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Information Technology Payoff and Time Lags

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ABSTRACT

A great deal of controversy exists about IT impacts on firm performance. While some researchers have reported positive impacts, other researchers have found negative or no impacts. Several reasons have been offered for the contradictory results including mismeasurement, poor quality of data, and possible time lags between IT investments and firm performance. As more research has found the existence of time lags between cost and benefits, failure to consider time lags in the previous research has received enormous attention and emerged as a main reason for the contradictory results. However, despite the important role in business value research, little attention has been given to what causes time lags and why different time lags exist among different firms and types of IT. Therefore, this study provides a conceptual framework of time lags between IT investment and firm performance.

INTRODUCTION

In response to the need to measure information technology (IT) impacts on firm performance, IS researchers have made impressive efforts to demonstrate the impacts of IT. However, a great deal of controversy still exists. While some researchers have reported positive impacts (Anderson et al. 2003; Osei-Bryson and Ko 2004; Stratopoulos and Dehning 2000), other researchers have found negative or no impacts (Loveman 1994; Roach 1991; Strassman 1997). Therefore, the results of recent studies of IT business value are at best inconclusive.

Several explanations from both theoretical and methodological viewpoints have been offered for these contradictory results, including mismeasurement problems, poor quality of data, and possible time lags between IT investments and firm performance (Bakos 1998; Brynjolfsson 1993; Chan 2000; Senn 2003). Recently, failure to consider time lags between investment and performance has received enormous attention and emerged as a main reason for the contradictory results (Anderson et al. 2003; Brynjolfsson and Malone 1994; Devaraj and Kohli 2000; Stratopoulos and Dehning 2000). The research has argued that IT investments may take years to add value to a firm, so using data covering a limited time period immediately after IT investments have been made may not reveal the real impacts of IT.

However, although a large number of studies have found time lags between IT investment and firm performance, little attention has been given to what causes time lags and why different time lags exist among different firms and types of IT. We propose to develop a conceptual framework for such lags in order to enhance understanding IT pay-offs. This study attempts to answer the following questions:

1. Within the same industry, Do different time lags exist among different types of Information Technology? In other words, does the technology itself create the delays?
2. Within the same industry, Do different time lags exist differ among different firms? In other words, are there characteristics of the individual firm which create delays?

THEORETICAL BACKGROUND

To information systems (IS) researchers, the contradictory findings on the value of IT have been an invitation to seek better theory and

explanation (Soh and Markus 1995), and research has responded to seek answers for this 'productivity paradox'.

Mismeasurement

Mismeasurement has consistently been introduced as one of main reasons for productivity paradox (Bakos 1998; Brynjolfsson 1993; Chan 2000; Kohli and Devaraj 2003). For example, the primary focus of much of the earlier research in the business value of IT has been on the productivity impacts of IT. However, considerable research has found that a large proportion of the benefits from IT has not appeared in *productivity* statistics (Bakos 1998; Bharadwaj et al. 1999; Soh and Markus 1995; Tallon et al. 2000). In other words, most intangible benefits, such as improved inventory management, greater product variety, and enhanced customer service, have been excluded from analyses of IT pay-off. Further, it is very difficult to separate the specific contribution of IT which mostly affects firm performance indirectly (Peffers and Saarinen 2002). Other research has found that firms have difficulty observing some values because they are captured by trading partners or competed away (Melville et al. 2004).

Poor Quality of Data

The quality of data used in the previous research has also contributed to the inconclusive results (Barua et al. 1995; Grover et al. 1998; Panko 1991). Often firms are reluctant to divulge their data for competitive reasons, leading to conclusions based on secondary or incomplete data (Senn 2003). Secondary data though easier to obtain and generally objective, are limited in detail and lead to significant differences in the result of the study (Kohli and Devaraj 2003).

Time Lags

It was often believed that "the best opportunity to find an impact of IT on performance is near the time of first deployment" (Lucas 1993), and many researchers and managers have been anxious to see what impacts IT can have on organizations. However, information technology's history has been described as an "overestimation of what can be accomplished immediately and underestimation of its long term consequences" (Strassman 1985, pg. 199). In other words, investments in IT may take years to add value to a firm and are more likely to be reflected in future firm performance, while company and industry indicators may show low or even negative returns in the meantime (Bakos 1998; Bharadwaj et al. 1999; Brynjolfsson 1993). Brynjolfsson and Malone (1994) found that the decline in firm size is greatest after a lag of one to two years following investments in IT, and Kohli and Devaraj (2003) found that investment in IT labor yields results in about 2-3 months. Anderson et al. (2003) also found that it takes one to four years for firms to realize the benefits of IT investments.

According to Devaraj and Kohli (2000), specific lags vary depending on the nature of the industry and the processes being considered. IT's role and intensity are often influenced by the competitive nature of the industry, and technology applied in manufacturing industry, such as electronic data interchange (EDI) or computer aided design (CAD), may yield different levels of outcomes compared to technology applied in the

healthcare industry, such as clinical information systems (Kohli and Devaraj 2003). Therefore, for example, the health care industry may experience shorter lags than manufacturing and engineering industries (Devaraj and Kohli 2000).

These empirical findings on time lags between IT investments and firm performance have forced researchers to consider new measures.

Timing of Data Collection

Peter Drucker once mentioned that “few people learn that the most meaningful information in social and economic matters is found within ranges and not in precise figures”(Umbaugh 1988). However, many of the earlier studies use cross-sectional or short-term series data to measure firm performance (i.e., Alpar and Kim 1990; Bender 1986; Kelley 1994; Prattipati and Mensah 1997; Weill 1992), and it has been argued that those research may not reveal the full IT impacts if there were time lags between IT investments and firm performance (Mukhopadhyay et al. 1995). Consequently, more recent research has thrown new light on the timing of data collection, and longitudinal study has received enormous attention.

Lucas (1993) suggested that longitudinal design allows the researcher to have the strongest evidence for a relationship between business value and IT. Among 66 IT payoff studies they used for their meta-analysis research, 48 (72%) studies used the longitudinal method while only 18 (27%) studies used the cross-sectional method. Further, among the most recent 22 studies (1999-2000), only two studies (9 %) used the cross-sectional method.

Method

Numerous attempts have also been made by IS researchers to find better methods to reflect time lags. Earlier research was based heavily upon historical accounting measures which are insensitive to time lags, such as Return on Assets (ROA), Return on Equity (ROE), and Return on Sales (ROS) (Bharadwaj et al. 1999), and mostly failed to find the positive impacts of IT on firm performance. Thus, Mahmood and Mann (1997) stated that “attempts should be made to use a time-lagged regression analysis” and, as an alternative to the standard accounting measures, financial market-based measures, which are time sensitive, have been frequently used. The results of the recent research using time sensitive methods or considering time lags are shown in Table1.

IT, Firm, and Time Lags

Although a large number of studies have found time lags between IT investment and firm performance, questions remain concerning why different time lags exist among different IT and firms. Although previous research explains why different time lags exist among different industries (Devaraj and Kohli 2000), no research has attempted to explain why different time lags exist for the same Information Technology by different companies in the same industry or why different time lags exist for different Information Technologies by the same firm. The next section provides the conceptual framework of time lags for different IT and firms by attempting to answer these questions.

Table1. Results of Recent Research Considering Time Lags

Study/year	Measures	Results of IT impact
Stratopoulos and Dehning (2000)	Financial performance	Positive
Anderson et al. (2003)	Future firm performance	Positive
Bharadwaj et al. (1999)	Tobin q	Positive
Brynjolfsson and Malone (1994)	Smaller firm size	Positive
Devaraj and Kohli (2000)	Revenue, Quality, etc.	Positive
Hitt et al. (2002)	Tobin q	Positive

CONCEPTUAL FRAMEWORK

IT Investment and Time Lags

Each investment in IT may have different objectives. IT investment may be aimed at changing IT infrastructure, at improving specific business processes, or at maintaining and renewing existing systems. According to Weill (1992), there are three different management objectives for IT: strategic, transactional, and informational. Strategic investments are defined as those aimed at creating competitive advantages and increasing market share or sales, and transactional investments focus on realizing productivity gains in processing the firm's routine business transactions. Finally, informational investments are those that provide the information infrastructure to manage the firm and meet other management objectives besides cutting costs or gaining sales. IT investment that is directed at creating competitive advantages may impact future firm performance differently than investment in IT that is directed at realizing productivity gains in processing the firm's routine business transactions.

A particular IT may deliver all three of these management objectives to a firm (Weill 1992), but a certain IT may not deliver any of these management objectives since not all of IT investments are successful. According to Lee (2001), many studies measure IT investment, but do not study whether such investment is transformed into actual hardware and software functions, or whether such functions are actually used. Thus, IT investment is not an adequate predictor of firm performance since information technologies that are not used do not generate any value or time lags (Lee 2001).

The Role of IT and Time Lags

Once IT is utilized, IT has a certain role in firms. Previous research found that this role of IT in firms can be classified into three distinct categories: automate, informate, and transform (Chatterjee et al. 2001; Zuboff 1985). When IT plays an automate role in firms, IT usually replaces human labor by automating business processes while informate IT provides data/information to empower management and employees. Finally, transform IT fundamentally alters traditional ways of doing business by redefining business processes and relationships. As a result, it is reasonable to believe that it takes longer for firms to realize the benefits of IT that transform than for IT that informate and automate (Figure 1). In their research using financial data from *Compustat* for the years 1987 to 2000, Anderson et al.(2003) found that future earnings of the industries where IT play informate roles were sustained longer than those of automate industries even though those of automate industries were quickly realized.

Time Lags in Different Firms

The expected time lags for IT may be longer or shorter depending on a firm's IT capability. A firm's IT capability is defined as “its ability to mobilize and deploy IT-based resources in combination or copresent with other resources and capabilities” (Bharadwaj 2000). Even though all firms have an IT capability, the level of IT capability is different from firm to firm (Peppard and Ward 2004). According to Bharadwaj (2000), key IT based resources in IT capability are classified into the following: the tangible resource comprising the physical IT infrastructure components, the human IT resources comprising the technical and managerial IT skills, and the intangible IT-based resources such as knowledge assets, customer orientation, and synergy

Stronger IT capability is needed as IT plays a more important role in firms (Figure 2).

For that reason, most firms may realize the automating effects immediately after a certain period of training or adjusting (Brynjolfsson 1993) regardless of their IT capability level.

However, firms having weak IT capability may not realize the full informational or transformational effects, and the timing of the realized value for each firm may also be different from firm to firm depending

Figure 1. IT Class and Time Lags

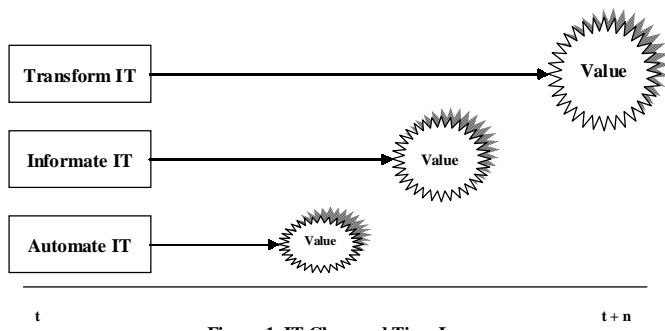
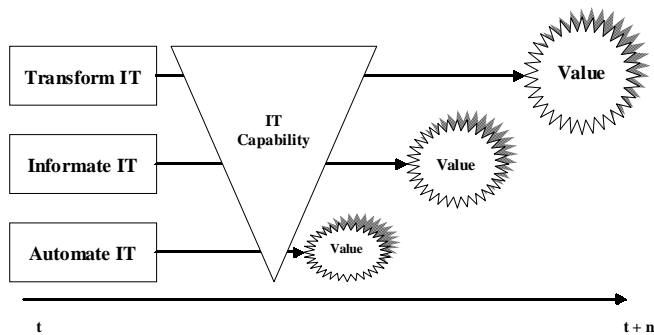


Figure 2. IT Class, Firm IT Capability, and Time Lags



on the level of IT capability. According to Moony et al. (1995), informational effects are primarily from IT capability to collect, store, process, and disseminate information. Thus, firms already having greater IT capability may accelerate the speed to reach the value while firms having less IT capability need more time to realize value.

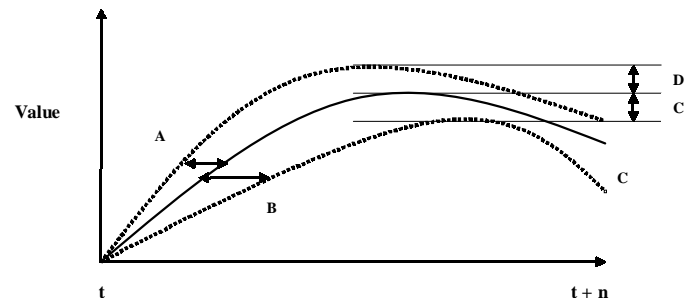
Further, it is not possible to have the transformational effects without strong IT capability since the transformational effects are derived from a firm's IT capability to facilitate and support process innovation and transformation (Mooney et al. 1995). For that reason, it takes longer for firms to realize the transformational effects than the previous two effects. Thus, firms having greater IT capability will have shorter time lags to realize the benefits of IT while firms having less IT capability need more time.

Time lags between IT investment and firm performance are the interaction of IT and firm factors (Figure 3). The bold line in Figure 3 represents the expected value for a certain IT, and the area between two dotted lines represents the value actually realized by firms based on IT capability. Some firms may realize the value of IT earlier than expected with greater IT capability (A), and some firms with less IT capability may realize value much later than the expected time and most of other firms (B). In addition, firms with less than average IT capability, while taking longer to realize the value, may not achieve the same level of value as firms which realize the value faster due to greater IT capability (C). Conversely, firms with greater than average IT capability may achieve greater than expected value gains due to the competitive advantage gained by being a "first mover" (D).

CONCLUSIONS

This study presents a conceptual framework of IT pay-off and time lags. Time lags are determined by IT type and a firm's IT capability. It takes longer for firms to realize the value of IT that requires more efforts and changes to implement and utilize, and the expected time lags caused by different IT may be modified by the level of IT capability of each firm. The stronger IT capability the firm has, the shorter time lags the firm

Figure 3. Time Lags and IT Value



experiences. No absolute time lag exists, and it is always changeable depending on IT and the IT capability of each firm.

However, firms should remember that any advantage they may have gained from IT is short-lived and not enduring like any other advantage. Any advantage from IT can be copied and will not sustain forever. This is the reason some researchers have argued that IT has become a commodity and not a strategic resource (Carr 2003). As more IT becomes a commodity, shorter time lags are required to gain first mover advantage for firms. Future research should focus on shortening time lags that allow firms to have longer competitive advantages.

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