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Abstract: In this paper, we revisit the "IT Productivity Paradox," which refers to the inconclusive relationship between IT investment and performance improvement found in empirical studies. We argue that the cause of the "IT Productivity Paradox" is more than empirical measurement difficulties. Based on a rather comprehensive review of the literature, we identified and contrasted three underlying theoretical perspectives of the empirical studies. We then propose a new theoretical framework toward an in-depth theoretical understanding of the paradox. Developed upon the contingency approach, the proposed framework considers the stages of technology life cycle. The framework not only can provide useful guidance for practicing managers but also potentially can resolve the "IT Productivity Paradox," hence making a significant contribution to the literature.

Keywords: IT productivity paradox; contingency approach; technology life cycle; firm performance

1. INTRODUCTION

It is highly intuitive that IT investment should lead to firm performance, empirical results have yet to provide a definitive answer. In the past two decades, many empirical studies confirmed the positive effect of IT investment on firm performance [1-3]. But there are also numerous studies showing that IT investment does not lead to firm performance, or that the relationship is actually insignificant [4]. Scholars have labeled this phenomenon as the "IT Productivity Paradox" [5-7].

Many IS/IT scholars have attempted to address this disturbing "IT Productivity Paradox." Reference [8] is one such noteworthy effort which certainly enhanced the methodological rigor of studies on IT investment and firm performance, the "IT Productivity Paradox" remains unresolved as of today. One decade later, our review of the IS/IT literature shows that many studies still found little or no impact from IT investment to firm performance [9-10], despite the application of more rigorous research methodologies. Furthermore, we were not able to find one study that provides a convincing explanation to the "IT Productivity Paradox."

This paper is organized as follows. The second section provides an overview of the "IT Productivity Paradox" and summarizes efforts toward resolving the paradox. We present a review of the relevant literature in section three. Our review effort focuses on the underlying theoretical perspectives of these studies. In the fourth section we propose a new theoretical framework toward an in-depth understanding of the "IT Productivity Paradox." We also present our research propositions in this section. Finally, we conclude the paper with a discussion of potential contributions to the literature, practical implications to managers, and future research directions.

2. THE IT PRODUCTIVITY PARADOX

Background

The "IT Productivity Paradox" has been perplexing IS/IT researchers for at least two decades even if many studies indicate that IT investment has a direct or indirect positive effect on firm performance,. In the 1980s, references [11] and [12] found that IT investment does not lead to expected firm performance improvement, a phenomenon they labeled as the "IT Productivity Paradox." The paradox was soon confirmed by many researchers. Reference [13] found that IT value as measured by key ratios (e.g., return on equity) are inconclusive when they applied the microeconomic theory of production in their study. In a two-stage analysis, reference [14] showed IT impact at the intermediate level of performance is more significant than its impact at the higher level. In another study, reference [4] found no significant relationship between IT investments and concurrent firm performance, though they made an argument that preceding IT investments would have a significant impact on subsequent firm performance.

The Empirical Measurement Difficulty Explanation

Since its inception, the "IT Productivity Paradox" has attracted attention of many IS/IT scholars. Much effort has been devoted to a resolution of the challenge. Researchers have proposed a variety of possible explanations for the paradox. Among them, the most accepted explanation is what we call the *empirical measurement difficulty* explanation in this study. This explanation recognizes that there is a positive relationship between IT investment and firm performance, but emphasizes the difficulty of measuring the IT investment payoff due to a number of reasons (e.g., time lag). Hence the expected performance improvement effect is not easily detected, mainly for methodology reasons. For example, reference [15] summarized four methodological issues in his study of the "IT Productivity Paradox:" measurement errors, performance lags, benefits redistribution, and mismanagement. Reference [8] reviewed empirical studies conducted during the period of 1990-2000. They concluded that many empirical studies failed to confirm the positive relationship between IT investment and firm performance due to methodological issues. Specifically, they pointed out that researchers need to carefully examine the influence of context, study characteristics, data sources, data analysis, and variable employed. Therefore, according to the *empirical measurement difficulty* explanation, to resolve the "IT Productivity Paradox," researchers ought to have a better and more rigorous application of research methodologies.

Unfortunately, enhanced methodological rigor seems to have not resolved the "IT Productivity Paradox." A decade later after reference [8] seminal work, research studies still report the existence of the "IT Productivity Paradox." For example, reference [16] showed that IT spending may not improve firm performance if it does not strategically emphasize related diversification to expand its existing products and services. Reference [9] found mixed impact of IT spending on firm performance when IT investment interacts with different levels and types of diversification in terms of related, unrelated, and geographic diversification. Therefore, researchers need to expand their effort to include other explanations for the "IT Productivity Paradox."

Other Explanations to the "IT Productivity Paradox"

Two alternative explanations to the "IT Productivity Paradox" can be identified as the *dynamic relationship* explanation and the *implementation effectiveness* explanation. According to the *dynamic relationship* explanation, to address the "IT Productivity Paradox" researchers must carefully uncover the underlying theoretical perspective upon which each empirical study is based. This is exactly what [17] did in their seminal work. They compared several theoretical perspectives used in previous studies (e.g., microeconomic theory, industrial organization theory, and sociology and socio-political perspectives), and proposed an integrative model of IT business value based on the resource-based view theoretical perspective. Specifically, they argue that IT value is determined by the macro environment, competitive environment, and focal firm factors. In another study, reference [18] examined the effect of information intensity of the industry and the time-lagging effect in their study of the relationship between IT investment and firm performance. In short, the *dynamic relationship* explanation suggests that the "IT Productivity Paradox" is an incorrect characterization of empirical observations of a dynamic and complex relationship between IT investment and firm performance.

The second explanation, which we call the *implementation effectiveness* explanation, argues that the effectiveness of implementation of an information technology can significantly affect IT investment payoffs. Generally, it is accepted that IT investment can lead to firm performance, but this relationship can only be observed if the information technology is successfully implemented. The observed "IT Productivity Paradox" is likely a manifestation of implementation failures. Studies have shown that both tangible and intangible benefits of IT investments can be delivered by successful information technology implementation [19-20]. A breakdown of information technology implementation can cause substantial financial losses to an organization [21-22]. Furthermore, a failed information technology implementation can even jeopardize the survival of organizations [23-24]. IS/IT researchers thus have examined many factors that affect IT project implementation effectiveness, including leadership performance [25], leadership styles across life cycle stages of IT projects [26], commitment to project objectives [27], and agency theory [28]. In short, the *implementation effectiveness* explanation suggests that the "IT Productivity Paradox" arises due to implementation failures.

3. LITERATURE REVIEW AND CRITIQUES

The Literature Search Effort

We conducted an extensive search to identify relevant studies in the literature. We searched several major research databases, including Business Source Premier, ABI Inform, and Elsevier Science Direct, for research studies published during the period of 1990–2013. The inclusion criterion is empirical studies addressing the relationship between IT investment and firm performance. We then reviewed the search results to determine the relevance of each paper. Irrelevant records such as book reviews or trade magazine articles were removed from further review. We focused our review effort on top tier academic journals including *Information Systems Research*, *MIS Quarterly*, *Journal of Management Information Systems*, *Journal of Computer Information Systems*, and *Information Resources Management Journal*. These journals are well-recognized for their high quality and methodological rigor. Our effort identified 98 research articles from more than 20 journals.

These research studies used a variety of theoretical perspectives as well as research methodologies. Some studies were conducted at the firm level, while others were at the division or plant level. Most studies are cross-sectional in nature, with a few of them being longitudinal studies. Some studies used regression and others used structural equation modeling. After we reviewed all the studies, it becomes clear that the underlying theoretical perspective of almost all studies can be classified as one of the three: *microeconomic theory*, *resource-based view* (RBV), and *institutional theory*.

Microeconomic Theory

As early as in the 1990s, researchers have used ratios such as return on equity to measure IT value, but they observed high variance for such measures, probably due to the fact that data was collected at different time horizons [13]. To address the data collection time horizon issue, reference [1] adopted Tobin's *q*, a forward looking measure of IT value, and captured a positive relationship between IT investments and firm performance. Other researchers focused on operational efficiency and found a positive IT-profitability relationship [29]. Reference [30] proposed four phases of IT evaluation procedures (strategic analysis, business process redesign, IT configuration, and performance evaluation) to capture the potential value of IT investments. His performance evaluation metrics included financial, strategic, and operational dimensions. Reference [31] used mixed metrics (order cost reduction, inventory reduction and customer satisfaction) to measure firm performance and his study confirmed a positive impact of IT investment on firm performance.

Several studies have considered the time-lagging effect in investigating the relationship between IT investment and firm profitability [4], [18]. Using data mining techniques (e.g., multivariate adaptive regression splines), researchers found that the impact of IT investment on productivity is complicated and the impact might be mixed due to interactions with other factors, such as non-IT capital and non-IT labor [32-33]. Following this line of thinking, reference [34] developed a Cobb-Douglas based mathematical production function to measure and compare the IT output between IT-intensive and non-IT-intensive industries. They found that IT-intensive industries are dominated by indirect effect of IT and non-IT-intensive industries are dominated by direct effect. Another empirical study indicated that IS support for product innovation does improve profitability (return on sales and return on assets) only if IS support has its complementary firm-specific information and knowledge [35]. Reference [36] drew a conclusion that the robust interaction between IT and boundary strategies (diversification and vertical integration) can determine the firm performance manifested by return and risk. However, it is worth nothing that *microeconomic theory* itself cannot provide an explanation to the occurrence of the "IT Productivity Paradox." The focus of these studies is the application of a quantitative measurement system. It is easy to observe the existence of the "IT Productivity Paradox" among studies based on *microeconomic theory*.

Resource-Based View

RBV is another common theoretical perspective upon which many empirical studies of IT value are based. Researchers argued that IT investment leads to inimitable resources which form the basis of a firm's competitive advantage [37]. This competitive advantage can help a firm gain market share and eventually, lead to the firm's good financial performance. Since IT investments can lead to inimitable resources, researchers naturally have applied RBV to study the impact of IT investments on firm performance [2], [38-41]. For example, reference [42] used RBV to conceptualize IT as an organizational capability and found a positive relationship between IT capability and firm performance. The IT competency model developed by [43] includes three components of IT resources: IT objects, IT knowledge, and IT operations. They found that organizational learning does mediate the effects of IT competency on firm performance. Reference [17] reviewed 202 IT business value articles published between 1990 and 2002 to propose an integrative model of IT business value which includes macro environment, competitive environment, and focal firm. Their model is clearly based on RBV.

Recently, IS/IT researchers focused their attention on knowledge management capability (KMC), which refers to the capability of utilizing knowledge resources. Reference [44] examined the effects of IT relatedness and KMC on firm performance from three different aspects of KMC: product KMC, customer KMC, and managerial KMC. In their study, KMC was found to have a positive mediation effect between IT relatedness and firm performance. Process performance variance could be explained by KMC which is positively dependent on IT capability [45]. Reference [37] proposed a conceptual model to understand the relationship between knowledge-based resources, KMC, supply chain technology investments, supply chain performance, and overall firm performance. Reference [46] conducted an empirical study to examine how four dimensions of KMC (technological capability, structural capability, cultural capability, and process capability) and supply chain practices affect firm performance. They found that the positive interactions between supply chain practices and KMC will positively affect firm performance.

In addition to KMC, several other knowledge management perspectives have been found in the study of IT investment and firm performance. For example, reference [47] investigated the effect of knowledge management systems (KMS) on firm performance and confirmed significantly positive benefits of adopting KMS. Knowledge management and IT is positively associated with project management performance [48], and firm performance [49]. By dividing KM strategy into codification and personalization, reference [50] found the moderating effect of human resource management control systems on the relationship between KM strategy and firm performance. KM has been also used to link IT investment to intangible output such as R&D process performance [45], and innovation productivity [51]. However, it must be pointed out that mixed results were reported in all these studies.

Institutional Theory

The institutional theory describes how an innovation or technology gets diffused into different organizations. The theory states that an early adopter of a technology focuses on the usefulness of the technology. In other words, firms adopt the technology for performance improvement reasons. As time progresses, the technology gained legitimacy. Late adopting firms are pressured to adopt the technology because it becomes a "standard." As a result, late adopters of the technology gain legitimacy but not necessarily performance improvement. Even if the technology can still help a firm improve performance when compared to the firm's past performance, this performance improvement can hardly be detected when compared to peers in the industry because every firm's performance has improved.

The institutional theory has been frequently used by business researchers to explain the adoption pattern of technologies and innovations. For example, reference [52] in their study of the adoption of total quality management (TQM), clearly showed that early adopters demonstrated better performance than non-adopting peer firms, but late adopters did not demonstrate any performance edge. IS/IT researchers have also applied the institutional theory in a wide variety of contexts including consumer adoption of technological innovations [53], the diffusion of internet banking [54], the acceptance of IT-based innovation [55], the adoption of mobile innovations [56], and the diffusion of online reverse auctions [57].

The institutional theory potentially can explain the "IT Productivity Paradox" because the adoption of the same information technology may have different performance implications, depending on the timing of the adoption. When a firm adopts an information technology, is the firm an early or late adopter? The answer to the question can have significant impact on whether the firm should expect performance improvement or not. The theory also suggests that the intensity of competition is important. The higher the intensity, the less likely a firm can expect performance improvement because the baseline is always moving forward.

4. PROPOSING A NEW THEORETICAL FRAMEWORK

The Contingency Approach

The dynamics and complexities of the "IT Productivity Paradox" imply that a one-size-fits-all type of theoretical framework will unlikely be a successful endeavor. Therefore, we adopt the well-established contingency approach to develop a new theoretical framework. The contingency approach has been widely used to study organizational interventions by scholars in various disciplines. Its central premise is that the effectiveness of a management intervention is contingent on both the internal and external environment or contexts [58]. A "fit" between the management intervention and the environment can lead to performance outcome [59]. An IT investment can be viewed as a management intervention; hence its relationship to performance improvement can be conceptually illustrated as in Figure 1. Of course the conceptual model needs to be further developed into a useful theoretical model. We first identify important contextual factors, and then determine their effect. The effect of contextual factors is usually specified as one of the six forms of "fit" [60], with moderation being the most commonly cited form.

Level of Performance Measurement

Level of performance measurement refers to where performance measurement takes place. Performance measurement is a complicated matter. Individuals and organizations measure their performance at many different levels using a variety of metrics. The literature has recognized that the choice of performance metrics may have significant impact to the results an empirical research study may obtain [8], [17]. When it comes to IT investment payoff studies, performance improvement has most often been measured at three levels: process, operational, and firm. At the process level, performance is often measured by productivity or efficiency metrics. The operational level performance metrics include the conventional cost, quality, delivery, and dependability. Metrics at the firm level vary. Many studies look at return on investment, or return on equity. Sales revenue, market share, and profitability are commonly used as well. A few studies use a firm's stock price (or derivative metrics of the same nature).

The common knowledge in the performance measurement literature is that the higher the level performance is measured, the more variation one can observe. This is highly intuitive and logical. At a lower level, metrics are more "absolute" or "direct" in nature. For example, productivity is measured by the quantity of output divided by the quantity of input. In contrast, metrics at a higher level tend to be more "relative" or "indirect." For instance, market share is a metric that is often used to measure a firm's performance. While the definition of market share is clear and without any vagueness, the metric itself is subject to the influence of many factors, particularly competitors' effort. A firm may have done an excellent job internally to improve its productivity, but if its competitors also have moved forward, then the market share metric may not show any improvement.

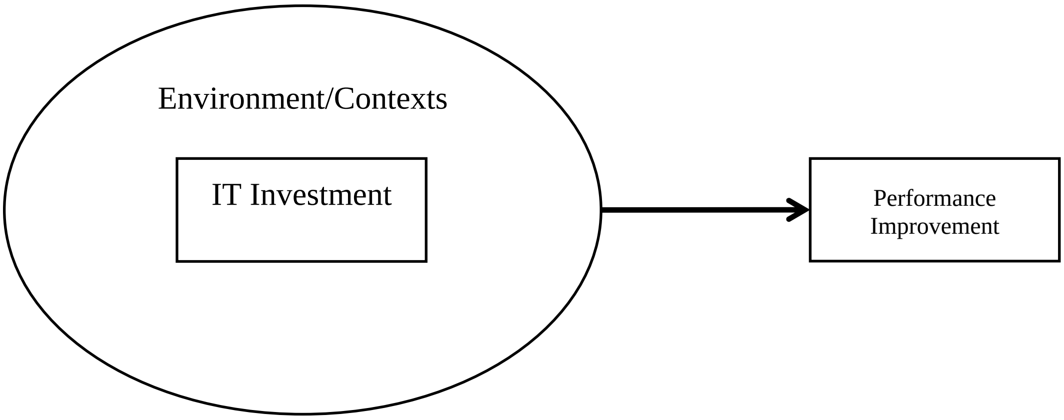

Figure 1. The conceptual model

IT investment is a firm's effort toward improvement. Most IT investment is carried out through IT projects. Most IT projects will either improve existing business processes for higher productivity or efficiency, or develop new business processes to enable a firm to perform new tasks. So it is reasonable to expect a strong relationship to process-level performance metrics. Logically, improved productivity and efficiencies can translate into better operational performance, for instance, reduced unit cost, better quality, more on time delivery, and dependability. However, operational performance is usually measured at the plant or division level. Other factors can also significantly affect operational performance. So while it is still reasonable to expect a positive relationship from IT investment to operational performance, the strength of the relationship may become attenuated. The argument can be easily extended to firm-level performance metrics, which is subject to the effect of even more factors. In summary, we would expect to see a weaker relationship between IT investment and performance as the level of performance metrics goes higher. We state this as proposition 1.

Proposition 1: *Information technology investment can lead to performance improvement. However, the strength of the relationship attenuates as the level of performance metrics goes higher, from process, operational, to firm level.*

Information Technology Life Cycle

The Concept of Life Cycle

The term "life cycle" originated in biology, referring to "the series of changes that the members of a species undergo as they pass from the beginning of a given developmental stage to the inception of that same developmental stage in a subsequent generation" [61]. Later the term has been used in a variety of fields and disciplines, including business, organization or corporate, project, product and technology. Product life cycle is probably the most well-known application. Business researchers use the term to refer to multiple stages that a new product goes through since its inception to eventual demise. Generally, a product's life cycle has four stages: introduction, growth, maturity, and decline [62-63]. Same as products, technologies also have a life cycle composing of the same four stages, although the meaning of the stages is slightly different [64-66].

The concept of life cycle is important because of the dynamics involved in the evolution of an organization or a new product. At different stages, both the internal and external environment can change, which can have significant implications. Therefore, researchers have considered the stage of the life cycle for precise research findings in such areas as TQM, corporate innovation, and marketing strategies. For example, reference [67] suggested that a successful implementation of TQM must have several critical factors matching the stages of the product life cycle. Many studies have shown that organizational life cycle is an effective and insightful theoretical perspective to examine firm performance or firm innovativeness [68-70]. Additionally, the product life cycle has also been used to examine the successful company strategies and marketing programs [71-72].

Unfortunately, the technology life cycle stages have been largely ignored in the study of the "IT

Productivity Paradox." In our review, we found virtually no study explicitly considered the impact of life cycle of the information technology being investigated. Yet it is clear that the impact of an IT investment will not remain the same if the technology is in different stages of its life cycle. For example, if a technology is newly invented, the technology could be highly innovative but also very risky. The relationship between the technology and performance improvement thus is highly unstable and unpredictable. In contrast, if a technology is in its maturity stage, we can expect a rather stable effect on performance improvement, although the effect may not be very strong. This simple contrast highlights the necessity of considering the technology life cycle in the study of the "IT Productivity Paradox."

Stages of Technology Life Cycle

Similar to the product life cycle, a technology also goes through four stages. If a technology has proven its usefulness in the *Introduction* stage, it will then enter the second stage, *Growth*. In this stage, the technology will be diffused to a wider population. More and more people and firms become familiar with the technology. Protocols for the implementation of the technology start to appear. The relationship between the technology and performance begins to be stable. One would expect to see performance improvement brought by the implementation of the technology, although stability sometimes may still be questionable.

The third stage is the *Maturity* stage. At this stage, the technology has been widely recognized, probably considered as the industrial standard. Firms will have little trouble to find people and protocols for the implementation of the technology. In fact, it is likely most firms in the industry have adopted the technology. If the technology has strong network externality effect, the effect is obvious at this stage. A firm has not adopted the technology will likely be considered lagging behind. The effectiveness of the technology is hardly questioned. Investing in the technology may lead to the performance improvement at the process, operational, or firm levels. However, it is worth noting that performance improvement at the firm level may not be easily detected at this stage. The main reason is that most competitors may have adopted the technology, and together they have made the baseline increasing all the time. While the firm's performance may have improved substantially when compared to its past performance level, such an improvement is not easily detected when measured by relative metrics such as sales revenue, market share, or profitability.

The last stage is *Decline*. In this stage, the technology is on its way out. Newer or better technologies have appeared and will likely replace the current technology in the future. Firms are not likely to implement such a technology for performance improvement reasons, but probably for reasons such as maintaining product compatibility or uninterrupted operations. As the technology is demising, fewer people will have knowledge or skills related to the technology. The difficulty of implementing such a technology will gradually increase. In other words, the required investment for such a technology will be high. However, it is hard for any firm to expect great return from such an investment. As stated above, the goal is probably just to maintain the performance level of an old process. One would expect to see a weak or even no relationship between the investment of the technology and process level performance. It is also unreasonable to expect any strong relationship between the technology and operational or firm level performance.

In summary, the relationship between IT investment and performance improvement changes as the technology evolves into different stages of its life cycle. At the *Introduction* stage, the technology is so new that it can become a truly inimitable resource for a firm to gain formidable competitive advantage. If so, then a strong positive relationship to performance improvement can be observed. However, the high uncertainty associated with the new technology also implies the technology can easily fail miserably. Therefore, in the *Introduction* stage, the relationship between IT investment and performance improvement is highly "unstable." If the technology makes to the *Growth* stage, then we should expect to see a "strong positive" relationship toward performance improvement. The technology is still relatively new, hence only a few firms have adopted it. Using *RBV*'s term, the technology helps firms create "inimitable" resources to gain competitive advantage. Significant performance improvement is to be expected at all three levels. This proposition is also in line with the *institutional theory*, which states that early adopters usually can enjoy much performance improvement. In the next stage, *Maturity*, we would expect the positive relationship remains but the magnitude weakens, particularly at the firm level. As a proven technology, we would expect it to improve process or even operational performance. But according to the *RBV*, resources created by this technology gradually lose the characteristics of being “inimitable,” hence they can no longer support firms to gain strong competitive advantage. The *institutional theory* also states that late adopters usually can only gain legitimacy but not much performance improvement. Finally, as the technology enters the *Decline* stage, we would not expect performance improvement from such IT investment. The best case will likely be to maintain the original performance level. In other words, the relationship between IT investment and performance improvement will be negative. We state this as proposition 3 below. And Figure 2 presents the proposed theoretical framework.

Proposition 2: *The relationship between IT investment and performance improvement changes as the technology goes through its life cycle: highly unstable at the Introduction stage, strongly positive at the Growth stage, weakly positive at the Maturity stage, and then negative at the Decline stage.*

The proposed theoretical framework potentially can resolve the “IT Productivity Paradox.” According to the proposed theoretical framework, the observed “IT Productivity Paradox” is likely a reflection of a dynamic and complex relationship that changes with different levels of performance measurement, or different stages of the life cycle of technologies. When researchers choose to study the effect of IT investments, but fail to specify these three important contextual factors, the “IT Productivity Paradox” is like to be observed. When these important contexts are clearly specified, scholarly research is likely to obtain a comprehensive understanding of the true relationship, which is dynamic and complex in nature. Our effort thus is a first step toward such an in-depth and comprehensive understanding.

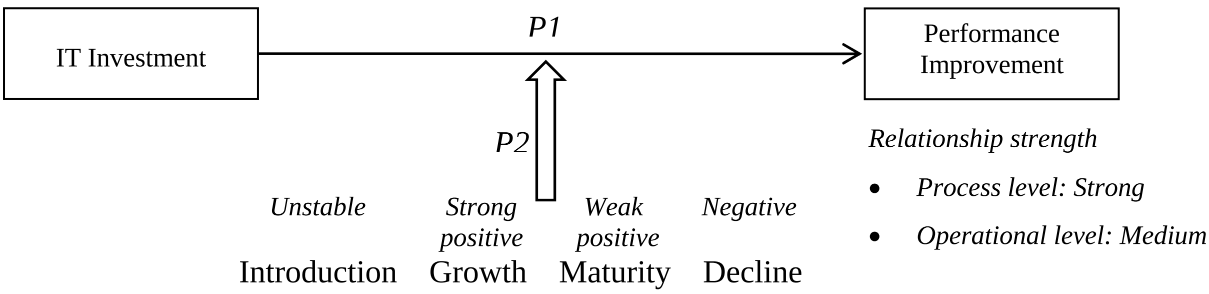

Figure 2: Proposed theoretical framework on IT investment and performance improvement

5. DISCUSSIONS AND CONCLUSION

In this paper, we attempt to develop a new theoretical framework regarding the relationship between IT investment and performance improvement. We started with a rather comprehensive review of the relevant literature. Our review effort identified three theoretical perspectives upon which extant empirical studies are built: macroeconomics theory, resource-based view, and institutional theory. Each theoretical perspective has its own merit but none of them can provide a convincing explanation for the “IT Productivity Paradox.” The main reason, we argue, is that each existing theoretical perspective only focused on one aspect of the relationship, but failed to conduct a holistic examination of the relationship.

This research also can provide useful guidance for practicing managers. First, firms need to be aware of the stage of the life cycle of the information technology to be invested, which help them set realistic performance improvement goals. Second, firms should measure performance at the right level for their IT investment. It has been pointed out numerous times that, incorrect expectation does not help IT project success, but instead, could potentially lead to project failure.

This research can be extended in multiple ways. First, qualitative analysis such as case studies can be conducted to further develop the proposed theoretical framework. Second, researchers may develop testable research hypotheses and corresponding measurement instrument, which lays a foundation for a large scale empirical examination. Finally, the proposed research framework can be further extended by including other relevant factors such as industry, IT infrastructure capabilities.

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