

Returns on Investment in Information Technology

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Abstract

In their quest to evaluate the impact of (IT) on business productivity, researchers have looked at many IT-performance relations but have not looked directly at how IT spending affects future firm performance. While some argue that the full impact of IT spending is not realized until subsequent periods because it takes time for organizations to assimilate and take advantage of new IT capabilities, little evidence has been produced about the association between IT spending and earnings in future periods. We study the relationship between IT spending in period t and earnings in periods $t+i$, $i = 0, 1, 2, 3, 4$, for a sample of firms drawn from the *InformationWeek 500* during 1990-1996. For firms in industries where IT had a more pervasive influence on business operations, we find a positive impact of IT on earnings that was *progressively greater* during the first three years after IT spending occurred and then started to taper off.

Previous research has relied on stock-price-based evidence to make assertions that new IT initiatives had a positive impact on expected future performance. These assertions depend on assumptions that stock prices were informative about the impact of IT on future performance – investors and analysts anticipated how new IT would impact future earnings. To investigate whether stock prices fully reflected information in IT spending for firms in our *InformationWeek* sample, we computed returns to buy-and-hold portfolios formed according to the level of IT spending. We document positive abnormal return differences between high IT spending and low IT spending portfolios, indicating that market participants *underestimated* the impact of high IT spending on future performance.

Key words: IT investment, IT spending, Business valuation, Firm performance, Productivity

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INTRODUCTION

Deployment of information technology (IT) to enhance business processes and facilitate changes in business operations is considered to be a key element of corporate strategy (Chatterjee et al. 2001). Firms integrate IT with key processes, knowledge and relationships to improve procurement and inventory management, increase manufacturing efficiency, nurture relationships with customers and suppliers and develop new business opportunities (Agarwal and Sambamurthy 2002). The impact of IT initiatives on firm performance depends on a variety of factors including the firm's strategic profile, its ability to assimilate new IT, actions of competitors and dynamics of the firm's business environment (Chatterjee et al. 2002; Clemons and Row 1991; Mata et al. 1995). Further evidence is needed to understand how and why IT-based capabilities shape firm performance (Sambamurthy et al. 2003).

Recognition of the power of IT to impact firm performance has gained momentum through studies that document higher productivity and firm valuation based on IT spending or IT capital (Bharadwaj et al. 1999; Brynjolfsson and Hitt 1996). But some argue that the strategic importance of IT is overplayed and that firm financial performance does not improve with IT spending (Carr 2003). In fact, recent studies by some consulting firms allege that high-performing firms are not necessarily those that spend lavishly on IT (Carr 2003). These studies look for a direct correlation between firm performance and IT spending in a specific period. If high IT spending in a period is aimed at improving future operating capabilities, then its impact on financial performance would not be realized until future periods. We develop and estimate an empirical model that enables us to observe how IT spending in one period is associated with earnings in future periods. By observing patterns in the association of IT spending and future

firm performance, we provide information that is useful for evaluating the underlying processes by which IT impacts performance.

LAGGED IMPACT OF IT SPENDING

In a critique of research on the impact of IT on firm performance, Brynjolfsson (1993) noted that research that relates earnings to contemporaneous IT spending would not detect the impact of IT spending on firm performance if there were a lag between the costs and benefits of IT. To evaluate the expected impact of IT on future performance, Dos Santos et al. (1993) examined stock price movements around announcements of new IT initiatives. They found positive abnormal stock returns associated with announcements of IT projects that were innovative for a firm's industry. Studies have also found evidence that market valuation of IT assets exceeded that of non-IT assets and of positive contribution of IT spending to Tobin's q, a measure that relates the stock-price-based value of firm assets to their book value (Brynjolfsson and Hitt 1996, Bharadwaj et al. 1999). These positive stock-price relations have been interpreted as evidence that IT spending positively impacts expected future performance. But observation of positive market valuation of IT spending is not sufficient to demonstrate that IT spending actually does impact future earnings (Abarbanell and Bushee 1997). Nor do these studies provide information about how and when IT spending affects earnings.

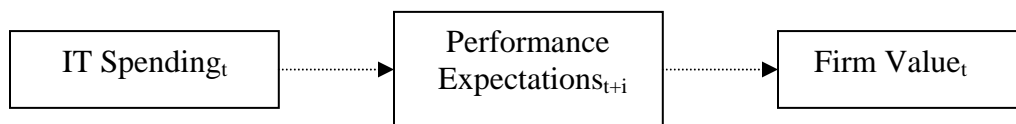
Various forces shape the impact of IT spending on firm performance. The sustainable value of IT depends on its complementarity and integration with business strategies, organizational design, structure and competencies (Barua and Mukhopadhyay 2000; Kettinger et al. 1994; Wheeler 2002). Firms may use IT to leverage existing resource capabilities (Barney 1991), to achieve new resource configurations as markets evolve (Eisenhardt and Martin 2000)

or to provide a platform for agility – the ability of firms to take diverse competitive actions (Sambamuthry et al. 2003).

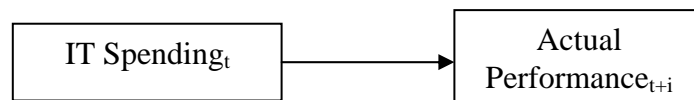
Assimilation has been identified as an important construct in the causal chain that separates the adoption of IT from its impact on firm performance (DeLone and McLean 1992; Jarvenpaa and Ives 1991; Mahmood and Soon 1991; Sethi and King 1994). Assimilation occurs as a technology diffuses across organizational work processes and becomes routinized in organizational activities (Cooper and Zmud 1990; Fichman and Kemerer 1997). Competitive actions predicated by new IT also mediate the relationship between the firm's IT capabilities and its financial performance. Competitive actions challenge the status quo of the firm's market or industry through innovations in products, services or channels (Ferrier et al. 1999; Jacobson 1992). Disruptions in the market or industry resulting from competitive actions provide opportunities for the firm to enjoy superior financial performance while competitors respond.

Hypotheses

In stock-price-based studies, higher market valuation is interpreted to represent expected improvements in future earnings resulting from IT spending (Dos Santos et al. 1993; Bharadwaj et al. 1999).



If IT spending is, in fact, a driver of future performance, then a direct link between IT spending in period t and performance in $t+ i$ should be observable (Abarbanell and Bushie 1997).



In this study, we evaluate the association between IT spending during the period 1990-1996 and subsequent firm performance.

Spending on information technology may be aimed at changing IT infrastructure to support future innovations in operations, at improving specific business processes, or at maintaining and renewing existing systems (Sambamurthy and Zmud 1999, Ross and Beath 2002). During the 1990s, building IT infrastructure that was dynamically aligned with firm strategy became a critical organizational objective (Rockart et al. 1996). In fact, more than 50 per cent of IT budgets at some large companies was spent on infrastructure (Broadbent and Weil 1997). Higher firm value was associated with investments in IT that complemented other organizational features such as greater use of teams, broader decision-making authority and worker training (Brynjolfsson et al. 2000). Because it takes time for organizations to adapt to new technology and to implement changes in business activities (Keen 1997), the performance impact of infrastructure changes may not be manifest until two or three years after the IT spending occurs. Studies indicate, for example, that it takes one to three years to implement an ERP system and benefits typically begin to accrue after 31 months (Hitt et al. 2002, O'Leary 2000). Accordingly, we expect IT spending in a period to have a positive association with future earnings.

Hypothesis 1: IT spending in a period is positively associated with earnings in future periods.

Because the firm's industry is the competitive arena that IT initiatives are played out in, the pattern of association between IT spending and future firm performance is likely to differ according to the dominant business role of IT in specific industries when IT spending occurs. Recent research (Chatterjee et al. 2001) has used a typology that classifies the industry business role of IT as "automate" or "informate" based on definitions of these terms by Zuboff (1985).

Automate industries are industries where the primary role of IT is to substitute for labor by automating business processes. Informate industries are industries where IT affects decision-making and business interactions by changing the collection, processing and distribution of information. When the informate role of IT is magnified so that IT actually alters the organization of the firm and industry, it is considered to have a transforming role (Schein 1992).

In its automate role, IT may enable a firm to pursue a cost leadership strategy by reducing the costs of performing key business processes. For example, in 1992 Federal Express introduced a hand-held device that generated optically scannable zip-code labels indicating the destination of packages. Because Federal Express had the IT infrastructure to provide an integrated database and high-speed network capabilities, this process innovation enabled the company to speed up processing at its hub facilities and reduce the number of misrouted packages. Federal Express could enjoy a cost and quality of service advantage until its competitors were able to implement similar package processing.

In its informate role, innovative use of IT may enable a company to differentiate its products and services. In 1993 Banc One introduced the first retail-banking system that linked all of a customer's accounts. This collocation of information allowed its bankers to spot opportunities to sell additional services to customers and to offer more integrated services. The benefits of this innovation would occur as the organization adapted to the new information capabilities. A competitive advantage may be sustained if the bank were able to use the new information capabilities to leverage other strategic resources such as its existing customer base.

For new IT that automates existing business processes, the lag between IT costs and benefits depends on the time required for the firm to realize efficiencies from the new IT. This may include a learning period as employees become familiar with the new IT and a cost-

reduction period as the firm unwinds commitments to employees and other resource-providers that are no longer needed (Banker et al. 2001). Because IT is easily imitable, the gains from new IT that improves business processes are likely to be constrained by competitors making similar improvements to their business processes (Clemons and Row 1991; Mata et al. 1995). In this case, the impact on earnings would be greater for firms that are able to leverage other idiosyncratic and inimitable resources.

When IT innovations play an informate role, it takes time to assimilate the new IT capabilities, take competitive actions made possible by the new IT and realize the benefits of those competitive actions. The lag between costs and benefits is likely to be longer for IT that informs than for IT that automates due to a longer assimilation process and less immediate realization of benefits from competitive actions.

H2: The lag in the association between costs and benefits of IT spending is longer for firms in informate industries than for firms in automate industries.

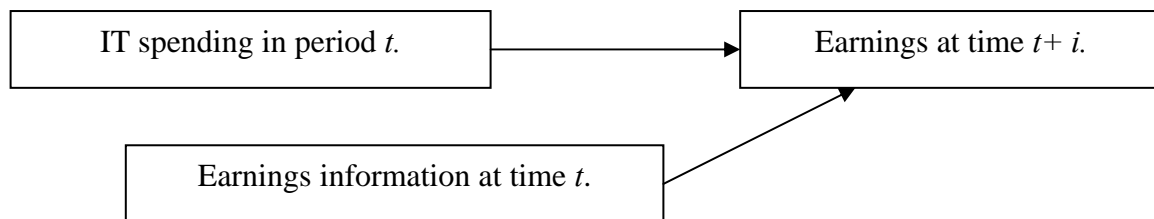
Competing firms can replicate IT that automates business processes but may not be able to imitate the competitive benefits of differentiation enabled by IT that informs. A firm that uses IT to successfully differentiate its products or services may obtain a sustainable strategic advantage, leading to improved performance for a number of periods. Thus, while the cost leadership benefits of automation are likely to be realized sooner and be more stable, the benefits of successful differentiation enabled by IT that informs are likely to be deeper and endure longer.

H3: The magnitude of the association between IT spending and future earnings is greater for companies in informate industries than for companies in automate industries.

RESEARCH DESIGN

For a variety of reasons, it is difficult to observe the impact of IT spending on a firm's present or future earnings. Contributions of IT occur at the level of applications systems and aggregate up to the enterprise level. As the distance between the first-order effects and higher levels increases, the ability to detect and measure an IT impact decreases (Barua et al. 1995). Internally, companies may be able to compare the costs of certain business processes before and after IT-enabled automation or measure changes in inventory holding costs that occur because of IT-enhanced inventory management but information at this level of analysis is not available in publicly distributed financial reports. For situations where IT alters the competitive position of firms and provides opportunities to initiate competitive actions, it is difficult to identify and isolate improvements in business performance that are attributable to the IT itself.

We analyze data for a cross-sectional sample of firms and look for patterns of performance over time that may be associated with greater IT spending.¹ Our research design relates earnings in future periods $t + i$ to earnings information available at time t and IT spending in period t . This structure enables us to observe differences in earnings between t and $t + i$ that are systematically related to IT spending in period t .



¹ Not just any IT spending will lead to higher firm value or greater future performance. For our cross-sectional econometric analysis, a maintained assumption is that most firms are optimizing their IT spending so that the relationship we are analyzing is between firm performance and optimal IT spending. In actuality, because some firms may be deviating from optimal IT spending, the observed IT spending measures the optimal IT spending with error. This "errors-in-variables" results in the estimated coefficient being biased downwards, making our tests of association conservative (Judge et al. 1988, pp. 583-585).

We perform our analysis separately for firms in industries characterized as automate and informate industries.

EMPIRICAL MODEL

Research studies have demonstrated that non-earnings information, in addition to information provided by current and past earnings, is useful in forecasting future earnings (Abarbanell and Bushee 1997, Baber et al. 1999, Brown 1993, Shroff 1999). These studies have compared the accuracy of earnings forecasts based only on information in the time-series of earnings with earnings forecasts obtained by supplementing that information with other non-earnings information. They document that supplemental information may decrease the forecast error, meaning that non-earnings information available at time t can be incrementally informative about earnings in periods $t+i$. Our empirical model includes information in the time series of earnings available at time t in order to evaluate how IT spending in period t is associated with earnings in subsequent periods.

Large-sample studies of the time-series properties of annual earnings have found that using sophisticated Box-Jenkins methods to model the earnings time-series is not superior to using a simple random walk or a random walk with drift model (Ball and Watts 1972; Watts and Leftwich 1977). An implication of these studies is that earnings in year t are informative about earnings in year $t+i$. In addition, Mozes (1992) found that past and future earnings growth is correlated. Hence, year $t-1$ earnings may also be useful in predicting year $t+1$ earnings. Based on these findings, we specify an earnings forecast model that relates earnings in years $t+i$ to IT spending in year t and earnings in years t and $t-1$ for firm j .²

² We limit the time-series of earnings to periods t and $t-1$ based on empirical comparisons that showed that including earnings in periods $t-2$ and $t-3$ added little explanatory power. Our results are robust to extending the earnings time-series back further.

$$Earnings_{j,t+i} = \alpha + \beta_1 * IT\ Spending_{j,t} + \beta_2 * Earnings_{j,t} + \beta_3 * Earnings_{j,t-1} + \varepsilon_{j,t+i}$$

In his analysis of components of earnings, Sloan (1996) tested whether there were differences in the information conveyed about future earnings in the cash and accrual components of current earnings. Our analysis is similar in the sense that we test whether information included in IT spending may be used to improve forecasts of future earnings. Following Sloan we normalized earnings and IT spending by total assets. The IT spending variable for year t is incrementally informative about earnings in the year $t+i$ if the IT spending amount conveys information about future performance not conveyed by the time-series of earnings for years t and $t-1$. Thus, a positive coefficient on the IT spending variable would mean that firm performance in year $t+i$ was higher relative to performance in years t and $t-1$ for firms that spent more on IT in year t , consistent with a positive association between IT spending and future firm performance (hypothesis 1).

Chatterjee et al. (2001) used the industry role of IT to discriminate across firms for the purpose of evaluating the market value impact of announcements of the creation of a chief information officer (CIO) position. They surveyed a panel of IT experts to classify industries according to a typology that identified IT as playing an automating role, an informing role or a transforming role. The transforming role is an extension of the informing role that identifies industries where IT has effectively altered the way firms do business. Chatterjee et al. asked their panel of experts to classify firms for two time periods, 1987-1994 and 1995-1998. In the earlier time period that corresponds most directly to our sample period of 1990-1996, only one industry was identified as a transform industry. In our analysis, we have combined the transform industries with the informate industries.³

³ None of the sample firms were classified as transform firms during 1990 to 1994. In 1995 and 1996, there were 112 informate firms and 75 transform firms. As examples, metals, ground transportation and utilities were classified

We estimate our model separately for informate and automate firms to obtain different sets of coefficients $\hat{\beta}_i^{Info}$ and $\hat{\beta}_i^{Auto}$. Hypotheses 1 and 3 imply that the magnitude of the association between IT spending in period t and earnings in future periods would be greater for informate firms than for automate firms, meaning that for some future periods $\hat{\beta}_i^{Info} > \hat{\beta}_i^{Auto} > 0$. Hypothesis 2, that the lag in the association between IT spending and future earnings is longer for informate than automate firms, suggests that an observed association between IT spending and future earnings would have a steeper profile (grow more from period to period) for informate firms than for automate firms.

DATA AND RESULTS OF ESTIMATION

To evaluate the association between IT spending and future earnings, we obtained data on IT spending from *InformationWeek* surveys for the years 1990 to 1996 (Bharadwaj 2000, Santhanam and Hartono 2003). The *InformationWeek* surveys included information about IT spending based on responses to questions about the firm's IT spending or budget. Surveys were conducted by phone. For companies that did not provide IT budgets, *InformationWeek* estimated their IT budgets based on revenue, number of IT employees, previous year's budgets if available and IT budgets of peer firms. Because there is subjectivity in the measurement of IT budgets, there is likely to be measurement error in the IT spending amounts. Therefore, our estimates of coefficients on IT spending are likely to be downward biased, making our tests conservative.

We obtained financial information from *Compustat* for the years 1989 to 2000. Our basic sample includes 661 firm-year observations for automate firms and 542 observations for informate firms covering the seven years 1990 to 1996. Descriptive statistics are provided in

as automate industries; various manufacturing, retail and food services were classified as informate industries and media, financial services and computer services were classified as transform industries (Chatterjee et al. 2001).

table 1. Firms included in the *InformationWeek 500* are typically large firms with mean sales upwards of \$8 billion throughout the sample period. Their average IT spending was over \$200 million in most years.

Our data is stacked so that each firm-year observation is included as an observation for period t in four separate models that relate $Earnings_{t+i}$ ($i = 1, 2, 3,$ and 4 years) to $IT\ spending_t$, $Earnings_t$, and $Earnings_{t-1}$. To provide information about contemporaneous effects, we also estimated a fifth model that relates $Earnings_t$ to $IT\ Spending_t$ and $Earnings_{t-1}$. The number of observations decreases with the forecast horizon because some firms did not appear in the Compustat data for all years. Because the data is stacked, an estimation may include more than one observation for a specific firm. To correct for autocorrelation in the error terms, we estimated all of the models using the Prais-Winsten method (Park and Mitchell 1980). We also identified influential observations using recommended cutoffs for leverage points, Studentized residuals, the DFFITS measure, and standardized influence of observations on the covariance of estimates (Belsley et al. 1980). Observations were excluded from the analysis if any one of the four cutoffs were exceeded.

Results of our estimations of the earnings models are presented separately for firms in automate and informate industries in panels A and B of table 2. The estimated coefficients on the IT spending variable represent incremental earnings in period $t+i$ that may be attributed to an additional dollar of IT spending in period t . For firms in the automate industries, there was a small positive association between earnings and IT spending in period t itself (coefficient = 0.0223, p-value = 0.0001). The association between IT spending in period t and subsequent earnings was highest in period $t+1$ (coefficient = 0.0738, p-value = 0.0001) and was sustained through period $t+4$ (coefficient = 0.0719, p-value = 0.0001) with slightly lower coefficients in

periods $t+2$ (coefficient = 0.0461, p-value = 0.0001) and $t+3$ (coefficient = 0.0530, p-value = 0.0001). This pattern suggests a nearly immediate positive performance benefit for firms in the automate industries that is carried forward steadily for at least 4 years.

For firms in the informate industries, the association in period t was slightly negative (coefficient = -0.0252, p-value = 0.0046). This could reflect the negative impact on earnings of adjustment costs required to make organizational changes that complement the IT investment (Brynjolfsson et al. 2000). A positive association similar in magnitude to that observed for the automate industries is observed in period $t+1$ (coefficient = 0.0815, p-value = 0.0001). But, unlike the leveling off that occurred in the automate industries, the positive association grows in periods $t+2$ (coefficient = 0.1432, p-value = 0.0001) and $t+3$ (coefficient = 0.2469, p-value = 0.0001) and diminishes in period $t+4$ (coefficient = 0.1325, p-value = 0.0001).

The results observed for both automate and informate firms are consistent with hypothesis 1 that IT spending in period t is positively associated with earnings in future periods. The increasing pattern for the informate firms in periods $t+1$ through $t+3$ compared with the leveling off for the automate firms in periods $t+2$ and $t+3$ supports hypothesis 2 that the lag between costs and benefits of IT spending is greater for firms in the informate industries. And the greater magnitude of the estimated coefficients for the informate industries versus the automate industries (p-values = 0.0001 for periods $t+2$ and $t+3$) supports hypothesis 3 that the magnitude of the earnings association over time is greater for firms in the informate industries.

IT Leaders

In the information systems literature, a resource-based view of IT has been used to make arguments that IT may lead to competitive advantage for certain firms (Clemons and Row 1991, Mata et al. 1995). Two arguments have been advanced. The first argument is that IT may

provide competitive advantage if it enables firms to leverage other non-IT resource advantages. The second argument is that IT capabilities themselves (abilities to implement and adapt to new IT provided by superior IT capabilities and flexible organization structures) may provide firms with a competitive advantage (Bharadwaj 2000). Recent studies have used the designation of firms as IT leaders by *InformationWeek* as a proxy for superior IT capabilities (Bharadwaj 2000, Santhanam and Hartono 2003).

The amount of IT spending (relative to firm spending) itself may act as a surrogate for a resource-based advantage that a firm is able to exploit. A resource-based advantage may not be observable directly by researchers, but firm managers are likely to know whether they have it. Firms that have a resource-based advantage that can be leveraged with IT spending enjoy a greater marginal value of IT and therefore it is optimal for them to spend more on IT. Thus, observed IT spending indicates the beliefs of a firm's management about a resource-based advantage that it can leverage, in contrast to the discrete IT leadership variable obtained from the *InformationWeek* surveys. To verify that IT spending is a different construct than IT leadership, we estimated a logistic model that related IT leadership to IT spending (deflated by total assets) in period t and previous periods $t-i$ ($i = 1, 2, 3, 4$). We found no significant relationship between designation of a firm as an IT leader and current or previous IT spending.

We estimated our earnings forecast models with an indicator variable for designation as an IT leader in place of the continuous IT spending variable and found that future earnings were not significantly different for firms designated as IT leaders than for other firms in the *InformationWeek* sample. Also, including IT leadership as both an intercept dummy and a slope dummy (interacted with IT spending) in our earnings forecast models did not change our IT

spending results. Thus, we find that IT leadership designation in period t did not give firms an apparent advantage with respect to future profitability.

These findings do not support the second argument that IT capabilities by themselves give firms a resource-based advantage. They are, however, consistent with the first argument that firms may use IT to leverage other resource-based advantages. Because firms that have resource-based advantages that can be leveraged by new IT would benefit more from spending on IT, the observed positive association between IT spending and future earnings may reflect the realization of these resource-based advantages enhanced by IT.

Innovative firms

Companies that spend more on IT may be innovative in other endeavors such as research and development (R&D). Firms that are innovative may earn higher profits by differentiating their products and services from other firms. To test whether we were picking up a non-IT innovation effect as opposed to an IT effect, we estimated our earnings model with R&D spending included as a separate variable. While the coefficients on the R&D spending variable were significantly positive, the coefficients on the IT spending variable were not diminished when R&D spending was included.

If innovation is persistent, then higher earnings in previous years may signal innovative activities not captured by R&D spending in period t . We tested whether IT spending in period t was positively related to earnings in three previous years and did not find significantly positive relations between IT spending and previous earnings.

BUY AND HOLD PORTFOLIOS

In event studies that measure abnormal returns associated with IT announcements (Dos Santos et al. 1993, Im et al. 2001) and in valuation studies that relate the market value of firms to

IT spending (Bharadwaj et al. 1999), firm value is linked to expectations about future firm performance, not actual performance. Results of our estimation of the earnings model lend credence to the idea that IT has an impact on actual firm performance. Thus, our results provide support for the interpretation of results of the valuation studies that IT is informative about future earnings.

This does not mean, however, that the market is omniscient in forming expectations about the impact of current IT activities on future earnings. Market participants (investors and analysts) may not observe all of the IT activities that firms engage in and may not correctly evaluate the future impact of activities they do observe. Because the market is not likely to know the full extent of companies' IT activities, they may underestimate the impact of IT on future earnings. This would make an important caveat for interpreting the results of studies that relate market values to IT spending.

Our analysis of portfolio returns proceeds in two parts similar to Sloan's (1996) analysis of earnings components. First, Sloan documented that components of earnings were differentially informative about future earnings. Then, he tested whether market valuations properly incorporated the information provided by different components of earnings. To perform this test, he formed portfolios of stocks that were selected based on the relative values of the earnings components in period t . Stocks that were high on the more informative component were placed in one portfolio and stocks that were high on the other component were placed in a second portfolio. If the market did not properly discriminate between the two components and undervalued the information in the more informative component, then abnormal returns in periods subsequent to period t would be higher for the first portfolio than for the second portfolio.

To test whether market valuations under or overestimated the impact of IT or captured it appropriately, we performed a similar analysis with respect to IT spending.⁴ In our case, we sorted stocks into portfolios based on the level of IT spending (relative to total assets) in period t . Based on our finding that IT spending in period t was positively associated with subsequent earnings, we investigate whether returns to the high IT spending portfolio exceeded returns to the low IT spending portfolio.

Hypothesis 4: Abnormal returns earned on high IT spending portfolios exceed abnormal returns earned on low IT spending portfolios.

This is a more conservative test than simply evaluating whether the high IT spending portfolio earned positive abnormal returns. An advantage of comparing abnormal returns on the two portfolios as opposed to looking at the level of abnormal returns of the high IT spending portfolio is that this method controls for potential differences in risk-return relations for firms in the *InformationWeek* survey and other firms. Firms surveyed for the *InformationWeek 500* are likely to be firms that are more IT-intensive than a random sample of firms in the Compustat data.

Because IT spending by firms in the automate industries is likely to be directed at improving specific processes whereas IT spending by firms in the informate industries is likely to be aimed at improving the general information capabilities of the firm, market assessments of firms' IT activities may be different for automate and informate firms. It may, for instance, be easier for market participants to form expectations about the influence of IT spending that improves a specific business process once the market is aware of the change than it is to predict how infrastructure changes would affect the ability of firms to manage changes in customer

⁴ Our variable, IT spending, is different from the components of earnings used by Sloan (1996) because information about IT activities is not readily available to analysts and investors at time t .

demand. Therefore, we test whether the market underestimated the impact of IT more for firms in informate industries as opposed to firms in automate industries.

Hypothesis 5: The difference between abnormal returns for high IT versus low IT firms is greater for informate firms than for automate firms.

For each of the years in our sample, we divided firms into informate and automate subgroups and formed high IT and low IT portfolios for each subgroup. We defined portfolios of *high IT* firms as those firms with IT spending (normalized by total assets) in the top 25% of their subgroup for a particular year and *low IT* firms as those firms with IT spending in the bottom 25% of their subgroup.

We computed abnormal returns by subtracting returns for market portfolios of firms with similar market-to-book and sales (size) from the actual returns earned on the low and high IT spending portfolios (Fama and French (1992)).⁵ We aggregated individual firm abnormal returns for high and low IT portfolios for each of the seven sample years and averaged the seven abnormal returns for each $t+i$ ($i = 0, 1, 2, 3, 4$) period to obtain mean abnormal returns for each $t+i$ period. Period t abnormal returns correspond to twelve-month periods beginning in the fourth month of period t , period $t+1$ abnormal returns correspond to the twelve-month periods beginning in the fourth month of period $t+1$ and so forth (Sloan 1996).

Results of our estimates of differences in portfolio returns are presented in table 3. The difference in mean abnormal returns for the high IT and low IT portfolios for period t was 3.3% (p-value for test that the mean abnormal return on the high IT portfolio exceeded the mean return on the low IT portfolio = 0.1198) for firms in the automate industries and 3.6% (p-value = 0.1372) for firms in the informate industries. These results indicate that abnormal returns for

⁵ We also performed our analysis using abnormal returns computed using market model methodology (Capital Asset Pricing Model) and found qualitatively similar results to those reported.

high IT spending firms were slightly higher during period t than for low IT spending firms and that the differences in abnormal returns between high IT and low IT firms was similar for the informate and automate groups.

For period $t+1$, the difference in mean returns between the high and low portfolios of 5.8% (p-value = 0.0217) for the automate firms is a little greater than the difference in mean returns of 4.9% (p-value = 0.0654) for the informate firms. But for period $t+2$, the high minus low portfolio return of 3.8% for the automate firms (p-value = 0.1105) is much lower than the robust high minus low portfolio return of 13.3% for the informate firms (p-value = 0.0003). For period $t+3$, the high minus low portfolio return for the automate firms virtually drops to zero (1.0% with p-value = 0.3697) but the high minus low portfolio return for the informate firms continues at a strong 12.2% (p-value = 0.0068). In period $t+4$, the high minus low portfolio return for the automate firms remains near zero (2.0% with p-value = 0.2913) and the high minus low portfolio return for the informate firms tapers off a little to 7.2% (p-value = 0.0791). Overall, the high IT spending portfolio returns are generally greater than the low IT spending portfolio returns, supporting our hypothesis 4. Moreover, the mean high minus low portfolio return for the informate groups is greater than the mean high minus low return for the automate groups for periods $t+2$, $t+3$, and $t+4$, consistent with hypothesis 5.

The pattern of abnormal returns for firms in the automate industries indicates that the market initially underestimated the value impact of IT spending in period t but recognized the incremental value in periods $t+1$ and $t+2$. For firms in the informate industries, the results indicate that the market initially underestimated the value impact of IT and did not recognize the increased value until higher earnings were actually observed in periods $t+1$ through $t+4$. In fact, the pattern of high minus low returns for the informate industries is similar to the pattern of

earnings associations observed earlier (table 2) where the relation between IT spending and earnings increased through period $t+3$ and then tapered off in period $t+4$.

Our analysis of portfolio returns shows that the market underestimated the impact of IT on future earnings, particularly for firms in the informate industries, consistent with hypotheses 4 and 5. Thus, if IT effects are detected in valuation studies, they are probably underestimated. Our results also show that the full value impact of IT spending is recognized earlier for firms in the automate industries than for firms in the informate industries. Even though the impact of IT spending on future earnings did not disappear after period $t+2$ for the automate firms, the market had caught up. For informate firms on the other hand, the market takes much longer to catch up with the abnormal return differences extending through period $t+4$. In the automate industries, IT spending is likely to be primarily for process improvements whereas in the informate industries IT spending may have a more strategic role. Our results suggest that the impact of IT spending is easier to observe and can be conveyed more objectively to analysts and investors for firms in the automate industries than for firms in the informate industries.

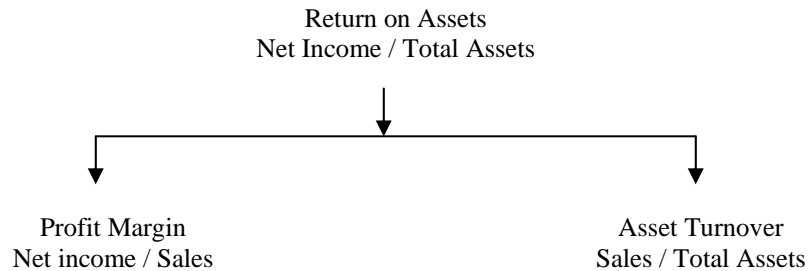
IT Leaders

As in our analysis of the impact of IT spending on future earnings, we questioned whether IT spending or IT leadership were driving high stock returns. To evaluate this, we constructed a portfolio of IT leaders and checked to see if this portfolio generated significantly positive abnormal returns. We found no evidence of positive abnormal returns for IT leaders.

ANALYSIS OF RETURN ON ASSETS

In our analysis of the association between IT spending and future earnings (table 2), we deflated both the earnings variables and IT spending by total assets. Earnings divided by total assets is a measure of a company's return on assets (ROA). With this in mind, we extend our

analysis to evaluate how different components of ROA are associated with IT spending. The Sloan or General Motors model splits ROA into profit margin and asset turnover (Stickney and Brown 1999).



Profit margins increase if companies are able to increase gross margins on products and services sold (higher selling price relative to product cost) or improve the efficiency of business processes. Asset turnover increases if companies are able to utilize their assets more effectively (support greater levels of sales revenue with a certain quantity of assets).

In tables 4 and 5 we provide results of estimating the impact of IT spending in period t on future profit margins from sales and future asset turnover. For firms in the automate industries, the impact of IT spending in period t on operating margins (panel A of table 4) is slightly positive in year $t+1$ (p-value = 0.1456) and positive in years $t+2$ through $t+4$ (p-values = 0.0001). The impact of IT spending in period t on asset turnover (panel A of table 5) is slightly negative in period $t+1$ and is not significantly different from zero for any of the other periods evaluated. This suggests that the primary impact of IT spending for firms in these industries is on profit margins and not on asset utilization.⁶

For firms in the informate industries, the impact of IT spending in period t on profit margin (panel B of table 4) is significantly positive in period $t+1$ (p-value = 0.0030) and periods $t+2$ through $t+4$ (p-values = 0.0001) and follows a similar pattern to the impact of IT spending in

period t on earnings (increasing in years $t+1$, $t+2$ and $t+3$ and diminishing in year $t+4$). As with the firms in the automate industries, IT spending in period t appears to have had a limited impact on asset turnover (panel B of table 5), with a strong positive impact in period $t+1$ (p-value = 0.0001) only.

Further decomposition of profit margin into ratios of cost of goods sold to sales (price recovery) and selling, general and administrative costs to sales (business productivity) indicates that IT spending improved both price recovery and business productivity for firms in the informate industries but improved business productivity only for firms in the automate industries. We also estimated turnover ratios for specific assets such as accounts receivable, inventory and property, plant and equipment but did not find that IT spending had a significant impact of future values of these ratios.

As a further robustness check, we excluded firms in service industries from our sample. The patterns of association between IT spending and profit margin and turnover ratios for the sub-sample of manufacturing firms is very similar to that reported above for the full sample.

DISCUSSION

The observed patterns of the association between IT spending and firm performance over multiple periods provide meaningful information about how IT helps shape firm performance. For the automate industries, the association between IT spending and earnings was apparent soon after the IT spending occurred. In addition, the IT benefits appeared to be locked in through the first four years after IT spending occurred. The steadiness of these benefits is surprising because process innovations are easily imitated making it likely that competitors would quickly implement similar IT changes. The observed persistence suggests that firms that spend more on

⁶ Throughout our analysis, IT spending is deflated by total assets. Our results are robust to deflating IT spending by sales.

process innovations have structural or resource advantages that make IT spending more valuable to them than to other firms, enabling them to obtain sustained benefits from IT (Clemons and Row 1991; Mata et al. 1995).

For the informate industries, the profile of the earnings association was steeper over time than for the automate industries. The magnitude of the positive association observed in the first year was similar in magnitude to that observed for the automate firms. The association increased substantially in the second year and reached its high point during the third year. This pattern is consistent with it taking some time for IT to be assimilated before firms are able to take competitive actions (Sambamurthy et al. 2003). The fact that the high earnings association observed in year 3 diminished appreciably in year 4 suggests that competitors were able to respond to the competitive actions taken by a firm, limiting the duration of the benefits.

The differences in abnormal returns observed between the high and low IT groups suggests that substantial value is created through combinations of investments in IT and other resources. The abnormal return differences were particularly high for the informate firms. One possibility is that high IT investment by these firms may involve higher risk that is not captured by the Fama and French (1992) adjustments.

CONCLUSION

Valuation studies that document positive relations between the market value of firms and IT spending are portrayed as evidence that IT has a positive impact on future performance. This evidence rests on the assumption that higher market valuation of IT spending means that IT spending leads to higher future earnings. We tested directly for an association between IT spending and future earnings and produced evidence that supports the idea that future performance is positively related to IT spending. However, we also provide an important caveat

to the interpretation of market valuations of IT. Our analysis of high and low IT portfolio returns indicates that the market underestimates the impact of IT when forming expectations about future performance.

Our evidence indicates that IT spending is more highly associated with subsequent performance for firms in informate industries than in automate industries and that market valuations reflect IT spending earlier for firms in automate industries. We found that IT spending was more clearly associated with future profit margin on sales than asset turnover, suggesting that IT led to improvements in cost recovery (gross margin) and business processes (lower selling and administration costs) as opposed to asset utilization. We also found that the relationship between IT and future earnings is driven by IT spending and not by IT leadership. Our results run counter to claims that the strategic impact of IT spending is overplayed (Carr 2003). They also demonstrate why it is inappropriate to draw conclusions about the impact of IT spending by comparing earnings performance to contemporaneous IT spending.

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Table 1 - Descriptive Statistics

		1990	1991	1992	1993	1994	1995	1996
Net Sales (\$Millions)	Mean	8567	7970	8266	7533	8309	10531	11280
	Std.Dev.	11764	11089	10984	9812	9989	16190	17330
	Median	4556	4163	4169	4434	4832	5511	5705
Total Assets (\$Millions)	Mean	16212	16731	15675	15005	16225	18348	19904
	Std.Dev.	24111	29229	27687	22019	26608	36548	40716
	Median	7051	6445	6029	6381	5526	5894	6354
IT Spending (\$Millions)	Mean	221	218	196	209	188	206	246
	Std.Dev.	389	462	455	473	368	362	441
	Median	90	72	74	82	83	78	101
Return on Assets ¹	Mean	0.0522	0.0470	0.0468	0.0396	0.0483	0.0429	0.0463
	Std.Dev.	0.0571	0.1205	0.0784	0.0573	0.0416	0.1327	0.0707
	Median	0.0511	0.0443	0.0455	0.0410	0.0469	0.0486	0.0480
Profit Margin ²	Mean	0.1088	0.1119	0.0987	0.1321	0.1246	0.1305	0.1283
	Std.Dev.	0.0990	0.1261	0.1134	0.1362	0.1081	0.0881	0.0882
	Median	0.1039	0.0897	0.0778	0.0925	0.0929	0.1137	0.1080
Asset Turnover ³	Mean	0.0089	0.0091	0.0101	0.0104	0.0122	0.0111	0.0109
	Std.Dev.	0.0070	0.0075	0.0081	0.0085	0.0110	0.0081	0.0080
	Median	0.0079	0.0083	0.0089	0.0093	0.0100	0.0100	0.0100

¹ Return on Assets = [Net Income + Interest Expense * (1 – Tax Rate)] / Total Assets

² Profit Margin = [Net Income + Interest Expense * (1 – Tax Rate)] / Net Sales

³ Asset Turnover = Net Sales / Total Assets

**Table 2 – Results of Estimation of Models Relating Earnings
in Period $t+i$ to IT Spending in Period t**

$$Earnings_{j,t+i} = \alpha + \beta_1 * IT\ Spending_{j,t} + \beta_2 * Earnings_{j,t} + \beta_3 * Earnings_{j,t-1} + \varepsilon_{j,t+i}$$

Panel A - Firms in Automate Industries

	<i>Earnings_t</i>	<i>Earnings_{t+1}</i>	<i>Earnings_{t+2}</i>	<i>Earnings_{t+3}</i>	<i>Earnings_{t+4}</i>
Variable	coefficient (p-value)	coefficient (p-value)	Coefficient (p-value)	coefficient (p-value)	coefficient (p-value)
<i>IT Spending_t</i>	0.0223 (0.0001)	0.0738 (0.0001)	0.0461 (0.0001)	0.0530 (0.0001)	0.0719 (0.0001)
<i>Earnings_t</i>		0.7785 (0.0001)	0.7139 (0.0001)	0.6342 (0.0001)	0.4783 (0.0001)
<i>Earnings_{t-1}</i>	0.9570 (0.0001)	0.1019 (0.0001)	0.1902 (0.0001)	0.2630 (0.0001)	0.4136 (0.0001)
	N = 653 adj. R ² = 0.9747	N = 640 adj. R ² = 0.9056	N = 643 adj. R ² = 0.9374	N = 639 adj. R ² = 0.9311	N = 619 adj. R ² = 0.9596

Panel B - Firms in Informate Industries

	<i>Earnings_t</i>	<i>Earnings_{t+1}</i>	<i>Earnings_{t+2}</i>	<i>Earnings_{t+3}</i>	<i>Earnings_{t+4}</i>
Variable	coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	coefficient (p-value)	coefficient (p-value)
<i>IT Spending_t</i>	-0.0252 (0.0046)	0.0815 (0.0001)	0.1431 (0.0001)	0.2469 (0.0001)	0.1325 (0.0001)
<i>Earnings_t</i>		0.7217 (0.0001)	0.5148 (0.0001)	0.3644 (0.0001)	0.3430 (0.0001)
<i>Earnings_{t-1}</i>	0.9965 (0.0001)	0.0815 (0.0001)	0.2910 (0.0001)	0.3361 (0.0001)	0.3973 (0.0001)
	N = 486 adj. R ² = 0.9262	N = 485 adj. R ² = 0.9215	N = 460 adj. R ² = 0.9031	N = 455 adj. R ² = 0.8424	N = 438 adj. R ² = 0.7512

Table 3 – Differences in One-Year Abnormal Returns on Equally-Weighted Portfolios Formed Based on IT Spending for Firms in Automate and Informate Industries^a

	Automate Portfolios	Informate Portfolios
	<i>High IT – Low IT</i> Difference (p-value ^b)	<i>High IT – Low IT</i> Difference (p-value ^b)
<i>t</i>	0.033 (0.1198)	0.036 (0.1372)
<i>t+1</i>	0.058 (0.0217)	0.049 (0.0654)
<i>t+2</i>	0.038 (0.1105)	0.133 (0.0003)
<i>t+3</i>	0.01 (0.3697)	0.122 (0.0068)
<i>t+4</i>	0.02 (0.2913)	0.072 (0.0791)

^a Firms are assigned to portfolios annually according to IT spending (deflated by total assets). Firms in the *Low IT* portfolios are among the lowest 25% in terms of IT spending and firms in the *High IT* portfolios are among the highest 25% in terms of IT spending for automate and informate firms respectively. Abnormal stock returns are measured for twelve-month periods beginning in the fourth month after the company's fiscal year-end. Period *t* returns are for twelve-month periods beginning in the fourth month of the current fiscal year, *t+1* returns are for periods beginning in the fourth month after the current fiscal year, *t+2* returns are for periods beginning in the sixteenth month after the current fiscal year, and so forth.

^b The p-values (one-sided) are based on tests that the abnormal return for the high IT portfolio is greater than the abnormal return of the low IT portfolio for automate and informate industries respectively.

Table 4 – Results of Estimation of Models Relating Profit Margin on Sales in Period $t+i$ to IT Spending in Period t

$$Profit\ Margin_{j,t+i} = \alpha + \beta_1 * IT\ Spending_{j,t} + \beta_2 * Profit\ Margin_{j,t} + \beta_3 * Profit\ Margin_{j,t-1} + \varepsilon_{j,t+i}$$

Panel A - Firms in Automate Industries

	<i>Profit Margin_t</i>	<i>Profit Margin_{t+1}</i>	<i>Profit Margin_{t+2}</i>	<i>Profit Margin_{t+3}</i>	<i>Profit Margin_{t+4}</i>
Variable	coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	coefficient (p-value)	coefficient (p-value)
<i>IT Spending_t</i>	0.0032 (0.9234)	0.0256 (0.1456)	0.0432 (0.0001)	0.0933 (0.0001)	0.1040 (0.0001)
<i>Profit Margin_t</i>		1.0528 (0.0001)	0.9800 (0.0001)	0.7083 (0.0001)	0.6586 (0.0001)
<i>Profit Margin_{t-1}</i>	0.9691 (0.0001)	-0.0783 (0.0001)	-0.0872 (0.0001)	0.1163 (0.0104)	0.1744 (0.0001)
	N = 534 adj. R ² = 0.9496	N = 533 adj. R ² = 0.9542	N = 524 adj. R ² = 0.8969	N=522 adj. R ² = 0.8715	N=509 adj. R ² = 0.9132

Panel B - Firms in Informate Industries

	<i>Profit Margin_t</i>	<i>Profit Margin_{t+1}</i>	<i>Profit Margin_{t+2}</i>	<i>Profit Margin_{t+3}</i>	<i>Profit Margin_{t+4}</i>
Variable	coefficient (p-value)	coefficient (p-value)	coefficient (p-value)	coefficient (p-value)	coefficient (p-value)
<i>IT Spending_t</i>	0.0103 (0.6327)	0.0349 (0.0030)	0.1105 (0.0001)	0.1233 (0.0001)	0.0895 (0.0001)
<i>Profit Margin_t</i>		0.7912 (0.0001)	0.7259 (0.0015)	0.5980 (0.0001)	0.3921 (0.0001)
<i>Profit Margin_{t-1}</i>	0.9747 (0.0001)	0.1900 (0.0001)	0.1779 (0.0003)	0.2898 (0.0001)	0.4977 (0.0001)
	N = 485 adj. R ² = 0.9555	N = 485 adj. R ² = 0.9726	N = 488 adj. R ² = 0.9718	N = 488 adj. R ² = 0.9645	N = 468 adj. R ² = 0.9286

Table 5 – Results of Estimation of Models Relating Asset Turnover in Period $t+i$ to IT Spending in Period t

$$Asset\ Turnover_{j,t+i} = \alpha + \beta_1 * IT\ Spending_{j,t} + \beta_2 * Asset\ Turnover_{j,t} + \beta_3 * Asset\ Turnover_{j,t-1} + \varepsilon_{j,t+i}$$

Panel A - Firms in Automate Industries

	<i>Asset Turnover_t</i>	<i>Asset Turnover_{t+1}</i>	<i>Asset Turnover_{t+2}</i>	<i>Asset Turnover_{t+3}</i>	<i>Asset Turnover_{t+4}</i>
Variable	coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	coefficient (p-value)	coefficient (p-value)
<i>IT Spending_t</i>	0.0081 (0.4613)	-0.0338 (0.0043)	0.0058 (0.6609)	0.0056 (0.7933)	0.0097 (0.6617)
<i>Asset Turnover_t</i>		1.0717 (0.0001)	0.8042 (0.0001)	0.7378 (0.0001)	0.6289 (0.0001)
<i>Asset Turnover_{t-1}</i>	0.9701 (0.0001)	-0.1004 (0.0009)	0.1428 (0.0003)	0.1828 (0.0001)	0.2623 (0.0001)
	N = 641 adj. R ² = 0.9894	N = 654 adj. R ² = 0.9871	N = 651 adj. R ² = 0.9602	N = 649 adj. R ² = 0.9381	N = 621 adj. R ² = 0.9186

Panel B - Firms in Informate Industries

	<i>Asset Turnover_t</i>	<i>Asset Turnover_{t+1}</i>	<i>Asset Turnover_{t+2}</i>	<i>Asset Turnover_{t+3}</i>	<i>Asset Turnover_{t+4}</i>
Variable	coefficient (p-value)	Coefficient (p-value)	coefficient (p-value)	coefficient (p-value)	coefficient (p-value)
<i>IT Spending_t</i>	-0.0744 (0.0034)	0.0590 (0.0001)	0.0277 (0.3117)	0.0470 (0.1676)	0.0421 (0.2264)
<i>Asset Turnover_t</i>		0.9694 (0.0001)	0.9146 (0.0001)	0.7212 (0.0001)	0.5500 (0.0001)
<i>Asset Turnover_{t-1}</i>	0.9795 (0.0001)	0.0086 (0.7412)	0.0493 (0.2902)	0.2091 (0.0001)	0.3861 (0.0001)
	N = 489 adj. R ² = 0.9876	N = 486 adj. R ² = 0.9867	N = 487 adj. R ² = 0.9631	N = 488 adj. R ² = 0.9349	N = 466 adj. R ² = 0.9025