



# Information technology investments and firm value

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## Abstract

Our objective in this paper is to develop a firm value model to assist IT managers and researchers in understanding the multiple effects that IT investments have on firm value. This firm value approach adds to the process-oriented approach through simultaneous evaluation of all of the factors that affect firm value. It is crucial for IT professionals to recognize the complex and diverse implications of IT investments on firm value. The implications of the firm value approach include forcing IT managers to think in terms of both industry and company-specific effects of IT investments, to consider both the magnitude and duration of competitive advantage due to IT investments, and the implications of the effect that IT investments have on risk and its relation to firm value. We demonstrate an application of the firm value framework by evaluating a major stream of research in MIS—event studies of IT investment announcements. Appendices to this paper can be found at <http://www.itandfirmvalue.com>.

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## 1. Introduction

The context for making IT investment decisions has been altered dramatically in the last few years. This change is primarily due to three factors. First, IT is no longer primarily confined to backroom operations. As Bob Martin, CEO of Wal-Mart's International Division says, "At Wal-Mart and at many other companies, technology has become integrated with every aspect of

the business" [53, p. 37]. Second, the role of CIO has been elevated from the back office to the board room [85] and companies now emphasize the ability of CIOs to contribute beyond IT functionality [48]. In the words of Jonathan Newcomb, CEO of Simon and Schuster, "I expect my CIO to have a rock solid business view of technology" [53, p. 43]. Third, the use and misuse of IT has become fertile ground for an ever increasing number of opportunities to either gain a competitive advantage or fall into a position of competitive disadvantage [11,13,21,22,64]. In light of these developments, it is apparent that managers involved in IT investment decisions must recognize

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the complex and diverse implications and trade-offs of IT investments.

Our objective in this paper is to develop a model that can be used by managers and researchers to understand the interrelated effects that IT investments have on firm value. A firm value framework (FVF) is important because management's first priority should be to maximize value for shareholders [15]. The firm value approach builds on the process-oriented approach. The latter was used during the 'Productivity Paradox' era to analyze the contribution of IT investments to firm performance through its impact on business processes [4,5,12,33]. The firm value approach adds to the process-oriented approach through simultaneous evaluation of the factors that affect firm value. As this study shows, there are some interesting implications of the firm value approach. These implications include forcing IT managers to think in terms of both the industry and company-specific effects of IT investments, the duration of competitive advantage due to IT investments, and the effect of IT investment on risk and its effect on firm value.

Hence, the FVF fills a very important gap in the IT researcher's and CIO's toolbox. We support and reinforce this observation in the following pages. We introduce the model in part 2 and in part 3 we discuss the implications of the model for managers. In part 4 we demonstrate the potential contribution of the FVF as a research tool by using it as the underlying business model to explain the interrelated effects of IT investments on firm value in the context of several recent event studies. We close the paper with our concluding remarks.

## 2. The firm value framework

If a firm is faced with a competitive environment where the opportunity set consists entirely of projects with a net present value of zero, then the value of a firm will be equal to its book value.

$$V_0 = BV_0 \quad (1)$$

where  $V$  = firm value;  $BV$  = book value of the firm.

However, if the opportunity set includes positive net present value projects, market value will exceed book value. We will assume that managers avoid

negative net present value projects, and therefore  $MV \geq BV$ . The residual income stock price valuation model, also known as the Edwards–Bell–Ohlson Model [46,75,49] shows that a company's value will be equal to its book value unless it can produce residual income. Residual income is a better measure of the true operating performance of a company than accounting income because it includes a charge for the capital employed in the business in addition to materials and labor. As shown in Eq. (2), the residual income model denotes firm value as current book value, plus the discounted sum of all future residual income,<sup>1</sup> which we will refer to as abnormal earnings.<sup>2</sup>

$$V_0 = BV_0 + \frac{I_1 - (r_e \times BV_0)}{1 + r_e} + \frac{I_2 - (r_e \times BV_1)}{(1 + r_e)^2} + \frac{I_3 - (r_e \times BV_2)}{(1 + r_e)^3} + \dots \quad (2)$$

This can be re-written as

$$V_0 = BV_0 + \sum_{t=1}^{\infty} (1 + r_e)^{-t} [I_t - (r_e BV_{t-1})] \quad (3)$$

where  $V$  = current firm value;  $BV$  = book value of the firm;  $r_e$  = the cost of equity capital;  $I$  = net income;  $I_t - r_e BV_{t-1}$  = abnormal earnings.

One of the most enduring debates in the management literature is the one regarding the determinants of firm performance (variation in abnormal earnings). The earliest views, stemming from economic theory, stress the importance of industry factors, while more recent theories from the field of strategic management stress the importance of firm-specific resources and capabilities. Researchers have responded to this debate with empirical studies probing the relation between industry and firm-specific factors and firm performance [91,52,86,54]. An emerging consensus is that firm performance is driven primarily by firm-specific factors and secondarily by industry or market factors. The residual income model is useful from a strategic perspective because it can be modified to

<sup>1</sup> It is important to stress that value today is based on expectations of future performance, which may or may not be realized. Past performance only matters to the extent that what has happened in the past affects the current book value of net assets.

<sup>2</sup> The residual income model assumes "clean surplus accounting", which basically means that all gains or losses flow through the income statement. This is akin to comprehensive income in US Generally Accepted Accounting Principles (GAAP).

illustrate both of these sources of abnormal earnings for a company.

Industry abnormal earnings can be attributed to the characteristics (attractiveness) of the industry in which the firm operates. If the average or normal level of profits in the industry is positive after deducting a charge for the cost of equity capital, then the entire industry has a competitive advantage relative to other industries. In our model we will denote this as IAE, the measure of the abnormal earnings of an entire industry.

We will use FAE to denote abnormal earnings from firm-specific factors. Thus we have the abnormal earnings of a firm (AE) expressed as the sum of the industry level of abnormal earnings plus the firm-specific deviation from the industry norm ( $AE = IAE + FAE$ ). To simplify the model in Eq. (3), replace abnormal earnings ( $I_t - r_e BV_{t-1}$ ) with AE. If a company earns only the industry level of abnormal earnings then its value will be given by:<sup>3</sup>

$$V_0 = BV_0 + \frac{1}{r_e}[IAE] \quad (4)$$

where  $V$  = firm value;  $BV$  = book value of the firm;  $r_e$  = the cost of equity capital;  $AE$  = abnormal earnings ( $I_t - r_e BV_{t-1}$ );  $IAE$  = industry level of abnormal earnings.

Firm-specific abnormal earnings can be attributed to IT as well as non-IT factors. Given the focus of this study, and in order to simplify the model, we will continue the discussion only including references to abnormal earnings that are a result of IT investments.<sup>4</sup> Sambamurthy [88, p. 245] argues that “during the last 15 years evidence and managerial belief have accumulated that information technology, when it is effectively deployed, contributes to superior firm performance”. In order to account for firm-specific deviations in the abnormal earnings of a company due

to its IT resources and capabilities, we add the FAE term to the model. Consider the present value of FAE that last  $n$  periods discounted back to the present:

$$\frac{FAE}{1+r_e} + \frac{FAE}{(1+r_e)^2} + \dots + \frac{FAE}{(1+r_e)^n} \quad (5)$$

This can be re-written as

$$\begin{aligned} &FAE \left[ \frac{1}{r_e} \left( 1 - \frac{1}{(1+r_e)^n} \right) \right] \\ &= \frac{1}{r_e} (FAE - FAE(1+r_e)^{-n}) \end{aligned} \quad (6)$$

Adding this to Eq. (4) results in Eq. (7).

$$\begin{aligned} V_0 = &BV_0 + \frac{1}{r_e}[IAE] \\ &+ \frac{1}{r_e}[FAE - FAE(1+r_e)^{-n}] \end{aligned} \quad (7)$$

where  $V$  = firm value;  $BV$  = book value of the firm;  $r_e$  = the cost of equity capital;  $AE$  = abnormal earnings ( $I_t - r_e BV_{t-1}$ );  $IAE$  = industry level of abnormal earnings;  $FAE$  = firm-specific deviation in abnormal earnings;  $n$  = the duration of FAE.

The benefits from IT investments are often delayed for a number of years. This is due to the time required to implement large IT projects, the time required to integrate IT into business processes, delays in employee acceptance, etc. [20,35]. We capture this delay by adding  $(1+r_e)^{-d}$  to the model. This increases the discount on abnormal earnings (reducing firm value) due to benefits from IT investments that begin  $d$  periods in the future. Adding this to Eq. (7) results in Eq. (8).

$$\begin{aligned} V_0 = &BV_0 + \frac{1}{r_e}[IAE] + \frac{1}{r_e}[(FAE \\ &- FAE(1+r_e)^{-n})(1+r_e)^{-d}] \end{aligned} \quad (8)$$

where  $V$  = firm value;  $BV$  = book value of the firm;  $r_e$  = the cost of equity capital;  $AE$  = abnormal earnings ( $I_t - r_e BV_{t-1}$ );  $IAE$  = industry level of abnormal earnings;  $FAE$  = firm-specific deviation in abnormal earnings;  $n$  = the duration of FAE;  $d$  = time lag before FAE begin.

Eq. (8) allows for the possibility of several strategic outcomes. Investment in IT will lead to one of the following scenarios: competitive advantage, competitive parity, or competitive disadvantage [68]. The model presented in Eq. (8) is versatile enough to allow

<sup>3</sup> We will assume that the industry levels of abnormal earnings are constant and persistent. A model with industry abnormal earnings with a finite duration is available from the authors. There are simplifying assumptions throughout the paper to focus the discussion on the results rather than the valuation model. Relaxing these assumptions unduly clouds the discussion without changing the implications or conclusions.

<sup>4</sup> IT investments go well beyond the simple acquisition of IT assets. We are referring to a company's effort to acquire IT resources and develop IT capabilities. We make this distinction because the theoretical and empirical evidence indicates that IT capabilities are a source of superior performance [13,60,68,89,99].

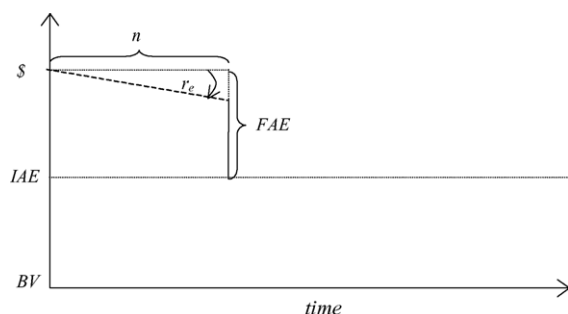


Fig. 1. A graphical illustration of the firm value framework (when  $d = 0$ ).

for all three possible outcomes. When  $FAE = 0$  the firm is earning only the industry level of profits and the company maintains competitive parity. A positive value of  $FAE$  implies a company with a competitive advantage, while a negative value of  $FAE$  implies a company at a competitive disadvantage. A combination between a positive  $FAE$  and a small or large  $n$  can be used to describe a company enjoying a temporary or sustained competitive advantage, respectively.

Fig. 1 is a graphical illustration of the FVF when there is no delay in abnormal earnings ( $d = 0$ ). In Fig. 1, the value of the firm is shown as book value (the horizontal axis) plus the present value of abnormal earnings (the area under the downward sloping dashed line). This demonstrates the effect of  $r_e$ , the cost of equity capital. As  $r_e$  increases, abnormal earnings decline, and are impounded into current stock price at a decreasing amount. Thus firm value decreases as  $r_e$  increases.

Fig. 2 demonstrates the effect of  $d$ , a delay in abnormal earnings. When  $d > 0$ , firm value decreases.

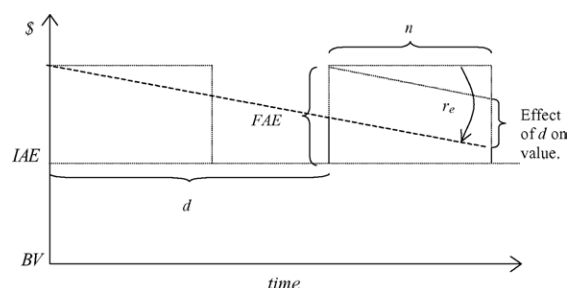


Fig. 2. The firm value framework incorporating the effect of  $d$  on firm value.

### 3. Implications for managers

As shown in Eq. (8), firm value is a function of six variables: IAE,  $FAE$ ,  $n$ ,  $d$ ,  $r_e$ , and  $BV$ . In the following sections we discuss the theoretical foundations for each variable, the effect of IT on each variable, and the effect of a *ceteris paribus* change in each of these variables on firm value.<sup>5</sup>

#### 3.1. IAE, industry abnormal earnings

In our model IAE represents the average or normal level of industry abnormal earnings. A change in IAE can occur due to a company changing the industry in which it operates or a shift in overall industry profitability due to structural changes within the industry. Structural changes may be attributed to internal as well as external factors such as wars, tax regime changes, and regulatory actions. The role of IT on industry structure and profitability has been argued and well documented. According to the competitive forces model or industry structure analysis [77,80], the state of competition in an industry depends on five basic forces: rivalry among existing firms, threat of new entrants, threat of substitute products, bargaining power of buyers, and bargaining power of suppliers. The collective strength of these forces determines the nature of the competition within an industry, which in turn determines the long-term equilibrium level of abnormal earnings (IAE) and the overall attractiveness of the industry. In industries where competition is intense, industry abnormal earnings are non-existent ( $IAE = 0$ ), and industry abnormal earnings are high in industries where competitive forces are weak ( $IAE > 0$ ). In micro-economic terms, the former is analogous to a perfectly competitive industry, while the latter is akin to a monopolistic environment.

The argument regarding the ability of IT to change each one of the five forces and as a result the profitability of the industry, has appeared in several studies [27,70,80]. This argument can be seen in the implications of the Internet on the bargaining power of

<sup>5</sup> Although firm size is not explicitly part of the model, it can affect many of the variables in the model indirectly. For example, large firms might be considered less risky, resulting in a lower cost of equity capital,  $r_e$ . Large firms might also have the market power to protect their competitive advantage *a la* Microsoft. Thus firm size should be considered while reading the following sections.

buyers and suppliers [104], on rivalry among existing competitors and the threat of new entrants [107], and the effect of IT enabled partnerships (supply chain management) and its impact on lowering cost [61,65,93]. For example, Internet real-estate brokers are cutting into the 6% commission that traditional brokers charge [98] and Wal-Mart is using IT to reduce costs by cutting suppliers out of the supply chain and dealing directly with manufacturers [100].

Dell's foray into the printer market demonstrates how IT affects competitive forces and can disrupt an industry. The use of IT to support Dell's direct business model and its virtual integration with suppliers has changed the structure of the PC manufacturing industry [65]. Dell leveraged this flexibility to venture into the server market, into the PDA market, storage market, and recently into the printer market [14,40,59]. Dell has a flexible business model, supported primarily by IT, that allows them to partner with existing suppliers in the printer industry (e.g. Lexmark). This implies the following effects: (1) Dell itself becomes the new entrant in the printer industry; (2) Dell accomplishes this by turning some of the existing competitors (Lexmark) within the printer industry into Dell's suppliers; (3) The bargaining power of buyers is changing. Customers accustomed to a market dominated by HP will now be offered a product that carries the Dell name, which is associated with high quality, yet will be sold at a lower price.

Consumers could end up as big winners. Dell likely will undercut the competition by slashing prices, much like it did with personal computers, and HP and other printer makers like Canon and Epson will probably be forced to respond [40].

Based on the above discussion we can conclude that IT has the potential to alter the forces determining the attractiveness of an industry and as a result affect the industry level of profitability. *Ceteris paribus*, a change in industry profitability changes firm value in the same direction. See Appendix I at <http://www.itandfirmvalue.com> for a numerical example of a change in IAE.

### 3.2. FAE, firm-specific abnormal earnings

Creation of economic value is the best measure of business success and profitability is the true manifesta-

tion of the creation of economic value [79]. Companies that successfully invest in IT improve their profitability and enjoy a competitive advantage relative to their direct competitors [1,13,62,68,70,80,88,99]. In the FVF, the increase in abnormal earnings due to investments in IT resources and capabilities (FAE) captures this change in competitive position.

Various theoretical models have been developed to explain how a company gains and sustains competitive advantage. These models can be used to explain how investments in IT resources and capabilities may lead to an increase in firm value through higher FAE. Porter and Millar [80] used the value chain framework to highlight the role of IT in competition. Porter and Millar argue that IT helps companies gain competitive advantage either by performing primary and support activities at a lower cost or performing these activities in a way that leads to differentiation and a premium price (more value). We expect to see the results of such investments in the development of IT capabilities to be captured in higher FAE.

McFarlan [70] analyzes the role of IT in the context of industry structure view. In his work he attributes the contribution of IT investments to firm value to IT's ability to build barriers to entry, switching costs, and even to change the basis of competition. McFarlan shows how aggressive companies that take advantage of IT to cement their competitive position force their rivals to play a difficult catch up game.

Companies like Wal-Mart, Dell, and Charles Schwab are known for their, *a la* McFarlan, proactive stance when it comes to IT. In several cases they also had the foresight implied in Porter and Millar's framework. They recognize the importance of IT initiatives not only for the company itself, but the need for their trading partners to adopt these changes as well. As a result of such IT initiatives, Wal-Mart has an inventory overhead cost of 15% while its rivals deal with overhead that is twice as high [63]. In a similar example, Dell has reduced its inventory holdings to 11 days while its rivals deal with 60–80 days [65]. On the other hand, companies like Kmart have been cornered into a reactive position, constantly trying to catch up with their competitors. As we have seen in the case of Kmart this game is not only difficult but also very expensive [94]. In the case of Charles Schwab, the company preempted Merrill Lynch in the use of the Internet to support online trading, which led to



significant cost savings and increased market share [102,103].

Proponents of the strategic conflict approach [92], argue that abnormal earnings are the result of strategic actions taken by companies trying to “keep their rivals off balance” [101, p. 510]. A company’s effectiveness in terms of creating product market imperfections or deterring entrance will be translated into a higher level of abnormal earnings. While the theory has not been explicitly linked to IT, the following quote from *BusinessWeek Online* is a testimony to companies with IT capabilities who do well in soft markets:

... [D]espite tepid demand for computer hardware, Dell is one of a few companies to consistently show revenue gains. With unit shipment up 28% in the third quarter over the same period in 2001, the company booked 22.5% higher sales—easily the best performance among tech’s heavyweights. It’s a smart way to do business in a soft market. [25]

While we could have continued with references to all theories of strategy to explain how investments in IT resources and capabilities lead to an increase in firm value through higher FAE, we are going to close this section with reference to the relational view [43,44]. The relational view focuses on pair or network routines and its proponents argue that companies that possess unique resource are likely to enjoy economies of scale if they are capable of combining their resources with unique resources of another firm. Wal-Mart and Dell have demonstrated such a capability in the process of building and enhancing their inventory management system and direct marketing system respectively. Enterprise Rent-A-Car leveraged proprietary software to form a value net to streamline operations for car insurers and auto body shops, leading to significant savings for the insurance companies. As a result, Enterprise’s volume of business with major insurance companies grew significantly [81].

Theoretical, anecdotal, and empirical evidence point to the fact that companies that have successfully invested in IT have improved their profitability [13,99]. *Ceteris paribus*, the change in FAE impacts  $V$  in the same direction. The size of the increase in firm value due to FAE will be influenced by the cost of equity capital ( $r_e$ ) and the duration ( $n$ ) of competitive advantage. See Appendix I at <http://www.itandfirm->

[value.com](http://www.value.com) for a numerical example of a change in FAE.

### 3.3. $n$ , the duration of competitive advantage

One of the most important factors affecting firm value is the duration of competitive advantage. The duration of a firm’s competitive advantage over a period of time (persistence of abnormal returns) is a measure of the sustainability of that firm’s competitive advantage. Several studies have examined the persistence of abnormal returns [34,39,50,58,71,83,84,106]. The ability of a company to protect its IT-enabled competitive advantage from competitors is captured in the FVF by  $n$ , the duration of the change in abnormal earnings due to IT investments. A firm that has a patent on a product or process might have a relatively fixed duration, whereas a company with constant innovation and long response time by its competitors may be able to extend  $n$  indefinitely. A change in customer preferences or innovations by competitors can reduce  $n$ , even to zero.

Traditional strategic analysis of IT investments relied on a static approach (e.g. industry structure view, value chain). Hidding [55] argues that in order to move to a dynamic approach, the duration of competitive advantage (the increase in abnormal earnings due to an IT investment) must be considered in the analysis. Mata et al. [68] develop a framework for evaluating the sustainability of an IT induced competitive advantage using the resource-based view of the firm. RBV is the most widely accepted framework for analyzing the sustainability of a competitive advantage [6–9,41,66,76]. RBV states that the supply of certain resources is inelastic, and this inelasticity can be attributed to any one or more of the following reasons: certain resources can only be developed over a long period of time (path dependence), it may not be clear how these resources contribute to a company’s competitive advantage (causal ambiguity), and the resources may be socially complex phenomena (social complexity). Given their inelastic supply, an increase in demand cannot be met in the short-term, and perhaps not even in the long run. Thus firms possessing these resources may be able to earn economic rents. Hence, resources having an inelastic supply can become a source of sustained competitive advantage.

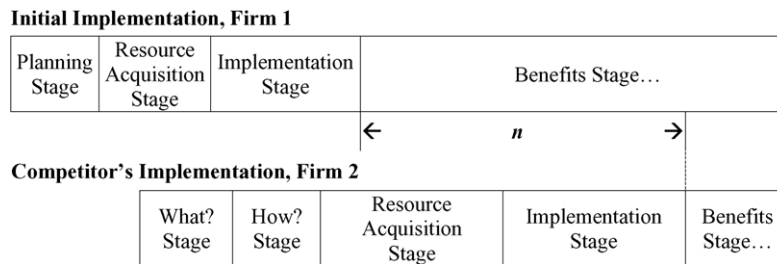


Fig. 3. IT competitive response model.

Feeny and Ives [47] developed a framework to evaluate the duration of competitive advantage due to IT. In their framework the magnitude of  $n$  is determined by both the IT investing firm and the potential reaction by competitors. The sustainability of competitive advantage ( $n$ ) is driven by such factors as competitor's response time, resource differences among competitors, and the potential to preempt competitive responses.

We will borrow from the Feeny and Ives framework to explain how companies develop IT-enabled strategic initiatives hoping to gain and sustain a competitive advantage. We will refer to this as the "IT Competitive Response Model".<sup>6</sup> The typical life cycle of such an initiative for a company (Firm 1) is captured in the top portion of Fig. 3. Firm 1's competitors will go through a stage of search as they try to understand why their competitive position has deteriorated. Eventually they will realize the "what-how" of Firm 1's initiative. This lifecycle of the competitor's response is captured in the lower portion of Fig. 3.<sup>7</sup>

Between the time Firm 1 gains a competitive advantage and the time the initiative is imitated ( $n$ ), Firm 1 earns abnormal economic profits. Hence the need to understand what factors contribute to the lag in Firm 2's response. In order to estimate  $n$ , one has to understand the four stages that a competitive response must pass through before a reasonable reaction is in place. These stages are the "What?" stage, the "How?" stage, the Resource Acquisition stage, and the Implementation stage. Although these stages occur primarily one after the other, they can also progress in

parallel. They will be shown and discussed in serial here for simplicity sake only. To the extent the competitor firm can perform these steps in parallel, response time will be shorter.

The "What?" stage is when Firm 2 figures out precisely what Firm 1 is doing. The start of the "What?" stage can be triggered by any number of things. It is possible that this stage will not occur until Firm 1 has the new IT in place and Firm 2 sees a shift in the competitive landscape. More likely Firm 2 will find out about the project before implementation is completed from customers, suppliers, or Firm 1's former employees. Initially it might just be a rumor or speculation, and this stage can drag on as Firm 2 gathers additional information about features, benefits, capabilities, and the scope and magnitude of the project. If the system has no obvious external component (e.g. a new data warehouse), there is greater likelihood of a longer delay before the "What?" stage begins.

Companies can avoid retaliation from their competitors and therefore sustain their competitive advantage when they introduce new strategic initiatives away from the prying eyes of the competition [78,30,39]. However, this need for secrecy collides with the need to generate publicity and the fact that CEO's beliefs cannot be kept private. We call this the "Manager's Dilemma" because executives need to continuously signal to employees, to partners, and to the market, the company's ability to stay competitive while knowing that their competitors analyze these signals in order to anticipate their agendas [45]. Hence, the lag before the "What?" stage begins depends on Firm 1's senior management's capability to attain this fine balance.

Assuming a loyal staff, the probability of keeping the initiative secret is higher if it is for internal use.

<sup>6</sup> This section is based on [47] except as noted.

<sup>7</sup> For simplicity there are only two firms in this model; however, Firm 2 in the model represents not just one firm, but any number of Firm 1's competitors.

However, the highest profitability is associated with IT projects extending beyond the company's value chain, i.e. projects involving customers and suppliers [23]. If Firm 1 has invested in close relationships with its customers and suppliers, they have an incentive to support the secrecy of the initiative. The more loyal are Firm 1's trading partners, the more likely it is that they will not share the details of Firm 1's initiative with competitors. Developing such relationships is a socially complex and causally ambiguous capability that competitors will not be able to imitate easily.

Large companies might get hints of projects undertaken by small or marginal competitors and dismiss them as unimportant, never fully entering the "What?" stage until the implementer demonstrates the ability to use the project as a viable competitive weapon. The so-called browser war between Netscape and Microsoft is a typical example [107]. A large project with questionable benefits (in the eyes of Firm 2) can also delay this stage until the payoff is obvious. In this case Firm 2 often starts at such a disadvantage that an adequate response never materializes.

When the competition knows the "What?" of Firm 1's IT initiative, their next hurdle is to figure out the "How?" of the initiative. The "How?" stage is when Firm 2 figures out how to respond to Firm 1. This involves gathering technical details as well as the business implications of the project. Firm 2 can respond in any of the following ways: acquire Firm 1, develop their own technique, copy the initiative, or outsource the project to an external party to either develop or copy the initiative of Firm 1. If Firm 2 develops a new technique, there is little Firm 1 can do to stop them. However, if Firm 2 attempts to copy the process, the loyalty of Firm 1's employees is the main factor that may affect their ability to do so. Increased sense of loyalty, low turnover of the IT staff, and Firm 1's ability to legally impose a gag order on staff who leave the company are likely to contribute to the length of the "How?" stage. Companies are aware of this. For example, Wal-Mart has taken legal actions to impose such legal restrictions on their employees in the past [95]. Besides former employees, there are other sources for the "How?" information: consultants used by Firm 1, Firm 1's customers and suppliers, and reverse engineering if it is a new IT-based product.

Understanding the business implications can be as important as the technical details, so the "How?"

stage is not complete until Firm 2 involves business side employees as well as technical side employees in this process. An additional determinant of the length of the "How?" stage is whether Firm 2 decides whether to copy Firm 1 or leap frog Firm 1 in anticipation of Firm 1's next step. Although jumping ahead might take longer than a simple replication, it is likely to preempt having to go through the entire process again in the near future.

A sustained competitive advantage is theoretically one that is not competed away. However, any competitive advantage will evaporate if other firms are able to acquire the resources needed to imitate the initiative. The third stage, the Resource Acquisition stage, is when Firm 2 acquires the necessary resources and capabilities to replicate or jump ahead of Firm 1. In this stage the number of potential competitors can be reduced substantially. Any firm that cannot acquire the necessary resources and capabilities will not be able to muster a response. Size can be an issue here, as a small firm might not be able to undertake a large project implemented by a competitor.

Resource acquisition can take two forms: surrogates or substitutes. Surrogate resources and capabilities are essentially trying to duplicate what Firm 1 did, using the same technology and processes. Substitute resources and capabilities are achieving the same outcomes and business implications, but with a different technical approach. For example, Firm 1 might find new ways to distribute their products through catalog sales with IT-based remote call centers. Firm 2 can use the same approach or an alternative such as Internet based sales (e-commerce). The key is that the resources and capabilities must be able to be combined in a way that they will perform the same function, not necessarily with the exact same technology or methodology.

Several other factors will affect the length of Firm 2's Resource Acquisition stage. The scope of the IT initiative is one of them. It will be easier for competitors to copy and implement Firm 1's technology if it is limited to a single value activity. On the other hand, projects transcending the value chain are more likely to be utilizing socially complex and causally ambiguous resources and hence are more difficult to imitate. For example, if the IT initiative utilizes resources and capabilities that the company developed over several years, Firm 1's competitors will be faced with an



additional path dependent hurdle. Last but not least, whether Firm 1 completed the project internally or outsourced portions of the project will determine the length of this stage. If outsourced, what was Firm 1's relationship with vendors? Does the vendor have any incentive not to disclose information to Firm 2? Obviously, a history of trust and loyalty in the relationship with vendors is another path dependent obstacle that will delay Firm 2's response.

Once Firm 2 acquires the necessary resources and capabilities for their response, implementation can begin. It is very likely that Firm 2's implementation stage will be shorter than Firm 1's implementation stage. This is because Firm 2 can learn from Firm 1's experience. By observing the successful outcome, Firm 2 can avoid the dead-ends and wrong paths Firm 1 explored on the way to successful implementation. Firm 2 might also have access to Firm 1's former employees or consultant used for the project to assist in a shorter implementation. This makes it important for Firm 1 to try and base new projects on unique characteristics such as unique locations, existing unique databases, or other experience based characteristics that Firm 2 does not have, and that will take a long time to replicate. This stage will be shorter for Firm 2 if they are able to build upon existing IT infrastructure.

The longer the duration of a competitive advantage, the larger its impact on firm value. As shown in Eq. (8), the term  $F AE(1 + r_e)^{-n}$  is subtracted from FAE, and therefore reduces firm value. Increasing  $n$  decreases the influence of this term. In the extreme case, when  $n \rightarrow \infty$ ,  $F AE(1 + r_e)^{-n} = 0$  and the portion of firm value due to FAE is given by  $1/r_e[F AE]$ . When  $n = 0$  the company operates at competitive parity and  $F AE(1 + r_e)^{-n} = F AE$  so the term  $F AE - F AE(1 + r_e)^{-n}$  is equal to zero and abnormal earnings are due only to IAE. When a company is able to increase the duration of their competitive advantage the size of the change in firm value will be proportional to the size of the change in duration, the size and sign of FAE, and disproportional to the level of risk ( $r_e$ ) and initial duration ( $n$ ). See Appendix I at <http://www.itandfirmvalue.com> for a numerical example of a change in  $n$ .

### 3.4. $r_e$ , the cost of equity capital

The cost of equity capital ( $r_e$ ) is a direct function of the riskiness of the company, and stresses the

importance of managing risk to maximize firm value. Managing risk has been the subject of a great deal of research in many business fields such as strategic management, finance, and accounting. Even without other strategic actions, reducing risk can increase firm value. Here we are concerned more with managing risk associated with IT investments, not managing risk as a strategic action (and therefore a source of firm value). We will focus on how risk management interacts with the other strategy literature in the FVF.

As shown previously, risk is an important determinant of firm value. There are various ways to manage risk, such as cash flow management, financing decisions, the use of derivatives and insurance, proper planning and forecasting, real option valuation, etc. What is important in the FVF is how to manage changes in risk brought about by investments in IT. For example, if new IT comes with increased risk, the firm may not realize an increase in firm value. Risk is related to two of the five variables in our framework.

One view of risk is captured by  $r_e$ , the cost of equity capital. The more risky the firm is perceived to be by market participants, the higher this level of risk. Even if firms are able to increase abnormal earnings, there may not be an associated increase in firm value if risk also increases. "Management should lower the level of their firm's risk in the eyes of the financial community" [28, p. 563]. This is controlled by management through financing decisions, control of income and cash flow variability, hedging of exchange rates, holding more or less risky securities, etc. Recently, the management literature has recognized many different types of risk, including tactical, strategic, and normative risk [28] and downside risk [73,82].

The second variable in the framework related to risk is FAE, the divergence of firm abnormal earnings away from the industry average. This type of risk is broad, and refers to any event that can cause FAE to decrease, especially for a short period of time. Examples include the loss of a warehouse due to fire, or a product liability lawsuit. In the case of Hershey Foods Corp., this was due to a failure to implement a US\$ 112 million ERP investment on time in the summer of 1999. As a result, sales dropped by US\$ 100 million and profits fell by 19% during the third quarter, the most critical for the industry due to Halloween [32,97]. Hershey Foods is not the only company to face such problems when implementing

IT; numerous other companies (e.g. Ben and Jerry's, Avis, Fidelity, Greyhound, OxfordHealth Plan, and FoxMyer) have had similar problems [74].

The success or failure of new IT is influenced by a wide spectrum of company-specific factors, as well as factors from the company's external environment. As a result, implementation of new IT, no matter how well designed and executed, will always be associated with a degree of uncertainty. For example, competitors may respond in an unanticipated way, suppliers may fail to deliver on their promises, customers may not like a new product or service, or employees may not support the IT initiative. The higher the degree of uncertainty, the higher the level of risk associated with the IT investment.

Consider the change in risk and therefore  $r_e$  due to IT investments that lead to a firm's competitive advantage. In the residual income model, risk has two effects. The first is a higher "hurdle" for companies to produce abnormal earnings. Remember that abnormal earnings are equal to  $(I_t - r_e BV_{t-1})$ . If a company has a higher cost of equity capital, the second part of this term ( $r_e BV_{t-1}$ ) is larger, making it more difficult for a firm to produce abnormal earnings. The second effect of an increase in  $r_e$  is that future abnormal earnings are impounded into firm value at a lesser amount.

Several studies [31,68,105], and the dismal record of successfully implemented projects documented in recent studies by IT consulting firms [87,96] point to the conclusion that investments in IT are risky. These studies discuss a broad spectrum of risks associated with investments in IT projects. Collectively, the message is that companies that fail to account for these risks are very likely to experience project failure prior to, during, or after IT project implementation.

The Standish Group's "CHAOS Report" [96], a study based on an extensive survey of IT executives and project managers, validates these concerns. The study found that approximately 84% of IT projects fail, where failure is defined as significant time and cost overruns, an inability of the IT system to deliver the desired functional results, or outright abandonment of the project. A more recent study by Andersen Consulting [87] reinforces this fact. They found that only 8% of large IT projects succeed. Among all IT projects, only 16% do not have significant quality problems, missed deadlines, or cost overruns. For this reason, IT Risk Management has become the crucial

factor in determining the success of IT projects. This was reinforced by Bob Martin (former CIO of Wal-Mart) who said, "IT risks are becoming increasingly entangled with business risks, and it is therefore the CEO's responsibility to distinguish between them" [53, p. 37].

There are three sources of IT risk, which if not properly addressed, may lead to unsuccessful implementation of IT projects and put the company in a position of competitive disadvantage [31]: IT projects may require technology that is not available (technical risk); IT projects may overwhelm the technical skills of the company's staff (project risk); or IT projects may be undermined by internal vested interests (internal political risk). In addition to these sources of risk, the inability of management to provide a reasonable estimate of implementation costs and the time required to implement are risks that are synonymous with project failure [69].

Although there is no empirical study that has explicitly determined the relation between IT risk and the cost of equity capital, one can argue that an increase of the former is very likely to lead to an increase of the latter. See Appendix I at <http://www.itandfirmvalue.com> for a numerical example that demonstrates the importance of managing risk when implementing new IT.

### 3.5. *d*, delay in abnormal earnings

One of the foundations of economics and finance is the concept of the time value of money. Very simply, a dollar received now is more valuable than one to be received in the future. This is captured in the FVF by  $d$ , the delay in the change in abnormal earnings due to an IT investment. Anything that causes  $d$  to increase will decrease firm value. A delay can be attributed to IT as well as non-IT factors. Given the focus of this study, we will continue the discussion only including references to delays that are a result of IT factors. In making investments in IT, this could be due to delays in implementation due to poor planning, delays in implementation due to inadequate technical skills, delays in implementation due to labor shortages, or delays in implementation due to technological infeasibility. McFarlan [69] considers time to implement IT projects that is much longer than expected as one of the explicit elements of IT project risk.

The results of the Standish Group's "CHAOS Report" [96] as well as ample anecdotal evidence [74] indicate that time to implement continues to be a serious problem plaguing IT projects years after Brooks [16,17] and McFarlan [69] raised the red flag. Besides time to implement, a company's ability to extract the appropriate rent from its IT investments may be delayed by such factors as the lags due to learning and re-adjustment. This is due to a period of learning associated with adjustment and a restructuring of the organization caused by new IT [20,35]. The value of the firm increases when abnormal earnings are received earlier. Thus it is important to consider the timing of future abnormal earnings in decision-making. See Appendix I at <http://www.itandfirmvalue.com> for numerical examples of changes in  $d$  and the related effect on firm value.

### 3.6. BV, book value

An IT investment is likely to involve large initial costs, followed by smaller annual expenses for support, maintenance, and depreciation. Under US accounting rules, purchases of IT that benefit future periods (computers, purchased software, IT infrastructure, etc.) should be capitalized and depreciated over their useful lives. In this case these items have no effect on book value. For example, consider the impact of the purchase of new servers, routers, software, etc. for a new e-commerce venture. If the IT is purchased with cash, it is simply an exchange of one asset for another, and therefore BV does not change. If the IT is financed with debt, assets and liabilities increase by the same amount and again there is no change in the book value of the firm.

There is a second set of IT investments that do have an effect on BV. Many of the development costs associated with IT investments are not capitalized due to the uncertainty surrounding future benefits (e.g. salaries and wages of IT employees). For example, less than 20% of the costs associated with a new US\$ 20 million SAP R/3 ERP system are capitalizable expenditures such as hardware and software [51, as cited in 24]. Other expenditures (consulting fees, labor expenses, training expenditures, etc.) must be written off as incurred, reducing book value. One benefit of the FVF is that regardless of the accounting method chosen for such expenditures, there is no impact on firm value.

Thus, the accounting method used for outsourcing, using application service providers, and leasing software is irrelevant.<sup>8</sup> This can be demonstrated with a simple numerical example that can be found in Appendix I at <http://www.itandfirmvalue.com>. Regardless if IT-related expenditures are initially capitalized and shown as assets or written off, firm value does not change. It is the benefits of the IT that increase firm value, not the choice of accounting for the IT investment.

### 3.7. Dynamic analysis

Comparative-static analysis is useful because it allows a *Ceteris paribus* evaluation of an IT investment on firm value via a change in any one of the value determining factors. Given the dynamic nature of IT investments, it is likely that IT implementation will affect multiple variables in the FVF simultaneously. Dynamic analysis allows us to observe the simultaneous change of multiple variables. As shown above, although an increase in profitability and duration of competitive advantage are the most desired results, it is not unusual to observe an increase in the level of risk. Other variables are often similarly affected.

For example, the first to implement a new product or service are often believed to gain a competitive advantage over their competitors [10]. However, with IT investments, it is often better to delay new implementation ( $d$ ) to avoid a decrease in FAE that comes from being the first mover. An abstract example of this is the Christmas tree grower. If a Christmas tree grower cuts down their trees early and brings them to market, they receive their abnormal earnings sooner (small  $d$ ). However, by waiting until later the trees are actually more valuable due to increased growth (larger FAE). This example stresses the trade-off firms often face between  $d$  and FAE.

An IT example of a change in  $d$  that results in a change in FAE can be found in the experience of many of the "dot coms" of the late 1990s. In the early days of e-commerce, there was a belief that first movers would have an advantage due to name recognition and

<sup>8</sup> As mentioned previously, this assumes a clean surplus relation. This requires that except for transactions with owners, changes in book value (BV) are due to earnings ( $I$ ) and dividends ( $D$ ):  $BV_1 = BV_0 + I_1 - D_1$ .

customer loyalty. However, many of the early e-commerce companies suffered from low profitability due to large initial investments in fixed costs such as infrastructure and few actual web customers. Companies that followed were able to make similar infrastructure investments at a lower cost, and have access to a potential customer base significantly larger than the first movers. While we do not have specific results pertaining to the dot com example, prior empirical research has shown that second-movers can duplicate first-movers venture for about 65% of the first-mover's cost [67]. See Appendix II at <http://www.itandfirmvalue.com>, for a numerical example of a delay in abnormal earnings more than offset by an increase in FAE.

Another example of an IT investment that affects multiple variables in the model is when a company attempts to enter a new industry with a higher level of industry abnormal earnings that is IT intensive. Moving into the more profitable industry can decrease firm value if a lack of the necessary IT resources causes a shift in FAE that more than offsets the benefits from operating in an industry with a higher level of industry abnormal earnings, IAE. See Appendix II at <http://www.itandfirmvalue.com> for two numerical examples. The first involves a company moving into an industry with a higher level of IAE that is offset by a decrease in FAE, and the second is a numerical example of a company increasing FAE due to new IT that is accompanied by an increase in  $r_e$ .

In the following section we show the implications of the model for researchers as we review five recent studies of the market reaction to IT investment announcements in the context of the firm value framework. Each of these studies has used an event study methodology. Event studies are interesting in the context of the firm value framework because they measure changes in firm value directly.<sup>9</sup>

#### 4. Implications for researchers<sup>10</sup>

The contribution of IT investments to firm performance and firm value has been and continues to be a major area of concern for IT managers and

researchers [26,38]. Over the years, several research studies [42,57,29,37,56] have responded to this challenge, employing event study methodology to measure the effect of IT investment announcements on firm value. In the following paragraphs, we demonstrate the contribution of the FVF as a research tool by using it as the underlying business model to explain the interrelated effects of IT investments on firm value in the context of these studies. More specifically, we use the model to discuss the variables used as well as the results of each study. In Table 1, we summarize the variables used in event studies in MIS to see how they fit into the firm value framework. Although you could argue that each variable used in these studies measures some aspect of IAE, FAE,  $n$ , and  $r_e$ , we focus on the main effects of each variable.

Dos Santos et al. [42] examine the stock price reaction to IT investment announcements in the context of two explanatory variables, industry and innovation. Contrary to the variable name, the industry variable (financial firms versus manufacturing firms) captures a firm-specific effect (FAE). An announcement of an IT investment by a firm would not be a signal of a change in IAE, the industry level of profitability, but a firm level change in profits (FAE). The reason this variable is expected to have a significant effect is that financial firms are more likely to have a change in FAE that is larger than the change in FAE for non-financial firms due to the information intensity of the industry. In essence this "industry" variable serves as a surrogate for a firm's degree of information intensity. The innovation variable measures both FAE and  $n$ . By being the first to use a new technology or to introduce a new technology-enabled product or service, a firm is more likely to have an increase in FAE that is difficult for competitors to duplicate (a longer duration,  $n$ ).

Im et al. [57] examine the stock price reaction to IT investment announcements in the context of three explanatory variables: industry, size, and time period. As in Dos Santos et al. [42], the industry variable measures expected changes in FAE. Firm size most likely reflects firm-specific aspects of competitive advantage (FAE), the duration of competitive advantage ( $n$ ), risk ( $r_e$ ), and the information set available to market participants. Smaller firms are more likely to have certain advantages when information is considered an asset and complete contracting is not possible

<sup>9</sup> For more information on the event study methodology see [18,72].

<sup>10</sup> Some material in this section appeared previously in Dehning et al. [36].

Table 1  
Event studies of announcements of IT investments

Author and year	Independent variables	Firm value framework	Summary of major finding(s)
Dos Santos et al. [42]	Industry—financial vs. manufacturing	FAE	No excess stock market returns on full sample or industry subsample. Innovative IT investments increase firm value by 1.03%, while non-innovative (−0.09%) and unclassified investments (−0.46%) do not increase firm value
Im et al. [57]	Innovation—innovative vs. non-innovative	FAE, $n$	Contextual factors such as size and time period help explain the stock price reaction to all IT investment announcements. Stock price and volume reactions relate negatively to firm size and become more positive over time
	Industry—financial vs. non-financial	FAE	
	Size—small vs. large firms Time—pre 1991 vs. post 1991	$n$ , $r_e$ FAE	
Chatterjee et al. [29]	Size—small vs. large firms	$n$ , $r_e$	Abnormal stock returns of 1.06% and 0.43% for IT infrastructure and IT application investments, respectively
	IT infrastructure vs. IT application investments	FAE, $n$	
	Growth prospects	$n$ , $r_e$	
	Diversity—number of lines of business	$n$ , $r_e$	
	Industry—service vs. non-service	FAE	
	Industry—financial vs. non-financial	FAE	
	Industry—IT producing vs. non IT producing	FAE	
Dehning et al. [37]	Industry—financial vs. non-financial	FAE	IT strategic role helps explain the stock market response to IT investment announcements. 1.5% reaction to transform IT investment strategic role, 1.4% for transform Industry IT strategic role, 2.3% reaction for transform strategic role for both industry and IT investment
	Size—small vs. medium vs. large firms	$n$ , $r_e$	
	Time	FAE, $n$	
	Industry IT strategic role	IAE	
	IT investment strategic role	FAE, $n$	
Hunter [56]	Explorative vs. exploitative IT investments	FAE, $d$ , $r_e$	The two types of IT investments did not have different mean returns. Exploitative IT investments are associated with greater reliability in expected earnings

[19]. The duration of competitive advantage is longer for small firms because they are less likely to undergo scrutiny, and viewed as less of a threat to larger firms in the industry. Small firms are also generally more risky, so this variable also captures some of the differences in  $r_e$  between firms. Firm size also measures the information set available to investors prior to the IT investment announcement, and the announcements for

small firms contain more news than those for large firms [2]. Due to the numerous possible effects of size on firm value, interpreting results of firm size variables is problematic.

The third variable, time period, does not actually measure what Im et al. [57] propose that it measures. A problem with using accounting measures of performance is that there is a time lag between when IT



investments are made and when the benefits show up in the financial statements ( $d$ ). While Im et al. [57] state that including a time period variable controls for this problem, this is not a problem with market measures but rather for accounting performance measures. Time period likely captures firm-specific effects, FAE and  $n$ . As IT investments become more integrated into business activities, not only does the likelihood of firm performance gains increase but it is increasingly difficult for competitors to figure out the exact nature of the competitive advantage granted by IT. Thus, in the latter time period (one of increased integration), an increase in firm profitability is more likely to have a longer duration ( $n$ ), and therefore a larger impact on firm value.

Chatterjee et al. [29] examine the stock price reaction to announcements of IT infrastructure and applications in the context of six explanatory variables: firm size, firm growth prospects, diversity of operations, industry type (service versus non-service), financial services institutions (financial versus non-financial), and IT producing firms (IT producers versus non-IT producers). Chatterjee et al. [29] postulate that IT infrastructure investments are more closely associated with positive abnormal returns than application investments. As shown in Im et al. [57], firm size indicates aspects of competitive advantage (FAE), the duration of competitive advantage ( $n$ ), risk ( $r_e$ ), and the information set available to market participants. Consistent with Im et al. [57], security price reactions to unanticipated information can have a larger impact on smaller firms. Growth prospects and diversity of firms reflect the duration of competitive advantage ( $n$ ) and risk ( $r_e$ ). Firms with high-growth options reinvest their earnings in positive net present value projects over time (increasing  $n$ ) and have greater incentives to make extensive IT investments despite risk ( $r_e$ ). Diversification increases the need for time to coordinate the internal requirements across multiple lines of business ( $n$ ) and leads to a higher demand for IT. Consistent with Dos Santos et al. [42], the industry variable measures a firm-specific effect (FAE) as an alternative for a degree of information intensity, financial orientation, and IT producers. Thus, IT infrastructure investments measure a significant determinant of long-run value creation and growth potential in business benefits (FAE).

Dehning et al. [37] examine the stock price reaction to IT investment announcements in the context of five explanatory variables: industry, size, time-period, industry IT strategic role, and IT investment strategic role. Industry, size, and time-period are virtually the same variables as in [57]. They add industry IT strategic role [29,90,108] as an overarching industry-level construct to explain the IT-firm value relation, and IT investment strategic role to capture the firm-specific use of the IT investment.

IT strategic role as conceptualized by Schein [90] consists of four states, automate, informate up, informate down, and transform. These have implications for IAE, FAE, and  $n$  in the firm value framework. Companies adopting IT to automate human labor generally invest in IT in order to improve the efficiency of existing business processes. Informate up and informate down involve the use of IT to induce decision-making and decision-taking at higher and lower organizational levels, respectively. When implemented well, these IT investments possess the potential to enhance competitiveness through improvements in the effectiveness of existing business processes. IT meant to both automate and informate will affect FAE and  $n$  in the firm value framework. Although there might be an increase in profits (FAE) from the new IT, it is likely to be short-lived ( $n$ ) as competitors copy and even improve the IT used. Thus, the IT investments become a strategic necessity within the industry and not a source of competitive advantage.

Companies that use IT in a transformative role introduce radical business models that disrupt industry practices and market structures as a means to position themselves more favorably within an industry. The intended market changes are disruptive rather than incremental, and hence promise high, sustainable returns if successful. Companies able to do this successfully form a new, more profitable sub-industry with a higher industry level of profits (IAE). Companies announcing IT investments when an industry is in transform mode are in essence announcing their intention to join the new, more profitable sub-industry. The market will react to the company's announcement based on the probability the company will successfully join the new sub-industry and the increased profits of the new sub-industry over the existing industry level of profits ( $\Delta$ IAE).

Hunter [56] examines how organizations learn from experience, thereby changing the consequences of IT on firm performance. Hunter [56] examines the stock price reaction to the type of learning exemplified in IT investment announcements: explorative IT investments or exploitative IT investments. The exploration–exploitation distinction has implications for a firm level change in profits (FAE). Each type of investment (exploratory or exploitive) is expected to have a different impact on the future variation of performance due to its change in risk ( $r_e$ ). The goal of exploration is generally attaining flexibility and developing new knowledge and a means of solving problems. The benefits or returns to exploration are considered to be more uncertain and risky ( $r_e$ ) because they can deviate spatial and temporal perspectives more than those associated with exploitation. In contrast, the goal of exploitation is clearly defined and has short-term objectives (small  $d$ ) with immediate targets. Thus, returns in exploration are more volatile, and are farther in the future (large  $d$ ) than those associated with exploitation.

The role of the FVF is equally important in the discussion of the results of these event studies. Dos Santos et al. [42] find that for the overall sample and the finance or manufacturing sub-groups there is not a significant market reaction to IT investment announcements. However there is a significant reaction for firms that made innovative IT investment announcements. Im et al. [57] also find no overall or industry effects, but find that firm size and time period are significantly related to the market reaction to IT investment announcements. Specifically they find that small firms experience a significantly positive reaction and larger firms a negative but insignificant reaction. Overall, they find a significant negative correlation between firm size and the market reaction to IT investment announcements.

The two periods examined by Im et al. [57] are 1981–1990 and 1991–1996. They find a significantly positive reaction to announcements in the later period and a negative but insignificant reaction in the earlier period. In the later period, they also find significant industry and size effects. The financial firms in the later period have a significant positive reaction to IT investment announcements, whereas the non-financial firms have a negative and insignificant reaction to their IT investment announcements. The size effect was the same as in tests of the overall

sample, small firms experience a significantly positive reaction, larger firms a negative but insignificant reaction, and a significant negative correlation between firm size and the market reaction to IT investment announcements.

Chatterjee et al. [29] find significant abnormal returns associated with IT infrastructure investment announcements. The authors also find significant increases in trading volume related to IT infrastructure investment disclosures. However, the results indicate that positive abnormal returns are not as strongly dependent on investments in IT applications. The authors argue that IT infrastructure investments enhance firm value across a diverse set of industries. These findings demonstrate the potential of IT infrastructure investments for the growth and revenue generation opportunities of firms.

Dehning et al. [37] find that in multivariate tests the variables that were significant in previous research [29,42,57] are not significant when IT strategic role is included in the model. Industry IT strategic role and IT investment strategic role are the only significant predictors of the market reaction to IT investment announcements. They find that companies making informate or transform IT investments when the industry IT strategic role is transform have a significant positive market reaction to their IT investment announcements.

The finding that IT strategic role explains the previous findings of Dos Santos et al. [42] and Im et al. [57] requires further analysis. It is most likely due to the fact that other variables such as industry, innovation, and time-period are actually measuring the same underlying construct as IT strategic role. It is easy to see how time is one dimension of industry IT strategic role, as industries move over time through the automate, informate, and transform modes. The innovation measure of Dos Santos et al. [42] also contains information about IT investment and the industry IT strategic role. Informate and transform IT investments are more likely to be innovative, and the first company or two announcing IT initiatives at a higher level of IT strategic role could signal the change in industry IT strategic role from automate to informate or from informate to transform. The financial versus non-financial industry variable also contains information about the industry IT strategic role. The incentive in information intensive industries

to move to higher levels of IT use would be elevated due to increased payoffs from IT relative to industries that are not as information or IT intense. Thus, the time variable and industry variables are proxying for the underlying construct industry IT strategic role, and innovation contains information about the informate and transform IT investment strategic roles. Thus in multivariate tests where only the orthogonal portions of each variable are used to estimate the influence independent variables have on the dependent variable, the non-strategic role variables are not significant.

The results of Hunter [56] indicate that explorative and exploitative IT investments do not have different mean returns whether measured as raw, market adjusted, or index-adjusted returns. However, the results show that exploitative IT investments are associated with greater reliability in expected earnings due to the impact of control variables, such as the log of sales, size, the level of slack sources, time, and industry on the variance in returns are different from those observed for the mean. Not surprisingly, managers in the financial markets believe IT investments were more likely to destroy value than to increase a firm level change in profits. This result is consistent with findings reported in several event studies examining the shareholder wealth effects of IT investments and its relationship to organizational change.

## 5. Conclusions

The FVF demonstrates that the effect of IT investments on firm value is channeled through five – some times opposing – forces. It is important for both managers and researchers to understand the impact that IT investment decisions have on all variables that make up firm value. Trying to capture the effect of IT on firm value requires the ability to decode the impact of IT on IAE, FAE,  $n$ ,  $r_e$ , and  $d$ . If managers make decisions thinking that they can impact one variable and do not consider the consequential effects on the other variables, they could be in for an unpleasant surprise. This was discussed as the model was introduced, but bears further discussion here.

Consider the impact of a change in industry structure. IT has the ability to transform organizations and industries [90]. As an industry is transformed, two

sub-industries evolve. The first sub-industry is made up of the companies successfully using IT to change relationships with customers and suppliers, to alter their products and markets, and revamp their organizational structure. The second sub-industry contains the companies unwilling or unable to achieve this transformation. The sub-industries co-exist, each with a different level of profitability (IAE). The old industry shrinks as companies adopt transforming IT and join the new sub-industry. The transformed companies will enjoy higher firm value because IAE is higher in their sub-industry relative to the IAE prior to transformation and realization of the benefits from IT [37].

However, there is a drawback if management focuses solely on the effect on firm value of an increase in IAE, and neglects the effect on FAE,  $n$ ,  $r_e$  or  $d$ . If the company or management do not have any particular expertise (core competency) in IT, the company will also have a negative FAE, at least until the firm acquires the managerial IT skills necessary to compete with other firms in the new sub-industry. There might also be an increase in  $r_e$ , as investors increase their estimate of the probability that the firm will not be able to compete in the new sub-industry, and it will become a cash flow drain on the rest of the organization.

Another example is management's failure to see the long-run benefits from new IT. If management looks only at short-term profits, they will see a slight decrease in their competitive advantage (FAE), due to the cost of the new IT. Focusing only on short-term changes in FAE, managers may choose not to make an IT investment. However, the effect on the other variables in the model might more than make up for the decrease in firm value due to the initial decrease in FAE. IT might allow the firm to form long-term relationships with suppliers and customers, thus increasing  $n$ , the duration of the firm's competitive advantage. This is also likely to decrease  $r_e$  due to less variability in cash flows and earnings. Both of these might easily make up for the temporary decline in FAE and increase firm value.

Researchers familiar with the productivity paradox will appreciate the contribution as well as the limitations of our model. Much of the productivity paradox literature due to mismeasurement [20,3] could have been due to the inability to measure FAE

given the confounding effects of IAE in cross-sectional models. A second measurement problem is incorporating differences in  $d$  between firms (lags due to learning and adjustment in [20] and diffusion delay in [3]). If  $d$  is positive there will be a negative correlation between IT spending in the current period and total firm earnings in the current period. This is true even for IT investments that result in large, positive future values of FAE.

Measuring the duration of an increase in abnormal earnings due to an IT investment ( $n$ ) implies a longitudinal study comparing IT implementing firms to industry average abnormal earnings or the profitability of a direct competitor [e.g. 39]. The firm itself may also be used as a control, examining the duration of the change in abnormal earnings before and after IT implementation.

Most of the risk factors that determine  $r_e$  are impossible to measure directly, but several proxies are readily available. The variability of earnings, cash flows, and market returns remain the best proxies for market participant's judgment of the riskiness of the company.

The advantage of using firm value to evaluate the benefits of IT investments is that firm value considers all future benefits to the firm, both short-term and long-term. This eliminates the problem of estimating the time lag between implementation and increased profitability or productivity. A problem with firm value is that it is not directly observable, but there are numerous proxies, all based on stock price. Stock price can be measured in levels (Market Capitalization, Tobin's  $q$ ) or in changes (Event Studies, Long-Window Returns).

An advantage and a disadvantage of stock price is that it captures the effect of all six variables in the firm value model, BV, IAE, FAE,  $n$ ,  $d$ , and  $r_e$ . The advantage is that there are no missing variables; all factors that affect firm value are considered. Dos Santos et al. [42] recognized this as a reason that event studies are better than accounting performance measures, because event studies capture both risk and return. The disadvantage is that any significant relation between an IT investment and stock price cannot be attributed to any one of the six variables without further investigation.

The FVF presented here can be used by managers as a reminder of the factors influenced by their IT

investments, and by researchers interested in measuring the impact of IT investments. It also places existing theoretical and empirical literature in a system that allows for consistent analysis of how firm value is affected by managements' decisions. This is especially useful when comparing what often appear to be unrelated theories.

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