THE IMPACT OF INFORMATION TECHNOLOGY SPENDING ON FUTURE PERFORMANCE

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Abstract

In this study, we investigate the association between information technology (IT) spending and future firm performance. Critics contend that greater expenditures on IT rarely lead to superior financial results, citing studies that compare firm performance to current IT spending. But valuation and stock-return studies have found a positive association between the market value of firms and their current IT spending or announcements of new IT initiatives. These observed relations are interpreted to mean that expected future earnings increased with new IT spending, consistent with a delayed impact of new IT on earnings. If actual future earnings increased with IT spending in a period, then a positive association between IT spending and future earnings should be directly observable.

We describe a methodology for studying the association between IT spending in period t and earnings in future periods and evaluate this association for a sample of firms based on their IT spending during the years 1990 through 1996. We divide our sample into firms according to the business role IT played in their industries during this time period. For firms in industries where IT played an informating role (improved information flows throughout organizations), we find a strong positive association between future earnings and IT spending. The magnitude of the association increased during the first three years after the IT spending occurred and then began to taper off. For firms in industries where IT played an automating role (facilitated automation of business processes), we find a smaller but significantly positive association between future earnings and IT spending that lasted at least four years after the year the IT spending occurred.

Keywords: IT spending, firm performance, IT productivity, market valuation, lagged impact

Introduction

Recent criticism asserts that the strategic importance of IT is overplayed and that firm financial performance rarely improves with IT spending (Carr 2003). This criticism rests on evidence from studies that look at contemporaneous relations between firm performance and IT spending. But the impact of IT spending may not be immediately reflected in firm performance because it takes time for firms to assimilate IT and realize related performance benefits (Barua et al. 1995; Brynjolfsson 1993; Chatterjee et al. 2001). Consistent with this latter argument, researchers have found evidence that the stock-price-based market value of firms increased with announcements of certain IT initiatives (Dos Santos et al. 1993; Im et al. 2001) and that Tobin's q (the ratio of the market value to book value of firms) increased with IT spending (Bharadwaj et al. 1999). This stock-price-based evidence is interpreted to mean that expected future earnings increased with signals of higher IT investment. Nevertheless, as Abarbanell and Bushee (1997) observed, this indirect approach cannot be used to validate links between current signals (such as IT spending) and future performance. To validate the link between IT spending and future firm performance, a direct analysis of the association between IT spending and future earnings must be performed.

In this study, we evaluate the association between spending on IT in period *t* and earnings in future periods $t + i$ ($i = 1, 2, 3, 4$). To do this, we estimate models that relate earnings in $t + i$ to IT spending in period *t* and time series information about earnings available at the end of period *t*. In these models, the coefficient on IT spending measures the incremental earnings in future periods associated with IT spending in period *t*. Our analysis uses information about IT spending obtained from *InformationWeek* surveys (Bharadwaj 2000; Santhanam and Hartono 2003). We perform our analysis separately for firms in industries classified as *informate* and *automate* industries (Chatterjee et al. 2001; Zuboff 1985). In informate industries, IT informates by improving the collection, processing, and distribution of information throughout the organization. In automate industries, IT acts primarily as a substitute for labor in automating business processes. For firms in informate industries, we find a strong positive association between IT spending in period *t* and future earnings that increased progressively for three years and then started to taper off. For firms in automate industries, we find a significantly positive association between IT spending in period *t* and future earnings that lasted through the four subsequent periods that we evaluate.

In dollar terms, our results indicate that each $1 of IT spending by firms in informate industries added $0.468 worth of additional earnings (discounted back to year *t*) during the four years subsequent to the IT spending. For firms in automate industries, each $1 of IT spending added $0.194 worth of additional earnings in the subsequent four-year period. These amounts are over and above the IT expense incurred, providing evidence of high returns to investments in new IT. Our findings provide evidence of a large sustained impact of IT spending on future firm performance and stand in stark contrast to assertions that there is rarely a positive relation between firm performance and IT spending (Carr 2003).

Our analysis evaluates changes in earnings based on assets employed. Improvements in return on assets (ROA) may occur because a firm increases its profit margin on sales (makes a greater net profit on each dollar of sales) or increases its asset turnover (generates more sales per dollar of assets employed). New IT may enable a company to increase profit margins by improving its selling effectiveness (increasing the selling price relative to the cost of its product or service) or the efficiency of its selling, general, and administrative (SG&A) functions (reducing the SG&A costs needed to support each dollar of sales). For example, IT that enables companies to recognize and respond more nimbly to changes in market demand for its products may lead to greater profit margins. New IT may also enable a company to increase its asset turnover by reducing the investment in assets needed to generate sales. For example, IT that improves supply chain and inventory management may reduce the inventory needed to support sales. We employ the Sloan or General Motors model of financial analysis to investigate how IT spending was associated with improvements in ROA. We find for both informate and automate firms that the observed positive association between IT spending and future earnings is due to higher profit margin on sales, not higher asset turnover.

We dig deeper to investigate whether improvements in profit margins associated with IT spending were due to greater selling effectiveness (higher selling price relative to cost of sales) or improved efficiency of SG&A activities (lower SG&A costs per dollar of sales). For informate firms, where IT improves information flows throughout the organization, we observe significant improvements in both selling price margins and the ratio of SG&A costs to sales but improvements in SG&A to sales occurred more immediately and were sustained longer. For automate firms, where IT spending is more likely to be directed at specific business processes, improvements were observed in the ratio of SG&A to sales but not in selling price margins.

In the next section, we position our analysis in the context of previous studies and develop our research hypotheses. We then describe the empirical model that we constructed to investigate how information about IT spending in period *t* was reflected in performance in periods $t + i$. In the fourth section, we describe the sample and present the results of our analysis of the association between IT spending and future earnings. We document additional analyses of earnings that we performed to evaluate how IT spending affected profit margins and asset utilization. We conclude by discussing the implications of our research for managers and researchers.

Impact of IT on Future Firm Performance

Researchers have tangled with the question of how IT impacts firm performance for nearly two decades. Early research failed to find positive productivity effects of IT (Baily and Chakrabarti 1988; Loveman 1994). While the results of these studies painted a bleak picture of the business value of IT, Bryjolfsson (1993) observed that there were a number of possible explanations for the failure to find a positive impact of IT. Along with other measurement problems, he cautioned that, as with all new technology, there may be a period of learning, adjustment and restructuring necessary to reap the full benefits of IT.

More recent research has documented higher marginal productivity of IT inputs versus non-IT inputs (Brynjolfsson and Hitt 1996) and stronger performance by IT leaders versus other firms (Bharadwaj 2000; Santhanam and Hartono 2003). A related body of

research has investigated the relationship between the market value of firms (based on stock prices) and their IT investment or IT spending. Event study research documents positive abnormal stock returns associated with announcements of IT investments (Dos Santos et al. 1993; Im et al. 2001). Valuation studies have found higher market valuation of IT versus non-IT assets (Brynjolfsson et al. 2000) and higher incremental market value associated with IT spending or implementation of new IT (Anderson et al. 2003; Bharadwaj et al. 1999; Hitt et al. 2002). In fact, the market value associated with IT in these studies has been remarkably high. Brynjolfsson et al. (2000) found market value multiples of 5 to 20 with respect to the value of IT capital and Anderson et al. (2003) found multiples of 30 or more on Y2K spending. In all of the stock-price-based studies, higher market valuation is interpreted to represent expected improvements in future performance resulting from IT spending (see Figure 1)

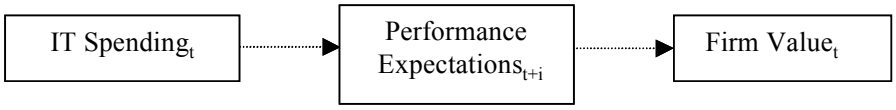

Figure 1

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* (see Figure 2) should be observable (Abarbanell and Bushie 1997).

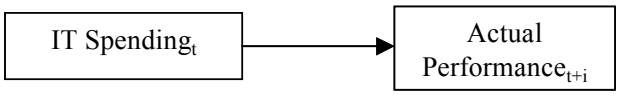

Figure 2

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 (Ross and Beath 2002; Sambamurthy and Zmud 1999). 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 percent 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 (Chatterjee et al. 2001; 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 period *t* to have a positive association with future earnings.

Hypothesis 1: IT spending in period t has a positive association with earnings in future periods.

Zuboff (1985) and Schein (1992) distinguished between IT that automates business processes and IT that informates organizations. Spending on IT that is directed at improving specific business processes is likely to impact future firm performance differently from spending on IT that is aimed at improving the flows of information through organizations. Efficiencies gained from improving processes may be realized differently over time and the performance impact may be muted if competitors make similar process improvements. When IT informates an organization, it provides an opportunity to use information more effectively than competing firms. Changes to IT infrastructure may improve coordination between subunits or enable the company to respond more effectively to market dynamics. The benefits of informating depend on the company's ability to adapt and may play out differently between one company and its peers. For these reasons, we decided to separately analyze the impact of IT spending on firm performance for companies that were more likely to have been spending on IT that informates versus those that were more likely to be spending on IT that automates.

Recent research has used an industry classification scheme to discriminate across firms based on the role IT played in their industries during the time period that we are studying. Chatterjee et al. (2001) surveyed a panel of IT experts to classify industries according to a typology that identified IT as playing a transforming role, an informating role or an automating role. The transforming role is an extension of the informating 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.[1] Chatterjee et al. 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 found greater valuation impact in informate and transform industries than in automate industries. We test whether the magnitude of the association between IT spending and future earnings is greater for firms in informate than for firms in automate industries.

H2: The magnitude of the association between IT spending in period t and future earnings is greater for companies in informate industries than for companies in automate industries.

Empirical Model

Research studies in accounting and finance have demonstrated that nonearnings 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 information in the time-series of earnings with other information and found that supplemental information may decrease the forecast error, meaning that nonearnings 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 measure the association between IT spending in period t and 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]

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

We estimate this model separately for informate and automate firms. Hypotheses 1 and 2 imply that $\hat{\beta}_1^{\text{Info}} > \hat{\beta}_1^{\text{Auto}} > 0$. In his analysis of components of earnings, Sloan (1996) tested whether there were differences in the information conveyed about future earnings in different 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 normalize 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 IT spending having a delayed impact on firm performance.

Data and Results of Estimation

To evaluate the impact of IT spending on future earnings, we obtained data on IT spending from *InformationWeek* surveys for the years 1990 to 1996. The *InformationWeek* surveys included information about IT spending based on responses to questions about the firm's IT spending or IT 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 their measurement of IT budgets, there is likely to be measurement error

[1]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.

[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.

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 1987 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 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.

Table 1. Descriptive Statistics

		1990	1991	1992	1993	1994	1995	1996
Sales	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
Assets	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	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	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	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	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

Our data is stacked so that each firm-year observation is included as an observation for period t in four separate models that relate $Earnings_{t+i}$ to $IT\ spending_t$, $Earnings_t$, and $Earnings_{t-1}$, for $i = 1, 2, ,3$ and 4 years. To provide information about contemporaneous effects, we also estimated a 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,[3] we estimated all of the models using the Prais-Winsten method (Park and Mitchell 1980). We identified influential observations using recommended cutoffs for leverage points, Studentized residuals, the DFFITS measure, and standard influence 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. For firms in the automate industries, the association between IT spending in period t and future earnings was highest in period $t + 1$ and was sustained through period $t + 4$. For firms in the informate industries, the association between IT spending in period t and future earnings was significantly positive in periods $t + 1$ through $t + 4$, increasing progressively from period $t + 1$ to period $t + 3$ and diminishing in period $t + 4$. These results strongly support hypothesis 1.

The coefficients on the IT spending variables represent the incremental earnings in period $t + i$ associated with IT spending in period t. Because IT costs are already taken out of earnings, the coefficients may be interpreted as the additional profit earned

[3]The average autocorrelation coefficient across the various models was 0.11.

in period $t + i$ attributable to a dollar of IT spending in period t. To put the coefficients in perspective, we calculated the present value of the additional profits earned in periods $t + 1$ to $t + 4$ attributable to $1 of IT spending in period t using a discount rate of 10 percent. For firms in the automate industries, the present value of the additional profits in periods $t + 1$ to $t + 4$ is $0.194 per $1 of IT spending in period t. For firms in the informate industries, the present value of the additional profits in periods $t + 1$ to $t + 4$ is $0.468 per $1 of IT spending in period t. The larger magnitude for firms in the informate industries is consistent with hypothesis 2.

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

	$Earnings_t$	$Earnings_{t+1}$	$Earnings_{t+2}$	$Earnings_{t+3}$	$Earnings_{t+4}$
Variable*	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
$IT\ Spending_t$	0.0223 (0.0001)	0.0738 (0.0001)	0.0461 (0.0001)	0.0530 (0.0001)	0.0719 (0.0001)
$Earnings_t$		0.7785 (0.0001)	0.7139 (0.0001)	0.6342 (0.0001)	0.4783 (0.0001)
$Earnings_{t-1}$	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

*The IT spending and earnings variables are normalized by total assets

Panel B: Firms in Informate Industries

	$Earnings_t$	$Earnings_{t+1}$	$Earnings_{t+2}$	$Earnings_{t+3}$	$Earnings_{t+4}$
Variable*	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
$IT\ Spending_t$	-0.0252 (0.0046)	0.0815 (0.0001)	0.1431 (0.0001)	0.2469 (0.0001)	0.1325 (0.0001)
$Earnings_t$		0.7217 (0.0001)	0.5148 (0.0001)	0.3644 (0.0001)	0.3430 (0.0001)
$Earnings_{t-1}$	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

*The IT spending and earnings variables are normalized by total assets

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.

Analysis of Return on Assets

In our analysis of the impact of IT on 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 impacted by IT spending. The Sloan or General Motors model (Figure 3) splits ROA into profit margin and asset turnover (Stickney and Brown 1999).

Profit margins increase if companies are able to improve selling effectiveness to obtain higher margins on products and services sold (higher selling price relative to product cost) or improve the efficiency of business processes to reduce the selling, general, and administrative costs per dollar of sales. 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).

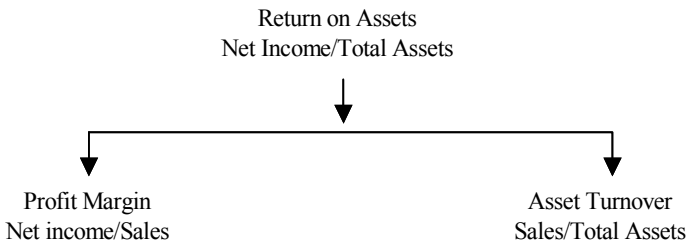

Figure 3

New IT may improve information flows between subunits of an organization to enable the company to identify and respond more quickly to changes in market demand. This may, for example, lead to improvements in gross profit margins if the company takes advantage of its information to meet customer needs earlier than its competitors, reducing the need for price promotions. This type of improvement in gross profit margins takes place when IT plays an informating rather than an automating role. Alternatively, new IT may help to streamline business processes, leading to savings in selling, general, and administrative costs as a percentage of sales. Improvements in asset turnover may occur if new IT leads to reductions in the value of accounts receivable, inventories, or property, plant, and equipment (PP&E) needed for a given volume of activity. For example, IT that speeds up the collection process may improve accounts receivable turnover and IT that enables companies to improve supply chain management and implement just -in-time processing could lead to improvements in inventory turnover or PP&E turnover. These types of improvements may occur when IT plays either an informating or automating role.

In Tables 3 and 4, we provide results of estimating the association between IT spending in period t and future profit margins from sales and asset turnover. For firms in the automate industries, there is a positive association between IT spending in period *t* and profit margins (panel A of Table 3) in years *t + 1* through *t + 4*. The association between IT spending in period *t* and asset turnover (panel A of Table 4) is slightly negative in period *t + 1* and is not significantly different from zero for any of the other future 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.[4] For firms in the informate industries, the association between IT spending in period *t* and profit margin in future periods (panel B of Table 3) is significantly positive in periods *t + 1* through *t + 4* and follows a similar pattern to the association between IT spending in period *t* and earnings observed in Table 2 (increasing in years *t + 1, t + 2*, and *t + 3* and diminishing in years *t + 4*). As with the firms in the automate industries, IT spending in period *t* appears to have had a limited association with asset turnover in future periods (panel B of Table 4), having a significantly positive association in period *t + 1* only.[5]

Profit margin can be analyzed further by evaluating the ratio of cost of goods sold (COGS) to sales and the ratio of selling, general, and administrative (SG&A) costs to sales. In Tables 5 and 6, we provide results of estimating models that relate IT spending in period *t* to these ratios in future periods. The ratio of COGS to sales is inversely related to the gross profit margin. Therefore, a decrease in this ratio indicates greater selling effectiveness in terms of obtaining higher gross margin on sales. For

[4]In our analysis, IT spending is deflated by total assets. Our results are robust to deflating IT spending by sales.

[5]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 on future values of these ratios.

firms in automate industries (panel A of Table 5), IT spending in period *t* is not associated with decreases in the COGS to sales ratio in future periods. For firms in informate industries on the other hand (panel B of Table 5), there are significantly negative coefficients in periods *t + 2* and *t + 3,* indicating that IT spending in period *t* did improve selling effectiveness in these periods.

A negative association between IT spending in period *t* and future values of the ratio of SG&A costs to sales would indicate improvements in the efficiency of business operations. Results of estimating the model for SG&A costs indicate improvements for both automate and informate firms. For automate firms (panel A of Table 6), the associations are significantly negative in periods *t + 2* and *t + 3*. For informate firms (panel B of Table 6), there are strong negative coefficients in all periods *t + 1* through *t + 4*.

Table 3: 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

	Profit Margin$_t$	*Profit Margin*$_{t+1}$	*Profit Margin*$_{t+2}$	*Profit Margin*$_{t+3}$	*Profit Margin*$_{t+4}$
Variable*	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
IT Spending$_t$	0.0032 (0.9234)	0.0256 (0.1456)	0.0432 (0.0001)	0.0933 (0.0001)	0.1040 (0.0001)
Profit Margin$_t$		1.0528 (0.0001)	0.9800 (0.0001)	0. 7083 (0.0001)	0. 6586 (0.0001)
Profit Margin$_{t-1}$	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

*IT spending is normalized by total assets

Panel B: Firms in Informate Industries

	Profit Margin$_t$	*Profit Margin*$_{t+1}$	*Profit Margin*$_{t+2}$	*Profit Margin*$_{t+3}$	*Profit Margin*$_{t+4}$
Variable*	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
IT Spending$_t$	0.0103 (0.6327)	0.0349 (0.0030)	0.1105 (0.0001)	0.1233 (0.0001)	0.0895 (0.0001)
Profit Margin$_t$		0.7912 (0.0001)	0.7259 (0.0015)	0.5980 (0.0001)	0.3921 (0.0001)
Profit Margin$_{t-1}$	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

*IT spending is normalized by total assets

Table 4: 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

	$Asset\ Turnover_t$	$Asset\ Turnover_{t+1}$	$Asset\ Turnover_{t+2}$	$Asset\ Turnover_{t+3}$	$Asset\ Turnover_{t+4}$
Variable*	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
$IT\ Spending_t$	0.0081 (0.4613)	-0.0338 (0.0043)	0.0058 (0.6609)	0.0056 (0.7933)	0.0097 (0.6617)
$Asset\ Turnover_t$		1.0717 (0.0001)	0.8042 (0.0001)	0.7378 (0.0001)	0.6289 (0.0001)
$Asset\ Turnover_{t-1}$	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

*IT spending is normalized by total assets

Panel B: Firms in Informate Industries

	$Asset\ Turnover_t$	$Asset\ Turnover_{t+1}$	$Asset\ Turnover_{t+2}$	$Asset\ Turnover_{t+3}$	$Asset\ Turnover_{t+4}$
Variable*	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
$IT\ Spending_t$	-0.0744 (0.0034)	0.0590 (0.0001)	0.0277 (0.3117)	0.0470 (0.1676)	0.0421 (0.2264)
$Asset\ Turnover_t$		0.9694 (0.0001)	0.9146 (0.0001)	0.7212 (0.0001)	0.5500 (0.0001)
$Asset\ Turnover_{t-1}$	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

*IT spending is normalized by total assets

Table 5. Results of Estimation of Models Relating Cost of Goods Sold as a Percentage of Sales in Period $t + i$ to IT Spending in Period t

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

Panel A: Firms in Automate Industries

	$COGS_t$	$COGS_{t+1}$	$COGS_{t+2}$	$COGS_{t+3}$	$COGS_{t+4}$
Variable*	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
IT Spending$_t$	-0.0047 (0.6223)	0.0151 (0.0055)	0.0063 (0.4671)	-0.0086 (0.3137)	-0.0065 (0.4743)
$COGS_t$	1.0038 (0.0001)	1.1010 (0.0001)	1.0170 (0.0001)	0.9421 (0.0001)	1.0218 (0.0001)
$COGS_{t-1}$		-0.1212 (0.0001)	-0.0711 (0.0522)	-0.0133 (0.7601)	-0.1022 (0.0277)
	N = 647 adj. R^2 = 0.9694	N = 654 adj. R^2 = 0.9674	N = 640 adj. R^2 = 0.9297	N = 642 adj. R^2 = 0.8945	N = 612 adj. R^2 = 0.8811

*IT spending is normalized by total assets

Panel B: Firms in Informate Industries

	$COGS_t$	$COGS_{t+1}$	$COGS_{t+2}$	$COGS_{t+3}$	$COGS_{t+4}$
Variable*	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
IT Spending$_t$	0.0141 (0.0448)	0.0052 (0.5879)	-0.0476 (0.0001)	-0.0326 (0.0001)	-0.0042 (0.6368)
$COGS_t$	0.9709 (0.0001)	0.9628 (0.0001)	0.9774 (0.0001)	1.0158 (0.0001)	0.8226 (0.0001)
$COGS_{t-1}$		0.0305 (0.1545)	0.0212 (0.5162)	-0.0025 (0.9493)	0.1738 (0.0003)
	N = 504 adj. R^2 = 0.9802	N = 496 adj. R^2 = 0.9830	N = 497 adj. R^2 = 0.9618	N = 490 adj. R^2 = 0.9441	N = 464 adj. R^2 = 0.9154

*IT spending is normalized by total assets

Table 6: Results of Estimation of Models Relating Selling, General, and Administrative Costs as a Percentage of Sales in Period $t + i$ to IT Spending in Period t

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

Panel A: Firms in Automate Industries

	SGA_t	SGA_{t+1}	SGA_{t+2}	SGA_{t+3}	SGA_{t+4}
Variable*	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
IT Spending$_t$	-0.0233 (0.1910)	-0.0059 (0.4111)	-0.0162 (0.0001)	-0.01959 (0.0001)	-0.0092 (0.2657)
SGA_t	0.9959 (0.0001)	1.1617 (0.0001)	1.1844 (0.0001)	0.9955 (0.0001)	0.9505 (0.0001)
SGA_{t-1}		-0.1628 (0.0001)	-0.1953 (0.0001)	-0.0047 (0.0001)	0.03878 (0.6392)
	N = 442 adj. R^2 = 0.9879	N = 438 adj. R^2 = 0.9922	N = 425 adj. R^2 = 0.9678	N = 425 adj. R^2 = 0.9802	N = 405 adj. R^2 = 0.9810

*IT spending is normalized by total assets

Panel B: Firms in Informate Industries

	SGA_t	SGA_{t+1}	SGA_{t+2}	SGA_{t+3}	SGA_{t+4}
Variable*	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
IT Spending$_t$	0.0241 (0.0001)	-0.03959 (0.0001)	-0.0327 (0.0001)	-0.0357 (0.0001)	-0.0373 (0.0001)
SGA_t	0.9928 (0.0001)	0.9612 (0.0001)	0.8898 (0.0001)	0.8669 (0.0001)	0.7717 (0.0001)
SGA_{t-1}		0.0456 (0.1735)	0.1109 (0.0169)	0.1643 (0.0025)	0.2665 (0.0001)
	N =429 adj. R^2 = 0.9868	N = 422 adj. R^2 = 0.9873	N = 423 adj. R^2 = 0.9750	N = 417 adj. R^2 = 0.9803	N = 396 adj. R^2 = 0.9863

*IT Spending is normalized by total assets

Discussion and Conclusion

Our analysis is motivated by the argument that evaluation of new IT must consider how IT spending impacts future performance because it takes time for organizations to assimilate new IT. In addition to the reduction in earnings caused by IT spending itself in period t, new IT is often accompanied by costly organizational changes that reduce earnings further during the assimilation period (Brynjolfsson et al. 2000). The pattern of coefficients observed for informate firms (panel B of Table 2) is consistent with this assimilation argument. In fact, there is a small negative association between IT spending and earnings in period t itself followed by the increasing coefficients that we observed in periods $t + 1$ through $t + 4$. The pattern is less dynamic for firms in the automate industries (panel A of Table 2), where a small positive coefficient is observed in period t. The differences in the patterns between informate and automate firms indicate that it takes longer for firms to realize the benefits of IT that informates than for IT that automates. This is reasonable because firms have to learn how to take advantage of new information capabilities whereas the benefits of automation are realizable almost immediately.

The observed pattern of coefficients clearly demonstrates the problem with conclusions drawn from studies that compare current earnings performance with current IT spending. Not only is there a strong positive association between IT spending in period t and future earnings, but this association is sustained for at least four years. The high incremental earnings associated with IT spending provide evidence of high returns to IT spending consistent with evidence obtained from valuation studies (Anderson

et al. 2003; Bharadwaj et al. 1999; Brynjolfsson et al. 2000). An interesting question to be addressed in future research is whether the capital markets fully incorporate information that is contained in IT spending. Because our data is limited to large firms surveyed for the *InformationWeek* 500, it would also be interesting to perform a similar analysis for mid-sized and smaller firms.

Business firms face almost unlimited opportunities to implement new IT-enabled initiatives but the resources available to carry out these initiatives, including capital, IT capability, and organizational capacity for change, are limited (Ross and Beath 2002). Managers responsible for innovating through IT must compete for scarce resources meaning that they must make business cases to support their proposals (Sambamurthy and Zmud 1999). However, forecasting and tracking the impact of IT spending on performance is difficult because IT initiatives may impact earnings over multiple periods in diverse and indirect ways (Barua et al. 1995). By performing a cross-sectional analysis, we were able to observe associations that may not be apparent in analyses of the impact of IT spending for individual firms. We also provide information about the pattern of returns associated with IT spending that could be used by managers to make projections and evaluate the success of IT projects.

Carr (2003) argues that IT has become a commodity and not a strategic resource, implying that companies cannot expect to obtain sustainable competitive benefits from IT. Our results suggest that companies have achieved sustained earnings improvements from IT investments. These sustained earnings improvements were even observed for firms in industries where IT primarily played an automation role. Of course, firms do not benefit equally from IT spending. Future research may evaluate characteristics of firms that have higher associations between IT spending and future firm performance.

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