MIT Sloan School of Management

Working Paper 4449-03
November 2003

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Starling Hunter, Kevin Kobelsky, Vernon J. Richardson

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Starling Hunter

Sloan School of Management

Massachusetts Institute of Technology

Cambridge MA 02142

Voice: (617) 252-1427 Fax: (617) 253-2660

Email: starling@mit.edu

Kevin Kobelsky

Marshall School of Business

University of Southern California

Los Angeles, CA 90089-0441

Voice: (213) 740-0657 Fax: (213) 747-2815

Email: kobelsky@usc.edu

Vernon J. Richardson

School of Business

University of Kansas

Lawrence, KS 66045-2003

Phone: (785) 864-7507; Fax: (785) 864-5328

Email: vrichardson@ku.edu

Abstract: This study investigates the impact of IT investments and several contextual variables on the volatility of future earnings. We find evidence that IT investments strongly increases the volatility of future earnings and that four contextual factors- industry concentration, sales growth, diversification, and leverage- strongly moderate IT's effect on earnings volatility. It is notable that while the main effect of IT spending on earnings volatility is strongly positive, not all of the moderators are. This suggests that there are conditions under which the positive risk-return relation can be either offset or even reversed. Taken together, these results suggest an explanation for what has recently been termed the "new productivity paradox", i.e. the apparent under-investment in information technology despite evidence of highly positive returns for doing so.

INTRODUCTION & MOTIVATION

Evaluating information technology investments has been a central concern in information systems research and practice for decades. A substantial body of research has found that IT's average (Brynjolfsson and Hitt 1995, 1996; Dewan and Min 1997; Hitt and Brynjolfsson 1996; Lichtenberg 1995, Bharadwaj et al. 1999) and maximum (Banker et al, 1990) effects on financial performance are highly positive. This has generated a new twist to the so-called 'IT productivity paradox' (Strassman, 1990; Loveman, 1994): given evidence of such high returns, firms would appear to be under-investing in IT. Financial management theorists have long maintained that "returns" should be evaluated relative to the "risk" associated with an investment. This raises an intriguing possibility: if investments in IT lead to increases in risk, e.g. in the volatility, as well as the returns of future earnings, perhaps firms and their managers willingly forgo higher returns when the increased risk can not be offset. Interestingly, the impact of IT investment on risk and return of future earnings has yet to be addressed in theoretical or empirical research within the IS field. There are very good reasons, however, why it should be.

Firstly, research in accounting and finance investigating the consequences and determinants of *intra-firm* earnings heterogeneity, i.e. earnings *volatility* is well-established. Earnings volatility can impose significant costs on the firm including: reduced market value (Barth, et al 1999; Lev, 1979); reduced ability of investors and owners to predict future cash flows (Barnea et al 1976); increased cost of capital and reduced access to external capital markets (Badrinath, et al, 1989); and, as a result, decreased discretionary investments, e.g. capital expenditures, R&D and advertising (Minton and Schrand, 1999). These consequences combine with the fact that top managers' compensation is often tied to firm performance to create strong incentives for managers to anticipate the impact of their decisions on the volatility of future earnings (Bartov, 1993) and take concerted action to reduce it (Beidleman, 1973; Badrinath et al, 1989).

Prior research has yet to examine whether investments in information technology are determinants of earnings volatility. There are, however, important reasons why this question should be examined. IT investments are not unlike other capital expenditures, e.g. R&D spending, that prior research has been shown to increase the volatility of future earnings (Kothari, Laguerre, & Leone, 2002). That said, it is also important to note that IT investments possess characteristics which differentiate them from other capital expenditures, resources, and capabilities and which may contribute to earnings volatility in unique ways. The uniqueness stems from whether we view IT as a "solution" or as a "project". The information processing view of the firm (Galbraith, 1977) suggests that as a "solution", IT investments may enable firms to better and more quickly respond to external and internally-sourced uncertainty. As a "projects", IT investments can be very difficult to manage, sometimes failing spectacularly (Financial Times, 1998) and often falling short of management expectations (Compass, 1999). While each of these ways of viewing IT investments has potentially different implications for earnings volatility they are not mutually exclusive. For one, each suggests the possibility that firm-specific and industry-level contextual forces may act as moderators of earnings volatility.

This study reviews prior theoretical work and empirically investigates how IT affects earnings volatility. We find that IT has a direct positive impact on both earnings volatility, and that the effect is significantly moderated by several organizational and industry-level factors, including a firm's leverage, sales growth, product-market diversification, and industry concentration. The remainder of this study is organized as follows. In the next section we develop several hypotheses concerning the effects of information technology investments on the volatility of future earnings. The section which follows contains a description of our data and research methods. The next two sections provide a view of the results of the test of our hypotheses and a discussion of the implications of those results, respectively. We conclude with a discussion of the contribution of the paper to the extant body of knowledge on the IT-firm performance relationship.

LITERATURE REVIEW & HYPOTHESIS DEVELOPMENT

As previously suggested, because of their strongly dualistic nature, IT investments may have distinctly different impacts on earnings volatility than other kinds of investments and resources. On the one hand, IT investments frequently take the form of distinct, substantial, highly important, and quite risky "projects." On the other hand, IT may be viewed a "solution", one which enables the firm to better and more quickly respond to external and internally-sourced uncertainty.

The existence of these two opposing explanations for earnings volatility raises three possibilities, each with different implications: first, that one effect dominates the other on a consistent basis (an 'IT determinist' view); second, that the two explanations offset each other in ways unique to each organization such that there is no systematic direct relationship between IT and earnings heterogeneity (an 'organization determinist' view), and third, that each systematically dominates in different contexts i.e. that IT's effects are moderated by situational factors that are shared by firms (an 'ecological' view) (King and George, 1991).

In the remainder of this section we first develop several hypotheses regarding IT investments' direct and moderated impact on earnings volatility. First we develop two competing sets of hypotheses of IT investments' main effect on earnings volatility- one that views IT as a solution and the other which views IT as a project. We then develop two additional sets of hypotheses concerning the possible moderating influence of four factors on IT investments' impact on earnings volatility. Those factors are industry concentration, unrelated diversification, sales growth, and leverage. Again we take the dualistic nature of IT investments into account: the first four factors are combined with the 'solution" perspective while the latter two are combined with the "project" perspective.

IT & Earnings Volatility: The "Solution" View

The express purpose of information technology in organizations is as a solution to the data and information processing needs attendant to the attainment of its goals. Those goals may include, but are not limited to, minimizing costs, increasing productivity and profitability, improving coordination among internal units and value chain partners, and securing or maintaining competitive advantage. To that end, IT is increasingly applied to organizational tasks, processes, and functions as widely varying as transaction, data, document, and order processing (Dinan, Painter, & Rodite, 1990; Lasher, Ives, Jarvenpaa, 1991; Strader, Lin, & Shaw, 1999), decision support (Hagglund, 1989), workforce scheduling (Kumar & Arora, 1999), financial planning & reporting (Jablonsky & Barsky, 2000; Green, 2000), human resource management (Strauss, Weisband, and Wilson, 1998; Scott & Timmeran, 1999), new product development (Corso & Paolucci, 2001; Baba & Nobeoka, 1998), marketing (Good & Stone, 1995) and customer relationship management (Cooper, Watson, Wixom, & Goodhue, 2000), manufacturing (Fulkerson, 2000; Freund, 1997), organizational design (Nault, 1998) and the facilitation of geographical dispersed work-teams (Mowshowitz, 1994), and enterprise resource planning (Robey, Ross, & Boudreau, 2002). And while the while the specifics of how the application of IT to these processes may help organizations achieve the aforementioned goals varies widely, the common denominator is requirement that data or information be analyzed, retrieved, stored, displayed, accessed, exchanged, or otherwise processed. By doing so, IT plays a central role in resolving information-based uncertainty associated with the achievement of those goals. For example, Dell's on-line sales system provides updates to manufacturing several times per day, enabling the company to exploit its JIT inventory system with suppliers more effectively, reducing the costs associated with changes in sales levels and mix (Kraemer, Dedrick & Yamashiro, 2000).

If, as in the above example, IT improves firms' response capability and reduces the cost and revenue impacts of unforeseen events, the result would be a concomitant reduction in the volatility of

earnings proportional to the extent of the firm's IT use. Thus, under the assumptions of the "IT as solution" view, it follows that:

H1a: The greater a firm's spending on IT, the lower its volatility of earnings.

IT & Earnings Volatility: The "Project" View

Large scale studies of IT returns indicate that they vary widely (Brynjolfsson and Hitt, 1996). IT projects can be very difficult to manage, sometimes failing spectacularly (Financial Times, 1998) and often falling short of management expectations (Compass, 1999). Given the magnitude of IT projects and their impact on a firm's operations, they can significantly affect the volatility of earnings. Anecdotal evidence suggests that firms differ markedly in how they manage such projects and what they gain from them, in return. Some firms, for example, have experienced spectacular operational and strategic benefits from IT (Kraemer, Dedrick & Yamashiro, 2000) while others have experienced equally spectacular failures (Financial Times, 1998).

In addition, a variety of factors in systems development makes implementation difficult to manage, costly and disruptive (Lyytinen et al, 1998), all of which may have a direct impact on earnings volatility. Even if a system is implemented as planned, it may not have the expected impact due a variety of contextual moderators at the industry and firm level. As a result, IT projects often fail, increasing the volatility of firm earnings.

Previous research suggests that IT investments are subject to several types of risk that can affect their contribution to earnings (Benaroch, 2002; Clemons and Weber, 1990). Many of these risks relate to *implementation*: IT projects may require technology that is not available (technical risk); they may overwhelm the technical skills of the company's IT staff (project risk); they may involve revisions to processes that overwhelm the operations staff (operational risk) or undermine internal vested interests

and in response are fought by them (internal political risk). Finally, the inability of management to provide a reasonable estimate of implementation costs and the time required to implement (management optimism risk) are risks that are synonymous with project failure (McFarlan 1981). Benaroch (2002) also describes the *technological market risk* associated with newer, superior technologies rendering a project obsolete.

These risks are quite salient for IT projects. The Standish Group (1996) reports that a large majority of IT projects have experienced some form of failure. Its 1995 survey of 365 large organizations indicates that 31 percent of projects are not completed. Some 53 percent are completed, but with an average cost overrun of 189 percent (about 3 times the original budget). One third of chief executives surveyed in 1999 believed that IT's contribution to firm performance was low (Compass, 1999). Large scale studies of IT returns indicate that they vary widely (Brynjolfsson and Hitt, 1996) however this has not been linked to effects on the volatility of a firm's total earnings. Given that computers, software and communications technology have been the largest category of corporate fixed investment since 1995 ($345 billion in the US in 2001) (Bureau of Economic Analysis, 2002), the uncertainty of these investments can have a significant impact on the volatility of firm earnings. The higher level of risk associated with IT relative to other projects is expected to lead to IT spending having a direct positive effect on earnings volatility.

Dewan et al (2003) find empirical support for this view. They examine the direct effects of IT on the standard deviations of return on assets and market value using an economic production function approach and find that investment IT leads to higher levels of volatility in earnings and stock market returns. This provides evidence that the 'IT as a project' view is descriptive: IT investment leads to higher levels of earnings volatility.

H1b The greater a firm's spending on IT, the greater its volatility of earnings.

Moderating Effects of Context- the Solution View

IT investments can reduce volatility by acting as an information processing mechanism, enabling the firm to better and more quickly respond to external and internally-sourced uncertainty (Galbraith, 1977; Gurbaxani and Whang, 1991). For any given level of uncertainty, this improved response capability can reduce the cost and revenue impacts of unforeseen events, reducing the volatility of earnings. Thus the stabilizing effects of IT on volatility are conditional: they are only expected to be salient when both a high level of uncertainty exists and IT provides information that will mitigate that uncertainty. This view tends to assume the following main effects: contextual uncertainty has a positive effect on volatility, while coordination mechanisms (i.e., IT) have no main effect on volatility. This perspective contradicts the 'IT as a project' view: rather than amplifying IT's positive effect on volatility, context is seen as mitigating IT's effect on volatility.

Burns and Stalker (1961), Lawrence and Lorsch (1967) and Pfeffer and Salancik (1978) propose that environmental uncertainty is a function of the number of external actors that a firm must actively attend to in order to achieve marketplace success. Pfeffer and Salancik (1978) focus this logic on a firm's competitors, and find a positive relationship between industry concentration and environmental complexity. As noted above, when between two to five competitors together effectively exercise control over a market, their individual behaviors can significantly impact each other. As a result, when industry concentration is high (and, hence, only a few key rivals must be attended to), it becomes feasible to apply IT-enabled intelligence capabilities to gather information about these competitors, and respond more quickly to their actions. A well-known example of this is the computerized reservation systems used in the airline industry. Airlines can respond to competitors' fare initiatives on thousands of routes within hours, a feat impossible without advanced IT systems. As industry concentration decreases perfect competition approaches, and no single firm can have a significant impact on the others. Under perfect

competition, there is no strategic gamesmanship, nor the sudden adjustments associated with it, and less need for information systems that address these requirements.

H2a The positive impact of IT spending on earnings volatility will be lower in more concentrated industries than in less concentrated industries.

Sales growth can be negative or positive and is a measure the rate of change in an organization. While arithmetically related to earnings, it is distinct from them e.g., a firm may grow in size but not profit because it is unable to cope with the uncertainties associated with a higher level of operating activity. Following the arguments described in H2b, firms that have grown quickly have had to make decisions under rapidly changing conditions, and acquire assets and capabilities that are not as suitable as they would have had there been more time. Under the information processing view, IT could be used to help mitigate these challenges by providing information about rapidly changing circumstances. This would mitigate the volatility effects of growth.

H2b The positive impact of IT spending on earnings volatility will be lower in high sales growth firms than in low sales growth firms.

As described in H2c, fixed interest payments associated with debt reduce earnings levels, and debt covenants can impose significant costs for a firm not meeting minimum earnings levels. IT investments in highly leveraged firms may help anticipate and adjust to changes in operations that would lead to debt covenant violations, mitigating the impact of this uncertainty on firm earnings.

H2c The positive impact of IT spending on earnings volatility will be lower in more leveraged firms than in less leveraged firms.

Under the information processing view, one could argue that diversified firms are more complex than non-diversified firms of the same size because of the need for coordination of shared resources which generate competitive advantage. This complexity could lead to variation in earnings. IT can be used as a coordination mechanism to mitigate and reduce this uncertainty. Prior research suggests that

IT's benefits are expected to be greater in firms with related, rather than unrelated diversification. Related diversification is associated with higher levels of resource interdependence and monitoring than unrelated diversification, leading to higher levels of IT investment (Dewan et al, 1998). IT is expected to have a mitigating (i.e. negative interaction) effect that would be stronger for related than unrelated diversification.

A competing argument is based on a well-established arithmetic effect of diversification: to the extent earnings from diverse product markets are less than perfectly correlated, the sum of these earnings will exhibit less variance. Firms often diversify to smooth earnings, reducing managers' risk in meeting compensation targets (Beidleman, 1973). Diversification will similarly mitigate IT's main positive effect on volatility, leading to a negative interaction. This effect would be stronger for unrelated diversification since earnings from the different markets would be less correlated.

H2d The positive impact of IT spending on earnings volatility will be lower in more diversified firms than in less diversified firms.

The Moderating Effects of Context- The Project View

Under the 'IT as a Project' view, four dimensions of context are expected to exacerbate the challenges associated with IT investments, increasing the likelihood of failure and thereby the volatility of earnings.

Pfeffer and Salancik (1978) argue that when between two to five competitors together effectively exercise control over a market, their individual behaviors can have a greater impact on each other than if there are many firms in a perfectly competitive market. More concentrated industries are therefore expected to be more uncertain. Benaroch (2002) describes this as competitive risk: "the result of uncertainty about whether a competitor will make a preemptive move, or simply copy the investment and improve on it". This adds to variability in the payoffs to IT spending by an individual firm. As a result, industry concentration is expected to amplify IT's positive effects on earnings volatility.

H3a The positive impact of IT spending on earnings volatility will be greater in more concentrated industries than in less concentrated industries.

The risks associated with IT can be exacerbated during periods of high sales growth. Growth is nearly universal goal of firms (Dalton and Kesner 1985; Whetten, 1987) and is widely perceived as a positive signal, i.e. that the firm's strategy is working successfully (Grant, 2001). That said, the pressure that firms often face to grow quickly poses several important challenges and opportunities for organizations and their managers (Penrose, 1959). Prior research has found rapid organizational growth to be associated with an increase in organizations assets, and to help coordinate those assets, the adoption of new organization forms (Shane, 1996). These forms as well as entry into new markets often lead to the adoption of new technologies (Ohmae, 1989; Scott-Morton, 1991). In periods of slow growth, investments in assets and capability build upon strengths developed in previous periods and provide a sound basis for growth in subsequent ones (McGee and Thomas, 1994). During periods of rapid growth, several problems can arise: first, the conditions under which such decisions are made are subject to rapid change (Eisenhardt, 1989); and second, such decisions are only partially reversible (Ghemawat and Costa, 1993) and the assets in which the firms and the capabilities developed to deploy them are frequently found to be overly-specific (Williamson, 1975) or insufficiently dynamic to meet changing market demands (Pettus, 2001). These effects are expected to be particularly salient for IT investments, which are difficult to design and implement in any case. Thus, IT investments made during periods of high sales growth are more likely to fail, increasing earnings volatility.

H3b The positive impact of IT spending on earnings volatility will be greater in high sales growth firms than in low sales growth firms.

Benaroch (2002) describes firm-level 'monetary' risk as the risk that "the firm cannot afford the [IT] investment; [or] the financial exposure may not be acceptable and/or the projected investment costs may not remain in line with the projected investment benefits." The growth of IT spending has been

fueled in part by large, multi-year IT projects such as enterprise resource planning systems. Financial theory and empirical findings suggest that increases in a firm's debt levels (leverage) result in higher fixed charges to income which in turn constrain resources available for discretionary investments (Kothari et al, 2002). This in turn increases the likelihood of cancellation of multi-year IT projects, increasing the volatility of subsequent payoffs and thus firm earnings. In an analysis of the same data set used in this study, Kobelsky et al (2003) find that higher debt levels lead to lower subsequent levels of IT investment. These reductions in resources are expected to increase the likelihood of project failure, and thus the volatility of earnings.

H3c The positive impact of IT spending on earnings volatility will be greater in more leveraged firms than in less leveraged firms.

The larger number of product markets a firm operates in, the greater the likelihood that a portion of IT spending is for large complex IT projects that span business units. Such complex projects hold significant benefits, but are even more challenging to implement than traditional IT projects, as evidenced by the spectacular successes (Kraemer et al, 2000) and failures (Financial Times, 1998) of enterprise resource planning systems. Under the IT as a project view, the higher benefits of success and costs of failure associated with such projects would lead to higher earnings volatility.

H3d The positive impact of IT spending on earnings volatility will be greater in more diversified firms than in less diversified firms.

ANALYTICAL MODEL & METHOD

For tests of hypotheses relating earnings volatility we build on prior research by Kothari et al (2002). We use the standard deviation of the change (SDΔE) in earnings as a dependent variable because it is a better measure of earnings volatility over time than standard deviation of earnings (SDE) if earnings are expected to be related to the independent variable (IT). SDΔE measures deviation from a

linear relationship between earnings and IT, in contrast to SDE which measures deviation from a single mean value. The high returns to IT investment found in previous research suggest the former is the most appropriate approach.

We also control for the direct impact of several non-IT variables on earnings volatility, including the direct effects of advertising expenditure, research and development expenditure, capital expenditure, and size. Kothari et al (2002) found that all of these have a direct impact on earnings volatility. We do not propose that this model is exhaustive, and therefore our empirical model also controls for other industry differences at the two-digit SIC level, as well as exogenous annual effects (not shown for brevity). For the strongest test of the hypotheses, we examine the effects of these variables simultaneously rather than individually.

The significance of coefficients in the model is tested using OLS regression analysis of the pooled observations. To assess whether the moderating effects of context on IT's relationship to firm risk are monotonic (i.e., have no effect on the sign of the IT coefficient), or non-monotonic (cause the IT coefficient to become zero or switch signs), we follow the procedure used by Schoonhoven (1981). The level of each contextual variable at which IT's effect is zero is calculated and compared to the observed range for that variable. If the calculated value is within the range, IT's effect is non-monotonic. Extending Schoonhoven's analysis to enhance the interpretation of results, we also test the significance of the IT coefficient at the minimum and maximum values of the contextual variable.

Data

The source of IT investment data is *InformationWeek*. *InformationWeek* and *ComputerWorld* provide IT-related data such as IT budgets, number of IT employees and other IT-related information as part of an annual published survey. We use IT budget for the current survey year as a measure of IT investment. The data from both sources has been used extensively in other similar studies (see Brynjolfsson and Hitt

(1996) and Lichtenberg (1995)). Lichtenberg (1995) provides evidence that there is a high correlation between the estimates of IT data from both of these public sources suggesting that either source would be reasonable. Since *InformationWeek* has IT budget data for a broader set of firms than *ComputerWorld*, it is used as our source of IT budget data over the 1992 to 1997 sample period. Starting in 1998, *InformationWeek* no longer includes IT budget data in their annual InformationWeek 500 issues.

All data for other measures come directly or are calculated from the *Compustat* database. Industry concentration is measured using the combined market share for the top four firms in each four-digit SIC code (e.g., Besanko et al, 2001:227). To minimize the potential effect of outlier observations on the results, variables are winsorized by adjusting all values in the top and bottom percentiles to be equal to their 1st and 99th percentile values (Kothari et al, 2002). All variables in the model are mean-centered. This allows interpretation of the main effect of a variable as the effect of the variable when all other variables are at their mean values (Jaccard et al, 1990).

To provide the most reliable measure of industry concentration, which is calculated based on 4 digit SICs, only firms coded by Compustat as being in a 4 digit rather than 1, 2, or 3 digit SIC are included in the sample. This reduces the sample in the earnings volatility analysis by 28%, from 1428 to 1098. Adding the excluded observations back in to the sample does not qualitatively change the results. Table 1 provides the descriptive statistics for the dependent and independent variables. Table 2 provides Pearson correlation coefficients for each of the variables in the model. Since many of these variables are highly correlated, variance inflation factors (VIF) were computed to assess multicollinearity in the multiple regression analysis. Belsley et al. (1980) suggest that VIF's greater than 10 present a potential collinearity problem. The highest computed VIF in this sample was 2.36, leading us to conclude that collinearity is not a significant issue.

Insert Tables 1 & 2 About Here

RESULTS

Table 3, below, presents the standardized coefficients associated with each of seven OLS regressions of the standard deviation of the change in future earnings on IT expenditure and other covariates. Modeling was performed in a hierarchical fashion. The first model contains no controls or interaction terms. The second model includes controls for advertising, research & development , and capital expense ratios, as well as the natural log of market capitalization. The third model incorporates four contextual variables – industry concentration, sales growth, leverage, and unrelated diversification- while the fourth adds to them the interaction term between each contextual variable and the IT expenditure measure. The next three models add, respectively, eight (8) single-digit dummy variables for industry sector (Model 5), five dummies for years 1992-1996 (Model 6), and both industry and year dummies (Model 7).

Insert Table 3 About Here

The results indicates that the main effect of IT on earnings volatility is positive and highly significant ($0.928 < b < 1.332$, $p < 0.001$, 2 tailed test) across all six models. This provides strong support for H1a, i.e. the IT as a "project" view as its suggests that IT investments do increase the volatility of an individual firm's future earnings. Two other of the control variables also have significant and positive impacts on earnings volatility: R&D expense ratio, whose effect is positive ($0.380 < b < 0.576$, $0.001 < p < 0.01$, 2-tailed) and market capitalization, whose effect is negative ($-0.016 < b < -0.019$, $p < 0.001$, 2 tailed). It should be noted, as well, that findings of significant main effects for Advertising, R&D, Size and Capital Expenditures are consistent with Kothari et al (2002). Models 4-7 in Table 3 indicate that IT's effects on earnings volatility are moderated by all the variables proposed in the model except sales growth. Each variable's impact on earnings volatility is discussed in turn, below.

Insert Figure 1 About Here

Industry Concentration. In Table 3 it is observed that industry concentration has a negative and marginally significant main effect (Model 3: $b = -0.023$, $t = -1.79$, $p < 0.10$, 2-tailed) and negative and more highly significant interaction effect with IT on earnings volatility ($-2.49 < t < -2.46$, $p < 0.01$, 2-tailed). The latter finding strongly supports H2a as it suggests that IT enables firms to monitor and react to competitors' actions more quickly, reducing the volatility of earnings, and that this effect dominates the challenges introduced by industry concentration under the IT as a "project" view. Our analysis of the interactions indicates that IT's effect on volatility is highly significant both at the lowest level of industry concentration, 22%, ($b = 0.88$, $t= 5.39$, $p > 0.001$) and the highest, 100%, although slightly less so in the case of the former ($b = 0.41$, $t= 2.84$, $p < 0.001$). Thus firms in more concentrated industries appear to have slightly greater incentive (on a risk-adjusted basis) to invest in IT. This finding complements, but is distinct from, Dewan and Mendelson's (1998:603) theoretical prediction that incentives to invest in IT increase with industry concentration. Our finding it is based on risk reduction rather than differences in mean returns.

Sales Growth. The results indicate that neither the main effect of sales growth ($t = 0.41$, $p > 0.10$) nor its interaction with IT, has a positive effect on earnings volatility ($p > 0.10$). Thus, it would appear that neither hypothesis concerning sales growth, i.e. H2b or H3b, is supported. As would be expected from the lack of significance of the interaction term, IT's effect on earnings volatility is almost identical across the range of sales growth levels for firms in the sample ($b = 1.02$ vs. 0.97 at sales growth = -57% and 438%, respectively).

Leverage. The results further indicate that leverage has a significant and positive main effect (Model 3: $t = 4.69$, $p < 0.001$) and an even stronger and positive moderating effect on earnings volatility ($5.56 < t < 5.96$, $p<.001$), thereby confirming H3c. This suggests that the negative effects of leverage on IT project risk are far greater than IT's ability, as a solution, to mitigate the swings in earnings that

leverage creates. An analysis of the strength of the main effect across levels of leverage indicates that at the higher end (78%), IT's effect on volatility is highly significant ($b = 1.98$, $t = 12.99$, $p < 0.001$) and somewhat less so for firms without debt ($b = 1.02$, $t = 4.96$, $p < .001$). On the whole, the presence of a positive interaction demonstrates the sensitivity of IT projects to resource constraints, and may be consistent with the observation that IT budgets do not include much larger complementary investments necessary for success: firms facing significant debt service loads may be less able to make these complementary investments.

Diversification. The results presented in Table 3 also show that while unrelated diversification has a negative but insignificant main effect on earnings volatility ($t = -1.16$, $p > 0.10$), it has a much stronger, negative moderating effect ($-7.96 < t < -7.65$, $p < 0.001$). The latter result provides support for H2d. More specifically, this is consistent with the arithmetic effect of diversification: participation in a greater number of product markets whose earnings are imperfectly correlated will reduce volatility, and mitigate the effect of factors which would otherwise increase volatility. Our analysis of the strength of the main effect across levels of diversification indicates that IT increases volatility in firms operating in firms which evidence no diversification, i.e. firms operating in only one 4-digit SIC ($b = 1.02$, $t = 4.96$, $p < 0.001$). However, but this decreases with higher levels of diversification such that for the most highly diversified firms, IT has a significantly negative impact on earnings on volatility ($b = -0.91$, $t = -2.90$, $p < 0.001$). Consistent with the basic tenets of portfolio theory, diversification can mitigate the effects of project risk sufficiently that IT becomes a solution, rather than a source of uncertainty: IT investments that are diversified portfolios eliminate project risk so that their firms have *smoother* earnings than low-IT firms.

DISCUSSION

This study considers the impact of IT investments on the volatility of subsequent earnings of firms and the moderation of that impact by various organizational and environmental factors. Our results were as follows: IT had a positive impact on volatility of future earnings; this impact was moderated negatively as industry concentration and diversification increased, moderately positively as leverage increased, and uninfluenced by changes sales growth. We believe that these findings make three important contributions to the understanding of the IT-firm performance relationship.

First and foremost, the findings reported here important for the explanation they provide for the new productivity paradox (Andersen et al, 2003), i.e. firms' apparent under-investment in IT given recent evidence of high average returns (e.g. Bharadwaj, et al, 1999; Brynjolfsson and Hitt, 1995). Our findings are consistent with non-academic research indicating that many firms' evaluate IT projects using methods similar to those applied to financial portfolios (Hoffman, 2002), i.e. that they explicitly consider the risk involved in IT investments, not the impact on value. As mentioned earlier, no prior academic research of which we are aware has investigated this aspect of the IT-firm performance relationship. Since IT spending outstrips all other types of corporate investment (Bureau of Economic Analysis, 2002), recognizing and understanding IT's impact on earnings volatility is an important complement to prior research on IT returns.

A second contribution of this study stems from our formalization and test of the two perspectives of IT: the "IT-as-solution" and the IT-as project" perspectives. The former view of IT motivated hypotheses arguing that IT's impact on volatility, as well as the impact of the proposed moderators, would be negative. The later view motivated hypotheses that asserting the opposite, i.e. that the impact would be positive. Our findings when taken as a whole, leads us to conclude that there may be a relationship between the two perspectives. That IT increases the volatility of future earnings does suggest that, overall, the IT-as-project view dominates the IT-as-solution view. However, two of the three significant moderators, industry concentration and diversification, were consistent with the

solution view. Moreover, diversification was the only of the moderators whose effect on volatility was non-monotonic, i.e. changed the sign of the main effect from positive to negative. This might suggest that the solution view may be more useful in understanding the conditions under which the main effect is unlikely or less likely to hold. This is particularly salient for large infrastructure-focused IT projects where it may prove difficult for managers to invest in an equivalent diversified portfolio of smaller unrelated projects.

A third contribution of this study stems from its finding of significant moderation of the main effect (increased volatility) by several firm-specific and industry characteristics. First of all, this finding is line with Orlikowski and Iacono's (2002) call for more research on how context moderates IT's use and impact. While such relationships have has already been demonstrated in several studies of IT and mean performance levels (e.g. Brynjolfsson and Hitt, 1998), ours is the first study to date to do so on the volatility of performance. Our finding also has important implications for managers. Prior research has identified IT capabilities as an important determinant of firm performance associated with IT investments (e.g. Bharadwaj, 2000). Our findings suggest that a crucial IT managerial skill may be knowing how to adjust IT expenditure levels, as well as expectations of risk and return associated with them, in a way that recognizes the impact of context on earnings volatility.

Table 1 Descriptive Statistics

Description	Mean	Standard Deviation	Min	Max
St. Dev. Change in Earnings	0.079	0.114	0.00	0.70
IT Expenditure	0.040	0.050	0.00	0.32
Advertising Expenditure	0.011	0.027	0.00	0.15
R&D Expense	0.023	0.046	0.00	0.26
Capital Expenditure	0.095	0.103	0.00	0.67
Ln (Market Value)	8.39	1.243	5.13	11.28
Industry Concentration	0.598	0.224	0.22	1.00
Sales Growth	0.499	0.774	-0.57	4.39
Leverage	0.271	0.192	0.00	0.78
Unrelated Diversification	0.213	0.344	0.000	1.34

- ***St. Dev.*** is the ***standard deviation of the change in annual earnings*** before extraordinary items using the five annual earnings observations for years t to t+4, SD($\Delta E_{t,t+4}$).
- ***IT*** is the IT expenditures incurred in year t
- ***Advertising*** is the advertising expense in year t
- ***R&D*** is the research and development expenditures in year t
- ***CapEx*** is the capital expenditures in year t
- ***Size*** is the market value of common equity at the end of year t. It's natural log (LNSize) is used in subsequent analysis.
- ***Industry Concentration*** is the percentage of sales in a four-digit SIC code held by the largest four firms in year t.
- ***Sales Growth*** = ($Sales_t$-$Sales_{t-4}$)/$Sales_{t-4}$
- ***Leverage*** is the long-term debt divided by the market value of common equity and long-term debt in year t.
- ***Unrelated diversification*** (UD) is a measure of dispersion of sales across industries in different 2 digit SIC codes (Dewan et al, 1998:225).

Notes: (N=1098)**.** SD($\Delta E_{t,t+4}$), IT, Advertising, R&D and Capital Expenses are deflated by market value of the firm in year t-1.

Table 2 Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) St. Dev. of Change in Earnings	---								
(2) IT Expense Ratio	0.575a	---							
(3) Advertising Expense Ratio	0.171a	0.172a	---						
(4) R&D Expense Ratio	0.282a	0.230a	0.078b	---					
(5) Capital Expenditure Ratio	0.302a	0.313a	0.295a	0.147a	---				
(6) Ln (Market Capitalization)	-0.381a	-0.347a	-0.025	-0.059d	-0.194a	---			
(7) Industry Concentration	0.036	0.067c	0.128a	0.226a	0.028	-0.147a	---		
(8) Sales Growth	-0.051d	-0.032	0.000	-0.040	-0.069c	0.073c	0.081b	---	
(9) Leverage	0.335a	0.321a	0.137a	-0.095	0.423a	-0.324a	-0.137a	-0.162a	---
(10) Unrelated Diversification	-0.057d	-0.052d	-0.025	0.070	0.050d	0.006	0.249a	-0.062c	-0.069c

Legend: [a] $p < 0.001$, [b] $p < 0.01$, [c] $p < 0.05$, [d] $p < 0.10$

Table 3 **Results of OLS Regression of Standard Deviation of Yearly Earnings on IT Expense Ratio & other Covariates**

	1	*2*	*3*	*4*	*5*	*6*	*7*
IT Expense Ratio	**1.332**[a] (23.30)	**2.069**[a] (16.36)	**0.935**[a] (15.14)	**0.928**[a] (4.54)	**1.026**[a] (4.90)	**0.928**[a] (4.54)	**1.016**[a] (4.84)
Advertising Expense Ratio		**0.221**[a] (2.16)	**0.233**[b] (2.29)	**0.061**[b] (0.624)	**-0.055**[b] (-0.55)	**0.073**[b] (0.74)	**-0.045**[b] (0.44)
R&D Expense Ratio		**0.380**[a] (6.37)	**0.478**[b] (7.75)	**0.573**[b] (9.53)	**0.541**[b] (7.29)	**0.576**[b] (9.56)	**0.553**[b] (7.41)
Capital Expense Ratio		**0.098**[a] (3.45)	**0.046**[c] (1.55)	**0.036**[c] (1.24)	**0.040**[c] (1.25)	**0.036**[c] (1.24)	**0.042**[c] (1.29)
Ln (Market Capitalization)		**-0.019**[a] (-8.12)	**-0.017**[a] (-7.14)	**-0.017**[a] (-7.63)	**-0.016**[a] (-6.58)	**-0.018**[a] (-7.86)	**-0.016**[a] (-6.83)
Industry Concentration			**-0.023**[d] (-1.79)	**0.007**[d] (0.46)	**-0.013** (-0.80)	**4.71E-03**[d] (0.31)	**-0.014**[d] (-0.85)
Sales Growth			**1.41E-03** (0.41)	**1.04E-03** (0.25)	**1.82E-03** (0.42)	**3.60E-04** (0.09)	**1.47E-03** (0.34)
Leverage			**0.078**[a] (4.69)	**0.029** (1.56)	**0.042** (2.15)	**0.032** (1.68)	**0.044** (2.23)
Unrelated Diversification			**-9.25E-03**[d] (-1.16)	**0.038**[d] (3.82)	**0.033**[d] (3.15)	**0.036**[d] (3.68)	**0.031**[d] (2.98)
IT * Industry Concentration				**-0.610**[b] (-2.46)	**-0.619**[b] (-2.49)	**-0.599**[b] (-2.42)	**-0.605**[b] (-2.43)
IT * Sales Growth				**9.62E-03**[a] (0.17)	**-6.01E-03**[a] (-0.10)	**7.15E-03**[a] (0.12)	**-9.59E-03**[a] (-0.17)
IT * Leverage				**1.301**[a] (5.96)	**1.232**[a] (5.59)	**1.285**[a] (5.88)	**1.226**[a] (5.56)
IT * Unrelated Diversification				**-1.385**[a] (-7.70)	**-1.444**[a] (-7.96)	**-1.379**[a] (-7.65)	**-1.436**[a] (-7.91)
Industry Dummies	No	No	No	No	Yes	No	Yes
Year Dummies	No	No	No	No	No	Yes	Yes
df	1	5	9	13	21	18	26
Model F	542.7[a]	149.0[a]	88.6[a]	80.2[a]	51.8[a]	58.3[a]	42.0[a]
Adjusted R^2	33.1%	40.3%	41.8%	48.4%	49.3%	48.5%	49.3%

Non-standardized Coefficients, N = 1098
Legend: [a] $p < 0.001$, [b] $p < 0.01$, [c] $p < 0.05$, [d] $p < 0.10$

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