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IS IT INVESTMENT A LOSING PROPOSITION? VALUE CREATION AND PRISONER'S DILEMMA PERSPECTIVES

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Abstract

The inconsistent empirical link between IT investment and performance has fueled scholarly debate over IT value. Using the concept of resources and value creation, coupled with the logic behind Prisoner's Dilemma, this paper theoretically demonstrates that it is not likely that investing firms are the ones who enjoy a significant portion of value created by their IT investment. The dynamic interplay among firms, competitors, and IT suppliers makes it difficult for investing firms to truly realize the value from their IT investment.

Introduction

Scholars have long been in search of information technology (IT) investment value and resulting performance improvement. Unfortunately, research in IT investment value and performance has produced mixed results, and has evolved into *IT paradox* debate (e.g., Brynjolfsson, 1993). While the research findings at the economy and industry levels have shown little promise of productivity or value derived from IT investment, researchers have turned their attention to the studies at the firm and application levels and found more promising results. Nevertheless, the research on IT and performance at the firm and application levels has continued to yield inconclusive results (e.g., Devaraj & Kohli, 2000).

The common but implicit assumption that IT investment should create value to investing firms and result in the performance improvement has driven business managers to heavily invest in IT (Mahmood & Mann, 1993) and has fueled research efforts to demonstrate the connection between firm performance and IT investment (Thatcher & Oliver, 2001). This assumption may also have directed the explanation of mixed results towards methodology-related issues, especially performance measurement (Chan, 2000). This paper takes the position that both methodology and theory that research rests up on can limit empirical findings. Many scholars with the IT value assumption strongly held may have mainly argued that the methodological differences have led to inconclusive findings. However, I believe that in addition to methodological concerns, there is a need to step back and look at a bigger theoretical picture of IT investment value in order to understand or to explain why the consistent link between firm performance and IT investment has not been found empirically.

From practitioner standpoints, considering the massive IT investment worldwide and over \$300 billions of annual IT investment in the U.S. alone (Judge et al., 1998), it is legitimate to call for further understanding on IT investment value. From academic standpoints, the ongoing mixed research findings also call for further explanations. This paper aims to theoretically examine the potential IT investment value, which investing firms can gain, based on the concept of resources and value creation (Collis & Montgomery, 1998) and Prisoner's Dilemma in game theory (e.g., von Neumann & Morgenstern, 1944). Instead of holding on the common IT value assumption, this paper takes a step back and asks a fundamental question "*whether IT investment really creates value to investing firms*". I believe that by removing such assumption, we can gain more theoretical flexibility and can view the IT investment phenomenon from a broader perspective, which may hopefully yield a better understanding on IT investment value and resulting firm performance.

Literature Review

IT Paradox

The waves of the search for IT investment value was initiated at the economy and industry levels, which were particularly centered on aggregate IT investment and resulting productivity improvement. However, the research findings have been inconclusive and have shown little evidence of productivity gains. For example, Baily (1986) found the decline in productivity at the economy level in the 1970s when there was a massive IT investment. Jorgenson and Stiroh (1995) also found the productivity growth in the 1973-1992 period (extensive IT investment) was less than that in the 1947-1973 period (limited IT investment). At the industry level, Siegel and Griliches (1992) found a positive correlation between IT investment and productivity growth in manufacturing industries while Brendt and Morrison (1995) found no significant differences in productivity associated with IT investment and other kinds of investment. (see Chan, 2000; Devaraj & Kohli, 2000 for more thorough reviews)

While the first wave of the search for IT investment value at economy and industry levels has showed discouraging results, the second wave has taken on at the firm and application levels. Although the research at the firm and application levels has revealed more promising findings than the economy- and industry-level research, IT investment-performance research at the firm and application levels has continued to yield inconclusive results (e.g., Mahmood & Mann, 1993; Thatcher & Oliver, 2001). For example, Strassmann (1990) found no relationship between IT investment, productivity, profits and return on investment while Hitt and Brynjolfsson (1995) found the connection of IT with increased productivity and consumer surplus, but not with higher profitability. In addition, Lee and Menon (2000, p. 99) studied IT and non-IT investment in hospitals in the 1976-1994 period and found that “IT labor had a negative contribution to productivity and that non-IT capital had a greater contribution to productivity than IT capital”.

Since firms and applications are the focus of recent studies, more researchers have made research efforts towards the link between IT investment and business performance indices/quantitative measures. Mahmood and Mann (1993) found that individual IT investment variables were weakly correlated with organizational strategic and economic performance measures. However, they found the mixture of positive and negative results from canonical correlation analysis. The canonical functions suggested that IT spending on employee training was positively related to sales by total assets, market value to book value, and ROI while IT budget as a percentage of total revenue was negatively related to that set of performance measures. In addition, IT value as a percentage of its revenue was positively related to sales by total assets but negatively related to sales by employee and return on sales. Following the same line of research question, Rai and his colleagues (1997) found no relationship between IT investment and financial performance. Instead, they found a positive relationship between IT investment and revenues, and at the application level, they found IT capital and client/server expenditure were positively related to ROA, but IS staff, hardware, software and telecommunication expenditures were not. They also found that IT capital, client/server, IS staff, and hardware expenditures were positively related to labor productivity while IS staff, hardware, software and telecommunication expenditures were negatively related to administrative productivity. The positive relationship between IT investment and revenues were also found in Devaraj and Kohli's (2000) study on the DSS use in the healthcare industry. Sircar, Turnbow and Bordoloi (2000) replicated the finding of the revenue-IT investment relationship, but found no relationship between IT investment and profitability measured by net income. At the application level, they found that spending on IS staff and staff training were positively related to revenues, even more so than computer capital. However, they found no connection to net income.

In short, previous studies at all four levels of analysis have shown inconclusive results. The findings at the firm and application levels have been more encouraging than those at the economy and industry levels, and have shown the replication of revenue-IT investment correlation. Nevertheless, in most cases, they have failed to show the correlation between profitability and IT investment.

Performance Measures

Several IT researchers have largely attributed the mixed IT-firm performance research findings to the differences in research methodology, particularly performance measurement (Brynjolfsson, 1993; Rai et al., 1997). Chan (2000) has found that performance measures in IT investment research have been evenly divided into qualitative/individual (soft) and quantitative/organizational (hard) measures. Michalisin, Smith and Kline (1997, p. 379) have suggested that “the choice of performance measures should be a function of one's research”. This paper further argues that the choice of firm performance should reflect the purpose of business initiatives and organizational goals. Thus, when for-profit firms, whose IT initiatives appear to be for strategic/tactical purposes, are the focus of IT investment research, quantitative/organizational measures such as profitability

should be necessary firm performance indices. The logic is that profitability is a major organizational goal of for-profit firms and in many cases is a major driver of their strategic attempts. Thus, profitability should be a necessary firm performance index although it may not sufficiently reflect firm performance as a whole, considering a broad range of firms' responsibilities for stakeholders' well-beings (i.e., employee/customer satisfaction). In addition, from business practitioner perspectives, massive IT spending, accounted for up to 50% of businesses' total capital expenditures (Earl, 1989), can directly undermine firm profitability; thus, expected benefits of IT investment should somewhat be linked to firm profitability as well especially when the firms are profit-oriented. The scenario would be different for non-profit firms in which, by definition, profitability is not a major concern. Performance indices of non-profit firms could legitimately be qualitative/individual measures (i.e., employee/customer satisfaction).

Nevertheless, this paper focuses mainly on for-profit firms and is an attempt to theoretically examine the potential IT investment value and resulting firm performance improvement, which investing firms can gain, based on the concept of resources and value creation (Collis & Montgomery, 1998) and Prisoner's Dilemma (von Neumann & Morgenstern, 1944). It is noted that this paper still encourages the firm level of analysis and quantitative/organizational (hard) performance measures although recent studies have moved toward the application level and qualitative/individual (soft) performance measures, a more micro level of analysis, to search for stronger IT investment-performance connections.

Resources and Value Creation

Whether a firm's resources can create value to the firm depends on the dynamic interplay between the firm and its competitive environment particularly in the dimensions of demand, scarcity and appropriability (Collis & Montgomery, 1998). The intersection of these three dimensions is labeled 'the value creation zone' (see Figure 1). In other words, resources can create value to the firm when they meet these three criteria: demand, scarcity and appropriability simultaneously.

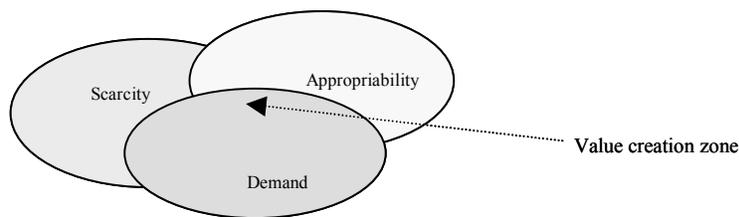


Figure 1. The Value Creation Zone (from Collis & Montgomery, 1998)

A firm's resources meet the *demand* criterion when one or more properties of the resources can help the firm to fulfill customers' needs at a price that customers are still willing to pay. It is noted that customers' needs and willingness to pay can change over time and are contingent on environmental changes (e.g., Collis & Montgomery, 1998). Scholars in the resource-based view (RBV) school of thought in the strategy field also describe this kind of resources as valuable resources (e.g., Barney, 1991). To meet the second criterion, *scarcity*, a firm's resources should not be plentifully available or easy for competitors to replicate. RBV scholars refer this characteristic to rareness, imperfect imitability, and non-substitutability (e.g., Barney, 1991). The final criterion, *appropriability*, is about the distribution of value: "Who captures the value created by the resources?" (Collis & Montgomery, 1998, p. 37) Put differently, it is the issue of whether revenues or profits generated by a firm's resources will eventually go to the firm or will be distributed to other parties. For example, revenues or profits made by a firm's salespeople may not entirely go to the firm, and may be partly distributed to the salespeople in the forms of salaries and commissions. In the extreme, if the salespeople's salaries and commissions become very high, the net revenues or net profits that the firm can appropriate may turn to be marginal although the salespeople are probably considered valuable human resources of the firm. To my knowledge, the issue of appropriability has not gained much research attention from RBV and strategy scholars, despite its important implications.

In sum, the value creation zone framework proposed by Collis and Montgomery (1998) can provide us an analytical lens to determine whether a firm's resources can create value to the firm. A firm's resources can create value to the firm when they simultaneously meet the three criteria: demand, scarcity, and appropriability.

Prisoner’s Dilemma

In game theory literature, Prisoner’s Dilemma has been a very well-known example to demonstrate that under some circumstances, rational actors acting in their own best interest and assuming others to do so can end up with the worst possible outcomes for all (e.g., von Neumann & Morgenstern, 1944). In the Prisoner’s Dilemma, police apprehend two individuals on suspicion of committing a serious crime. The police do not have enough evidence to convict on serious charges, but have enough evidence to convict on a charge for a three-year prison term. The police make an offer to one individual a one-year sentence if he confesses. If he does not confess and his partner does, the charge will be more serious and will carry a ten-year prison term. However, if both confess, each individual will receive a seven-year sentence. While both individuals are kept apart, one has to make the decision based on the expected behavior of the other. As rational actors assuming the other will act in his own best interest, they both confess and receive a seven-year sentence although the better outcomes for both could have been a three-year sentence if they had turned down the police’s offer. The payoff matrix of the Prisoner’s Dilemma is shown as follows.

		Individual 2	
		Confess	Does not confess
Individual 1	Confess	7 - 7	1 - 10
	Does not confess	10 - 1	3 - 3

Note: In each cell, the left is the year prison term for Individual 1 while the right one is the year prison term for Individual 2

Figure 2. Prisoners’ Dilemma Payoff Matrix

In short, the Prisoner’s Dilemma demonstrates a counter-intuition of rational decisions leading to negative outcomes. We can draw an analogy between the Prisoner’s Dilemma and some business situations where firms acting in their own best interest and assuming others to do so can bring destructive outcomes to all.

Theoretical Arguments, Analyses, and Propositions

Resources, Value Creation, and IT Investment

Several management scholars regard IT as a type of firm resource (e.g., Mata, Fuerst & Barney, 1995). The value creation zone framework can be used as an analytical lens to see whether IT resources can create value to the firm, based on the three criteria: demand, scarcity, and appropriability. The analyses are as follows.

Demand Criterion

The advancement in IT has offered firms new ways to do businesses and to fulfill customers’ needs in various industry sectors (e.g., Rayport & Sviokla, 1995). IT provides firms with various capabilities of managing information pertaining to business operations such as inventory, quality control, purchasing, and decision making, and hence can help firms to cope with business and customer demands (Turban et al., 1996). Yet, the information technology advancement itself may have escalated the expectations of customers. As the IT advancement escalates the customer expectations, investing in IT may increase the possibility that the firms can meet business and customer demands. The above discussion suggests Proposition 1, which indicates that IT investment is likely to meet the demand criterion of the value creation zone framework.

Proposition 1: IT investment is positively associated with the likelihood that investing firms can meet business and customer demands.

Scarcity Criterion

As the rate of IT advancement becomes so rapid and results in technological obsolescence (Yang & Huang, 2000), the trend that firms make IT investment through outsourcing become more prevalent (Slaughter & Ang, 1996). By doing so, firms can have an access to the best in class IT and specialized knowledge, and can reduce the risk of being locked in the obsolete technology. In other words, external IT specialists or IT vendors can help the firms to keep up with the pace of IT advancement, which is generally set by the IT specialist companies themselves. Although firms can have an access to the best in class IT and the specialized knowledge through outsourcing, so can their competitors. As rational actors, IT suppliers are ready to sell their products/services to any firm with a sufficient spending capacity. Thus, the best in class IT and specialized knowledge are always plentifully available in the market. Also, by having IT suppliers as outsiders to the firms, the coordination between the two parties may be diminished. Consequently, the firms' IT developed by the IT suppliers may be less likely to align with other organizational elements to create a unique value to the firms, which is relatively difficult to imitate by competitors. Additionally, IT suppliers, themselves, could potentially be the agents of technology and/or knowledge diffusion. These arguments lead to Proposition 2, indicating that IT investment is not likely to meet the scarcity criterion of the value creation zone framework.

Proposition 2: IT investment through IT suppliers is negatively associated with the IT unique benefits and the difficulty to replicate by competitors.

Appropriability Criterion

On the issue of appropriability, a significant portion of IT-created value may be distributed to IT suppliers or IT professionals who are in charge in developing, introducing, and maintaining IT in firms' IT investment. Researchers have found the positive relationship between IT investment and firm revenues, but found no consistent link between IT investment and firm profitability (e.g., Rai et al., 1997). Rai and his colleagues (1997) have interpreted such finding that IT-created value may be distributed across organizations or passed on to customers. It appears that the waves of massive IT investment in the past decade have coincided with the significant growth of IT-specialist companies and escalating salaries of IT professionals. Through inductive reasoning, this observation, coupled with the research findings of positive IT investment-revenue relationship and inconsistent IT investment-profitability link, may suggest that IT suppliers have appropriated a significant proportion of IT-created value. The IT-investing firms can only appropriate a relatively marginal proportion, which carries no significance to their bottom line. This argument suggests Proposition 3, indicating that IT investment is not likely to meet the appropriability criterion of the value creation zone framework.

Proposition 3: IT investment through IT suppliers is negatively associated with the proportion of IT investment value appropriated by investing firms.

Collectively, Proposition 1, 2 and 3 indicate that IT investment is not likely to meet the three criteria: demand, scarcity and appropriability simultaneously and thus is not likely to create value to investing firms.

Prisoner's Dilemma and IT Battles

Considering the potential that IT can change the way firms do businesses, practitioners and management scholars tend to believe that IT can evolve into a source of competitive advantage (e.g., Mahmood & Mann, 1993). From the research findings of the positive revenue-IT investment relationship, it is reasonable to assume that IT investment can reap a certain amount of financial value, but how much IT investing firms get their share is still questionable.

As mentioned earlier, the Prisoner's Dilemma can be a useful analogy to some business situations. IT investment payoffs can potentially be one of them. In this analysis, we can set a simple situation that an IT investment plan is offered to a firm by an external IT supplier. This IT investment plan can yield an increase of \$1,000 in annual net gains (\$400 from new sales, \$100 from overhead savings and \$500 from sales taken away from a major competitor) as well as an improvement of market recognition from investing in the advanced IT. The cost of this IT investment is \$350 paid to the IT supplier. If the firm does not accept the offer and its major competitor does, the firm may experience sale losses of \$500 to its competitor in addition to a relatively poor reputation of its technology commitment. On the other hand, the competitor can increase the net revenues by \$650 (\$1000 minus \$350) and improve its market recognition from investing in the advanced IT. However, if both the firm and the competitor accept this offer, they both will not lose or gain \$500 from the taken-away sales, and can gain new sales of \$200 (\$400 split by two) and overhead savings of \$100. No one gains an advantage over the other from the technology-driven market recognition. As a result, they will end up experiencing a loss of \$50 each (\$300 minus \$350) this year from the IT plan. By next year, they can expect

another new gain of \$200 in sales and overhead savings of \$100 (total of \$300), which can cover the loss of \$50 in the previous year. Thus, they can expect the net gain of \$250 (\$300 minus \$50) for the IT investment plan over the two-year period. As rational actors, both the firm and the competitor accept the offer and set to take a loss of \$50 this year while expecting the net gain of \$250 from the IT investment over the two-year period. Unfortunately, in the following year, the IT supplier approaches the firm and informs the firm that there is a technological change, which can make the IT plan adopted in the previous year become obsolete. The new IT plan can help firm to increase its annual net revenues by \$1,000: \$400 from new sales, \$100 from overhead savings, and \$500 from sales taken away from the competitor in addition to an improvement of market recognition. The cost of this new IT plan is \$350, and so on. In the end, the IT supplier keeps coming up with a new IT plan every year, and the firm and the competitor as rational actors make rational decisions but never realize the net gain from their ongoing IT investment. The payoff matrices of the firm, the competitor and the IT supplier are presented below.

		IT Investment offer		IT Battles		
		Competitor		Competitors		
Firm	Accept	Accept	Does not accept	Firms	High IT employment	Low IT employment
		-50/ (0) recognition	+650/ (+) recognition		Lose	Win
	-50/ (0) recognition	-500/ (-) recognition	Lose		Lose	
	700	350	Double Wins		Win	
Does not accept	-500/ (-) recognition	0/ (0) recognition	Low IT employment	Lose	Draw	
	+650/ (+) recognition	0/ (0) recognition	Win	Win	Draw	
		350	0			Draw

Note: In each cell, the top is the payoff for the firm(s), the middle is the payoff for the competitor(s), and the bottom is the payoff for the IT supplier(s).

Figure 3. IT Investment Payoff and IT Battle Outcome Matrices

Although the above IT investment situation is overly simplistic, it may adequately demonstrate the dynamic interplay among the firm, its main competitor and the IT supplier. As rational actors, all three parties want to improve their own payoffs. Both the firm and its competitor accept the IT investment plan on the basis of preventing their potential sales loss and reaping their net gain in future years, assuming other things being constant. Whereas, the IT supplier tries to improve its own payoffs by introducing new technology and new IT plans to both the firm and its competitor. Such dynamics make the net gain from IT investment become difficult to realize by the investing parties. These arguments suggest the following proposition.

Proposition 4: The IT advancement introduced by IT suppliers and the IT investment launched by competitors are negatively associated with the likelihood of IT investment value being realized by investing firms.

Discussion and Conclusion

This paper uses the value creation zone framework and the logic behind the Prisoner’s Dilemma to analyze the likelihood that IT investment will create value to investing firms. The value creation zone framework suggests that IT investment is not likely to meet the three criteria: demand, scarcity and appropriability simultaneously (Proposition 1-3). IT investment is likely to meet the demand criterion. However, it is not likely to meet the scarcity and appropriability criteria, considering the advanced IT of IT suppliers also available to competitors, the potential technology/knowledge diffusion through IT suppliers, and the high cost of IT investment as well as ongoing update/long-term training paid to the IT suppliers. Thus, it is not likely that IT investment will create value to investing firms. From the analysis based on the logic of Prisoner’s Dilemma, IT investment appears to be a vicious circle trapping investing firms and competitors into IT battles while IT suppliers is likely to reap the benefits from the IT investment. As rational actors acting in their own best interest and assuming others to do so, firms and competitors will have an ongoing IT investment and gravitate themselves into a lose-lose situation (see Figure 3) although they both would be better off not to have the ongoing IT investment in place. One may ask, “does this suggest managers not to invest in IT, or is IT investment a losing proposition?” The managerial implications from the analyses are broader than a yes-no answer. To ignore the appeals of IT and its potential to offer new ways to do businesses would be an opportunity cost and would not be a preferable managerial choice. The analyses imply that to reap significant benefits from IT investment, firms and competitors may need to cooperate

rather than compete and assume others will act in their own best interest. Including IT suppliers into the cooperative efforts may also increase the promise of success. However, a challenge may lie at how to get IT suppliers to truly cooperate when they are in the best position to harvest the benefits from IT battles between firms and competitors.

In conclusion, two different theoretical analyses in this paper show a convergent result that it is not likely that investing firms are the ones who enjoy a significant portion of value created by their IT investment. Despite its attempt to further understand the IT investment phenomenon, this paper still has some inherent limitations. For simplicity sake, this paper uses an overly simplistic IT investment situation in the Prisoner's Dilemma analysis to illustrate the dynamic interplay among firms, competitors and IT suppliers in the IT investment phenomenon. In reality, there may be many factors complicating the situation and influencing the payoff scenarios. In addition, this paper can only highlight the potential problems why IT investment may not create a significant value to investing firms, and may somewhat reflect the prevalent research findings of inconsistent link between IT investment and profitability. However, the solutions proposed in this paper are very limited in a practical sense. Future research may focus on various factors that can influence the payoff scenarios and may direct the research efforts toward finding IT investment solutions capable of providing mutual benefits to all parties involved.

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