifying factors specific to individual countries or regions, thereby contributing to the understanding of the diverse effects observed in different contexts.

In conclusion, the research model that investigates the moderating influence of environmental uncertainty on the association between IT investments and firm performance presents various opportunities for future research. We can better understand the intricate dynamics at play by delving into context-specific factors, sectoral and organizational distinctions, mediating mechanisms, longitudinal designs, and comparative studies. Pursuing these future directions will strengthen the research model's theoretical underpinnings and practical applications, thereby contributing to the broader body of knowledge on IT investments and environmental uncertainty.

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APPENDIX

Table A.1 Studies on IT Investments and Firm Performance

Study	Methodology	Independent Variables	Dependent Variables	Findings
Guo et al., 2022	Panel Data Analysis	• Information week • ComputerWorld	• Patent Count	Firms that make superior investments in IT and IT HR achieve higher innovation performance.
Dong et al., 2021	Panel Data Analysis	• IT Investments from CI database	• ROA	Firms invest in IT as a response to performance degradation, which leads to overinvestment in IT. Corporate governance reduces this overinvestment.
Mithas & Rust, 2016	OLS Regression	• Information week	• Profitability • Market Value	Firms with dual emphasis have a higher performance and profitability than the firms focusing on either cost, or revenue.
Dos Santol et al., 2012	Event Study	• Financial market data (current and new investments)	• Demand for firms in IT industry	Firms continue to invest in new IT initiatives and managers find new ways to use IT to improve performance as IT is a key driver of productivity.
Otim et al., 2012	Event Study	• IT Announcements	• Downside risk: firm performance relative to industry performance.	Strategic transformational IT investments reduce the downside risk when target firm leads the industry. Informational IT investments can be capitalized if a firm is a quick-learner of uncertainty resolution.
Kohli et al., 2012	OLS Regerssion	• IT Investments as reported by the NPT hospital	• Q ratio (first-hand) • ROA • OPINC • TOTNETINC	Impact of IT investments is more pronounced on a firm's value than exclusively on accounting measures. And, accounting measures complemented with firm's market value better explain IT's impact.
Mithas et al., 2012	Panel Data Analysis	• Annual IT Budget • Operating Expense	• Net Income	IT positively impacts profitability. Furthermore, IT investments affect sales and profitability more than other investments
Mithas et al., 2012	Panel Data Analysis	• IT Investments per employee	• Profitability • Sales • Operating Expense	The results show that IT-enabled growth in sales has a bigger effect on profits than IT-enabled reductions

				in running costs. Also, IT costs have a bigger effect on a company's bottom line than promotion and R&D costs.
Dewan & Ren, 2011	SUR Regression	• Firm Diversification • Vertical Integration • IT & Non-IT Cpital	• ROA • Stock Returns • Risk • Stock Returns • Analysts Earnings	Increasing investments in IT is associated with higher returns and lower risks for the firms with greater diversification
Henderson et al., 2010	OLS Regression	• IT Expenditures	• Market Value • Book Value • Earnings	IT investments are associated with future firm performance. However, the source of IT spending information may invalidate the results at managerial level.
Aral & Weill, 2007	OLS Regression	• IT budget as percentage of sales	• ROA • Net margin	IT investments boost innovation, profit, and cost, enabling firms to integrate infrastructure with new applications and improve performance beyond market value. Aggregate measurements may not affect cost leadership.
Brynjolfsson et al., 2002	OLS Regression	• Expenditures in PP&E	• Market value of equity	Financial markets value businesses with more installed computer capital more highly. Companies with complementary organizational change investments are valued more highly on the market.
Devaraj & Kohli, 2000	OLS Regression	• IT expenditures in labor, support and capital	• Hospital revenue • Patient mortality • Satisfaction	IT investments positively affect profitability and quality outcomes.
Sircar et al., 2000	Cannonical Analysis	• IT Staff • IT Training • Other IT • CPU • PC/EMP	• Sales • Net Income before Taxes • Assets • Market Share • Equity • Close • Shares	More of an exploration of how different kind of investments affect different performance parameters across multiple industries.
Bharadwaj et al. 1999	OLS Regression	• Industry concentration • Q ratio • Capital intensity • Regulation • Employees • Advertising	• Tobins' q	IT investments are positively associated with future performance of the firms

		• R&D		
Hitt & Brynjolfsson, 1996	OLS Regression	• IT Stock • Non-IT capital, • Capital intensity	• ROA • ROE	IT investments are positively related to productivity and consumer value. However, there is no evidence of their association with a firm's profitability

Table A.2 Environmental Uncertainty and Firm Performance

Article	Methodology	IVs	DV	Controls	Findings
Li & Simerly, 1998	Moderated Regression and subgroup analysis (for contingency relationship)	• CEO Ownership % • Industry (1 if dynamic) • CEO% X Industry	*(4-year average)* • ROA • ROE • ROI • OROA	• CEO stock value • Leverage • HHI • Firm age • Institutional holding • CEO duality • Firm size	For firms in the industry experiencing greater environmental dynamism, there exists a greater positive relationship between insider ownership and performance.
Simerly & Li, 2000	Multiple Regression	• Leverage • Dynamism (moderator)	• ROA • ROI	• Firm size • Return on invested capital • Tobin's Q • Return on capital • Firm dummy	Environmental dynamism affects performance in a way that competitive environments undermine the capital structure-performance link.
Garg et al., 2003	Hierarchical Regression	• Scanning emphases (task & general environment, innovation, and efficiency • Perceived environmental dynamism (moderator)	• Firm performance (self-reported measure)	• Firm size • Level of scanning	Chief executives must devote some of their limited time to scanning activities throughout pertinent areas of their firms' internal environments and external environments, based on the degree of dynamism they

					observe in their external settings.
Drnevich et al., 2011	Regression with clustering	• Ordinary capability • Dynamic capability • OC_heterogeneity • DC_heterogeneity	• Process-level (ordinary or dynamic) • Firm-level (benefits and costs of using capabilities)		Both, heterogeneity, and environmental dynamism negatively affects the contribution of ordinary capabilities and positively affects the contribution of dynamic capabilities to relative firm performance.
Girod & Whittington, 2017	Panel data regression using GMM estimator	*(Coded variables following the literature)* • Structural change ratio • Configuration change ratio • Environment Dynamism (industry-based measure)	• Tobin's Q • ROA	• $Q_{(t-1)}$ • Industry performance • Leverage • HHI • Internalization change • CEO succession • Size • Year dummies	The more pervasive restructuring is associated with positive performance outcomes, while the more limited reconfiguration is associated with negative performance outcomes. However, outcomes vary by environment. In dynamic environments, reconfiguration outcomes turn positive, while restructuring outcomes turn negative.
Ye & Zhang, 2023	Hierarchical regression	• Knowledge search (breadth and depth) • Opportunity discovery (mediator) • Environment dynamism (med^n moderator)- scale	• Corporate Entrepreneurship *(innovation, venturing and strategic renewal)*	• Firm size • Firm age • Firm ownership • R&D • Industry	OD facilitates knowledge search to pursue CE. ED positively moderates breadth, and negatively

					moderates depth on CE.
Liu et al. 2022	Bayesian regression	*(Survey and questionnaires)* • Unit head narcissism • Environmental complexity (-moderator) • Environmental dynamism (-moderator) • Inter-unit competition (+moderator)	*(Questionnaire)* • Inter-unit knowledge transfer	• Environmental munificence • Knowledge ambiguity • Centralization • Absorptive capacity • Organic structure • Autonomy • Self-sufficiency • Education, age, gender, experience • Firm age and size	Narcissism impedes knowledge reception. However, under complex and dynamic environments, narcissistic heads tend to give up their personalities to seek external knowledge for improving productivity and performance.
Chung et al. 2019	Panel data regression	• Software patent stock • Innovation orientation (exploration-exploitation)-moderator • Environmental uncertainty (competitiveness and dynamism) – mod^{rn} moderator	• Firm Value-Tobin's Q	• R&D • Industry Q • Firm size • Advertising intensity • Year dummies	Higher level of explorative orientation is associated with a higher firm value in environments exhibiting low dynamism and high competitiveness. By contrast, higher levels of exploitative orientation is associated with a higher firm value in environments with high dynamism and low competitiveness.
Turulja & Bajgoric, 2019	Structural Equation Modeling	*(All measures are survey indicators)* • Product and process innovation Mediators and IVs) • Environmental turbulence (IV and moderator) *[market, technological, competitive]*	• Business performance	• Firm size • Firm age	The findings show that environmental turbulence does not moderate the relationship between innovation and business performance. The authors have found a clear role of

					environmental turbulence in boosting innovation rather than moderating the relationship between innovation and performance.
Omri 2015	PLS	*(All measures are survey indicators)* • Innovative behavior (IV) • Successful innovative output (mediator) • Dynamism (moderator)	• Business performance	• Firm size • Firm age	Innovative behaviors have a positive association with performance, weaker than the innovative outputs. However, all the relationships are weakened in presence of a dynamic environment.
Schilke 2014	OLS regression	*(All measures are multi-item scale)* • Alliance management capability (5D variables) • New product development capability • Environmental dynamism (moderator)	• Competitive advantage- (i) strategic performance (ii) financial performance	• Industry • Firm size • Firm age • Alliance portfolio size • Product and market scope • Firm unit of analysis • Same respondent	The relationship between dynamic capabilities and competitive advantage is strongest under intermediate levels of dynamism but comparatively weaker when dynamism is low or high.
Goll and Rasheed 1997	OLS regression	*(All indicators are survey measures)* • Rational decision-making • Environmental munificence (growth rate in the value of shipments) and dynamism (variability in the value of shipments)	• ROA • ROS	• Firm size	Environmental munificence and dynamism moderate the relationship between rationality and performance. Further, the study found that rationality is strongly associated with performance in environments high in munificence and dynamism.

Richard et al. 2019	Panel data regression	• Relationship-related faultline indices (age, gender, education) • Task-related faultline indices (background, tenure) • Environmental dynamism [moderator]- (industry gross revenues)	• Strategic change (based upon six industry-standardized investment dimensions)	• Ownership (state and foreign) • Firm age • Firm size • Average tenure • Power disparity • Year dummies	Relationship-related faultline strength (Education level) negatively influences strategic change whereas task-related faultline strengths positively influences the strategic change. Furthermore, environmental dynamism weakens (strengthens) the negative (positive) impact of relationship (task) related faultline strength on strategic change.
Sabherwal et al. 2019	Panel data regression (GLS)	• Strategic IT Alignment [IV and moderator] (profile deviation approach) • IT Investment (as a proportion of sales- survey) • Environmental uncertainty (mod^{r}'s moderator) 1. Dynamism: industry sales volatility 2. Complexity: reciprocal of industry concentration 3. Munificence: industry's sales growth	• Firm performance (Tobin's q)	• Industry performance • Industry capital intensity • Regulation • Related diversification • Firm size • Business strategy (defender and prospector) • Organizational slack (assets/liabilities)	The results suggest that in dynamic, complex, and hostile environments, SITA does reflect a capability that enhances the positive effect of ITI on firm performance, but in stable, simple, and munificent environments, SITA reflects a rigidity that reduces the positive effect of ITI on firm performance.