

Value Implications of Investments in Information Technology

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Abstract

The year 2000 countdown provided a uniquely visible instance of spending on information technology by U.S. companies. With public attention riveted on potential Y2K malfunctions, managers were forced to evaluate their IT and make decisions whether to modify or replace existing systems. In the aftermath of Y2K, critics charged that the problem was overblown and that companies overspent on IT. In contrast, we posit in this paper that efforts companies made to renew and upgrade their IT may have positioned them to take advantage of new e-business applications. As Y2K approached, managers could invest opportunistically in IT that would enable them to connect with customers and suppliers in new ways. Contrary to the alleged overspending, we find that firm value increased on average with Y2K spending by *Fortune 1000* companies. In particular, higher firm value and subsequent earnings were associated with Y2K spending for firms in industries where IT was considered to have a transforming influence – altering traditional ways of doing business by redefining business processes and relationships. We also test whether the positive association between firm value and Y2K spending diminished with Y2K spending by industry peer firms but we do not find support for this relative investment hypothesis.

1. Introduction

Public interest in the economics of information technology has shifted from the productivity paradox (Brynjolfsson 1993) to a debate whether companies overspend on IT (Carr 2004). Skeptics charge that companies spend excessively on IT under the “mistaken” belief that strategic use of IT can provide a sustainable competitive advantage. They caution that companies should avoid investing in new applications and let their competitors bear the costs of experimenting with IT. Proponents argue that companies can make innovative use of IT to connect with customers and suppliers in ways that create value by taking advantage of the unique resources of a firm. On one side of the debate is the argument that IT is easily replicable and cannot provide sustained competitive advantage because profits obtained from improved business performance would be competed away. On the other side is an argument that IT may be used to leverage other firm-specific resource advantages or opportunities (Clemons and Row 1991). A separate argument is also made that firms may develop sophisticated IT architecture and skills that are not easily replicable so that IT capabilities themselves may become a strategic resource (Mata, Fuerst and Barney 1995). The debate leads to a question whether IT does create value that is reflected in the market value of firms and in their future profitability. This question has been hard to address empirically because of difficulties in obtaining data about IT investment that can be linked to firm performance.

Previous research relating the market value of firms to IT has relied on privately-gathered survey information (Bharadwaj, Bharadwaj and Konsynski 1999, Brynjolfsson, Hitt and Yang 2002) or public announcements of IT initiatives (Dos Santos, Peffers and Mauer 1993, Im, Dow and Grover 2001, Chatterjee, Richardson and Zmud 2003). Due to investor interest in potential business interruptions resulting from year 2000 turnover problems, the U.S. Securities and Exchange Commission (SEC) mandated disclosures about Y2K preparations in quarterly and annual financial reports issued by publicly-traded U.S. companies. Among the items companies were required to disclose were the amounts expended on IT to prepare for Y2K including costs of remediating existing systems and costs of replacing systems if the replacements were motivated or accelerated by Y2K concerns. These disclosures gave

investors and analysts unprecedented access to information about the cost of firms' IT activities. The public disclosure of Y2K spending enables us to relate shareholder value to IT spending in the same manner that previous researchers have related shareholder value to other items reported in periodic financial reports such as research and development spending (Lev and Sougiannis 1996).

The publicity and specter of potential disaster surrounding Y2K raised concern about Y2K solutions to top management levels of large corporations. Moreover, the Y2K frenzy occurred at a dynamic time in the development and deployment of enterprise systems and other e-business applications that could alter the way companies did business. So as managers looked towards the new millennium, they were faced not only with concerns about their preparation for the year 2000 date turnover but also their ability to compete effectively in an increasingly information technology-oriented business world. Thus, Y2K was more than fixing a bug; it was an opportunity for managers to improve their IT systems. The combination of advances in business applications of IT, universal IT investment decisions and unparalleled disclosure of IT costs across companies provides a unique opportunity to evaluate the association between firm value and IT spending.

Critics allege that the Y2K risk was inflated and that companies spent excessive amounts on IT during the late 1990s when sales of enterprise systems were sizzling because managers could tie IT needs to Y2K (Hopkins and Kessler 2002, Strassman 2000). We posit that Y2K helped open the way for managers to acquire IT that could position their companies to interact in new ways with customers and suppliers. We evaluate the veracity of claims that Y2K spending eroded shareholder value by looking directly at the association between Y2K spending and the market value of *Fortune 1000* firms. Contrary to the allegations that firms got carried away in their Y2K spending, we find no evidence of a negative association between shareholder value and Y2K spending during 1999 or in the subsequent four years from 2000 to 2003.

Recent research has identified differences in the strategic roles of IT across industries during specific periods of time (Armstrong and Sambarmurthy 1999, Chatterjee, Richardson and Zmud 2001). These strategic roles have been classified into three categories labeled *automate*, *informate* and *transform*

(Zuboff 1998, Schein 1992). In automate industries, the primary role of IT is to replace human labor by automating business processes. In informate industries, IT provides data/information to empower management and employees. In transform industries, IT fundamentally alters traditional ways of doing business by redefining business processes and relationships (Chatterjee, Richardson and Zmud 2001). Chatterjee, Richardson and Zmud (2001) employed a panel of experts made up of researchers and practitioners to classify industries according to these different strategic roles during the period 1995 to 1998, a time period that corresponds closely to the Y2K preparation period. They investigated the stock market response to announcements of appointments of IT executives and found significantly positive abnormal returns surrounding appointments of IT executives in transform industries but not in other industries. Their evidence supports the argument that managers of firms in these industries were more likely to pursue innovative IT projects that would enhance firm value than managers of firms in other industries.¹ It also indicates that investors and analysts discriminated across industries according to the strategic role of IT.

Our main thesis is that managers may have taken advantage of the Y2K situation to make opportunistic investments in IT that gave them capabilities to create value by interacting differently with their customers and suppliers. Because there would have been greater opportunities to make innovative investments in IT for firms operating in transform industries, we evaluate the association between firm value and Y2K spending separately for firms in automate, informate and transform industries. We find significantly greater positive associations between firm value measured during the years 1999 through 2003 and Y2K spending for firms in transform industries than for firms in the informate and automate industries.

Our research contributes to the debate whether IT matters. Carr (2003) observed that a competitive advantage obtained through innovative investment in IT is likely to be short-lived because competing firms would mimic successful IT applications. He encouraged managers to avoid the high

¹ Innovative IT projects may combine new IT with complementary investments in organizational assets that change the firm's business processes and relationships.

costs of IT leadership. The question whether a competitive advantage derived from IT may be sustained has been raised frequently in the IS literature (Vitale 1986, Clemons and Row 1991, Mata, Fuerst and Barney 1995). An empirical implication of the argument that IT-based competitive advantage would be nullified via replication by competing firms is that the positive influence of a firm's IT spending on shareholder value would be reduced as the level of spending by competing firms increased. We test this relative investment hypothesis promoted in the IS literature by including the industry median values of Y2K spending by industry type as separate variables in our empirical model relating shareholder value to firm Y2K spending. Contrary to the relative investment hypothesis, we do not find negative coefficients on industry median Y2K spending offsetting positive coefficients on firm IT spending.

Empirical research in IS has relied on stock market values to represent expectations of future earnings improvements associated with IT investments (Dos Santos, Peffer and Mauer 1993, Bharadwaj, Bharadwaj and Konsynski 1999). But due to difficulties in isolating the influence of specific IT investments on firm performance, this empirical research has not demonstrated sustained improvements in earnings associated with investments in IT. We estimate an earnings prediction model that uses time-series information about earnings and other information available in 1999 to forecast earnings in 2000 thru 2003. We find significantly positive associations between earnings in 2000 through 2003 and Y2K spending in 1999 for firms in the transform industries.

Our research has important implications for managers responsible for IT investment decisions. By documenting a high association between market value and Y2K spending in the transform industries, our analysis indicates that, in situations when IT facilitates changes in business practices in an industry, managers must respond aggressively by investing in IT in order to maintain or improve their firms' competitive positions. Our findings that the high association between market value and Y2K spending for firms in transform industries was sustained through the market downturn in 2000-01 and beyond indicates that this higher market valuation was not due to market infatuation with technology but to perceived sustained benefits from improvements in business operations.

The remainder of this paper is organized as follows. We describe features of the Y2K setting in section 2. We develop our hypotheses in the context of relevant previous research in section 3. We present our empirical models in section 4. We describe the data and provide the results of estimating the models in section 5. We conclude by discussing the implications of this research for managers and researchers in section 6.

2. The Year 2000 and Investment in IT

A number of features of the Y2K environment make it an interesting research setting. The two-digit date constraint that was dubbed the “Y2K bug” was carried forward in legacy systems that were costly to remediate and maintain. Managers faced decisions whether to expend the resources necessary to remediate existing systems or to apply those resources to the acquisition of new systems. Buchner (1999) observed that “Replacements and upgrades installed as part of the Year 2000 strategy provide immediate benefits such as performance gains that increase customer responsiveness and the ability to meet information needs, which in turn becomes a competitive advantage. Longer term, these infrastructure upgrades provide additional headroom to support growth in business volumes or to implement new strategic applications, such as data warehousing and Business Intelligence (BI) applications, or e-business and e-commerce applications”.

The SEC interpretation (August 4, 1998) mandating disclosure of Y2K costs stated that companies should include both corrective spending to remediate existing IT and opportunistic spending to replace and upgrade their IT in their estimates of Y2K costs. It read:

Companies must disclose material historical and estimated costs of remediation. This includes costs directly related to fixing Year 2000 issues, such as modifying software and hiring Year 2000 service providers. In most cases, the replacement cost of a non-compliant IT system should be disclosed as an estimated Year 2000 cost. This is so even if the company had planned to replace the system and merely accelerated the replacement date.

The SEC statement also indicated that reported Y2K costs were to include both historical costs (costs expended before the reporting date) and estimated costs (costs that the company anticipated incurring after the reporting date to achieve Y2K compliance). This means that reported Y2K spending included

amounts expended during the four or five years leading up to Y2K even though the reporting occurred during 1998 and 1999.²

The Y2K disclosures themselves do not indicate the type of investment in IT made by firms except in a limited number of cases.³ Reports from a variety of other sources link Y2K preparation to implementation of enterprise applications. In a 1999 survey of Fortune 500 firms that implemented enterprise systems, Benchmarking Partners found that year 2000 concerns topped the list of technology motivations for acquiring enterprise systems for 42 per cent of the sample (Manchester 1999). Annual surveys conducted by AMR Research (August 23, 1999 press release) found that enterprise systems including enterprise resource planning (ERP), supply chain management (SCM), and customer relations management systems (CRM), dominated applications budgets for the five years leading up to Y2K. In 1999, for example, ERP spending absorbed 43%, SCM spending grabbed another 17% and CRM spending accounted for 13% of IT applications budgets. Companies could fix their Y2K problems and at the same time upgrade functionality of their IT by investing in ERP systems, motivating investment in ERP systems during the Y2K prelude.⁴ We performed a logit analysis of Fortune 1000 companies based on whether they were included on SAP's best customer list (at the SAP AG website) in early 2000.⁵ We found a significantly positive relation ($p\text{-value} = 0.0040$) between being on the SAP list and Y2K

² For Fortune 1000 firms that provided information about their Y2K spending in reports for periods ending on or before December 31, 1998, the average of actual spending to date to total budgeted spending was 54.54% (median = 54.08%). This indicates that over half of anticipated Y2K spending occurred before December 31, 1998.

³ We reviewed the Y2K disclosures for a large number of firms in our sample and found that most indicated that their Y2K preparations included a mixture of remediation and replacement of existing systems. Except for a few cases where companies indicated directly that they had implemented ERP systems, the disclosures did not describe specific types of IT that were acquired.

⁴ Xenakis (2000) noted, "The Year 2000 problem was a bonanza for the major enterprise resource planning (ERP) software vendors in 1997 and 1998, as many companies replaced their noncompliant legacy software with new ERP systems." Similarly, Foremski (1999) wrote, "The ERP vendors, both US and European, profited handsomely from strong sales related to the year 2000 software problem, with companies rushing to install Y2K-compliant ERP systems, and the market growing at 40 per cent a year." Describing how consulting activity had tailed off at the top accounting firms after Y2K, Telberg (2000) reported, "Last year's phenomenal advance was fueled by massive enterprise resource planning projects in advance of the Year 2000 date changeover." Corporate press releases also cited Y2K as a driver of decisions to implement enterprise systems. "The primary driver for the Mobil Everest Project was the need to comply with year 2000 requirements," said Mike Brown, Everest Program Manager for Mobil (September 9, 1999 press release). At Rayovac, "the goal of the SAP implementation was to shut down all legacy systems simultaneously and transfer all open transactions to the new Y2K compliant system" (August 3, 1999 press release).

⁵ Other prominent providers of ERP systems including Baan, J.D. Edwards, Oracle and PeopleSoft did not make such customers list publicly available.

spending intensity (defined as planned Y2K spending divided by sales), indicating that companies making investments in SAP systems during this period spent relatively more on Y2K.

While we observe that investments in enterprise systems were prominent during the Y2K period, our research does not specifically isolate investments in enterprise systems because the Y2K data does not discriminate between investments in enterprise systems and other types of Y2K spending. Investments in enterprise systems are a type of investment in IT that may have a transforming effect on business operations (enabling changes in business processes and relationships). Implementation of enterprise systems requires companies to make costly changes to business operations including investments in organizational restructuring and employee training. In fact, Gormley et al. (1998) reported that IT costs made up only about one-fifth of the total costs of implementing ERP systems. Because the non-IT costs are typically recorded as expenses for financial reporting purposes, these organizational investments may contribute to the unrecorded intangible asset value of companies (Brynjolfsson, Hitt and Yang 2002).

3. Development of Hypotheses

Carr (2003) proclaims that opportunities for gaining strategic advantage from IT are rapidly disappearing and cites studies that show that companies with the biggest IT investments rarely post the best financial results. He advises companies to spend less on IT and especially to avoid leading or innovative investments in IT. Other technology critics charge that companies overspent on Y2K by amounts as high as \$150 billion (Scannell 2000, Strassman 2000) and that companies continued to squander billions on IT after Y2K (Hopkins and Kessler 2002). To support their arguments, they point to situations where individual companies spent millions on new IT and were disappointed because new systems did not deliver anticipated benefits. They accuse companies of making IT acquisitions too quickly, deploying new IT poorly, and purchasing unneeded technology. They allege that Y2K hype led to panic buying and that the technology boom of the late 1990s fostered a “me too” attitude that had companies buying new technology to “keep up” with their peer firms.

An investment in IT is innovative if it alters technological production possibilities or affords the creation of new products or services (Tirole 1988). Like investments in research and development and

other innovative activities, investments in IT are risky and produce a mixture of successful and unsuccessful projects. Anecdotal reference to a few instances of poor IT project performance is not sufficient to justify claims of general overspending on IT. Evaluation of the success of IT investing requires a broad look at the value implications of IT spending for a large set of firms. The Y2K case provides an opportunity to evaluate the effects of IT spending on shareholder value for a broad cross-section of firms.

A notion has prevailed in the information systems literature that productivity gains from IT are passed on to customers because innovative applications of IT are difficult to protect from imitation by competitors (Vitale 1986). According to this argument, if one firm in an industry realizes improved productivity from an innovative application of IT, its industry peers will obtain similar IT and drive away the abnormal profits of the first firm. This argument is based on an assumption of either perfect or Bertrand competition and equivalence of abilities across firms within an industry to utilize IT. But, as Clemons and Row (1991) and Mata, Fuerst and Barney (1995) observed, firms in an industry are not identical and may differ along dimensions that influence their ability to profitably employ new IT. Clemons and Row (1991) used transaction cost economics (Williamson 1975) as a basis for evaluating the economic effects of IT on the structures and processes linking different business activities. By reducing transaction costs, IT allows higher levels of coordination, increasing the value of the coordinated resources. Drawing on the study of strategy and the economics of innovation (Barney 1986, Rumelt 1987, Teece 1987), Clemons and Row (1991) argued that differences across firms in their access to complementary resources affect their abilities to exploit IT innovations. Complementary resources may be physical such as plant and equipment or intangible such as customer relations, brand names and know-how. Resources are complementary to an innovation if their value is altered by the innovation. Firms are able to defend gains from IT innovations if other firms cannot readily obtain the complementary resources. Some resources cannot be readily acquired or sold because they are specialized and non-separable from the firm that produces and controls them (Rubin 1973, Rumelt 1982, Williamson 1975).

Our analysis is aimed at the question whether companies can create value by making innovative investments in IT. We look at the Y2K case from the point of view that managers could have taken advantage of Y2K to make opportunistic investments in IT that positioned them for e-business opportunities. The Y2K bug effectively reduced the marginal cost of replacing old IT with new IT because remediation costs could be avoided if the firm acquired new IT that was Y2K compliant. Surveys and media reports linking Y2K to investments in ERP and other systems suggest that firms did make investments in innovative IT in preparation for Y2K (Buchner 1999, Foremski 1999, Manchester 1999, Telberg 2000, Xenakis 2000). But the Y2K spending disclosures do not distinguish between corrective spending on existing IT and opportunistic investing in new IT. If higher Y2K spending was due to greater investing in innovative IT, then we may observe a positive relation between shareholder value and Y2K spending.

Hypothesis 1: There is a positive association between shareholder value and Y2K spending.

In industries where IT primarily played an automating role during the Y2K period, it is unlikely that firms would have made innovative investments in IT that leveraged existing resources in a manner that could not have been easily replicated by other firms. However, in industries where IT played an informing role, new IT may have enabled improvement in the coordination of business activities by some firms. For example, investments in IT by firms with flexible human resource and structural capabilities may have allowed them to respond more quickly to information that conveyed shifts in product demand.

Hypothesis 2: There is greater positive association between shareholder value and Y2K spending for firms in the informate industries than for firms in the automate industries.

The marginal productivity of new IT may be affected by organizational changes made in tandem with implementation of new IT. In this regard, investment in new IT may complement new investment in other organizational assets. Milgrom and Roberts (1995) observed that complementarity and optimization give substance to claims that a firm's strategy, structure and managerial processes need to fit one another (Chandler 1962). Complementarity, in their analysis, means that doing more of one thing increases the

returns to doing more of another. Brynjolfsson and Yang (1999) found that \$5 to \$20 of firm value were associated with each dollar of IT capital whereas only about \$1 of firm value was associated with each dollar of property, plant and equipment recorded in the company's financial statements. They surmised that the high multiples on IT capital were due to costly but unrecorded investments in organizational assets. In a follow-up study, Brynjolfsson, Hitt and Yang (2002) found that the market value multiples on IT capital increased with specific organizational characteristics such as greater use of teams, broader decision-making authority and worker training.

When IT plays a transforming role, it facilitates changes to business processes and interrelations with internal and external parties that may improve the results of business operations. To the extent that investments in organizational changes are unrecorded, they may add to shareholder value without adding to the accounting book value of a company. If new IT and organizational changes are complementary (meaning that returns to investing in one increase the returns to investing in the other), additional intangible asset value is created.

Hypothesis 3: There is greater positive association between shareholder value and Y2K spending for firms in the transform industries than for firms in the informate and automate industries.

A potential competitive advantage from IT may be diminished if peer firms make similar investments in IT (Vitale 1986, Clemons and Row 1995, Mata, Fuerst and Barney 1995). This argument suggests that, in a cross-sectional analysis, firm value would increase with the firm's own investment in IT and decrease with the level of investment in IT by the firm's industry peers. But, if oligopolistic competition characterizes an industry, peer investment may not fully eliminate the value of IT investment for each firm (Tirole 1988). In addition, industry peer investment may have a positive influence on firm value if there are positive externalities created by investment in similar IT by a cluster of firms (Dixit and Nalebuff 1991). Griliches (1979) described the spillover effects that occur with respect to research and development activities. He observed that the level of productivity achieved by a firm depends not only on its own research efforts but also on the level of the pool of knowledge created by the investment of other firms in its industry. Similar spillover effects may apply to innovative applications of information

technology. We test whether, as argued in the prior IT literature, negative competitive effects of peer investment in IT dominate positive spillover effects, by adding the industry levels of investment in IT by industry types as separate variables to our model.

Hypothesis 4: There is a negative association between shareholder value and the industry level of spending on Y2K.

Research in financial accounting has evaluated the association between firm value and disclosures made in quarterly and annual reports including items such as R&D costs (Lev and Sougiannis 1996) and operating cash flows (Sloan 1996). In a discussion of this literature, Abarbanell and Bushee (1997) observed that the economic intuition underlying these studies is that the disclosed items are informative about future earnings and that they are value-relevant because stock market values reflect informed expectations of future earnings. They proposed that this research would be more credible if the circuit were completed by linking the disclosed activities directly to actual future earnings. Research in IS that links the market value of firms to announcements of IT investments (Dos Santos, Peffer and Mauer 1993, Im, Dow and Grover 2001, Dehning, Richardson and Zmud 2003) or IT spending (Bharadwaj, Bharadwaj and Konsynski 1999) interprets stock market values as proxies for future firm performance. This research would also be more credible if higher firm value associated with IT investments were linked to actual realizations of future earnings. The Y2K case provides an opportunity to draw this link because Y2K spending occurred during a well-defined time period. Consistent with our previous hypotheses, we test for differences across industry types.

Hypothesis 5: There is a positive association between earnings in future periods and Y2K spending that is higher for firms in transform industries than for firms in automate and informate industries and higher for firms in informate industries than automate industries.

4. Empirical Models

Investments in R&D are innovative and may complement investments in other firm assets, such as marketing and distribution networks, leading to higher marginal productivity and market valuation of IT spending (Griliches 1981, Hall 1993a, Lev and Sougiannis 1996). In their study of differences across

firms in the market value multiple of computer assets, Brynjolfsson, Hitt and Yang (2002) used a “Tobin’s q” framework similar to that applied to the valuation of R&D by Griliches (1981), Griliches and Cockburn (1988), and Hall (1993a, 1993b, 1999).

To evaluate differences across firms in the association between stock price-based values and Y2K spending we adopted a market valuation framework similar to that applied by Lev and Sougiannis (1996). We were precluded from using short window event study methodology because information about Y2K preparations was not discretely disclosed at identifiable dates.⁶ Our empirical model relates the market value of the firm (based on prevailing stock prices) to a combination of the current book value and earnings of the firm and other value-relevant variables (Ohlson 1995). A variable is value-relevant if it provides information about expected future earnings beyond that conveyed by book value and current earnings. Amir (1993) used the following empirical specification that controls for heteroskedasticity by scaling the model by *book value*_{t-1}.

$$\text{market value}_t / \text{book value}_{t-1} = \alpha_0 + \gamma_1 * \text{book value}_t / \text{book value}_{t-1} + \gamma_2 * \text{earnings}_t / \text{book value}_{t-1} + \beta * \text{other value relevant information} / \text{book value}_{t-1} + \varepsilon$$

We modified the Amir (1993) model to include the value of *Y2K spending*_t as potentially value-relevant information. *Y2K spending*_t is the total amount of Y2K spending (including spending to date and anticipated future spending) period as projected at time t.⁷ We note that the unamortized cost of existing IT assets is included in the book value of the firm and the value-in-use of existing IT assets is reflected in current earnings. We included *R&D spending*_t as a control variable because it has been shown to be value-relevant in previous research (Lev and Sougiannis 1996) and it provides a benchmark for evaluating the impact of Y2K spending. We also included, as additional control variables, *sales growth*_t (sales in year t minus sales in year t-1) and *asset growth*_t (total assets in year t minus total assets in year t-1) to

⁶ Analysis of abnormal returns during short windows (two or three days) around the release of Y2K information in 10K or 10Q reports reveals no significant relationship with the Y2K spending intensity.

⁷ The time-series standard deviation of planned Y2K spending by firms over five quarters from the fourth quarter of 1998 to the fourth quarter of 1999 was just 9% of the mean Y2K spending. We also performed our analysis using actual Y2K spending to date and found similar results to those reported.

control for the possibility that Y2K spending proxied for different dimensions of firm growth. Our empirical model (1) is specified as follows:

Model (1)

$$\begin{aligned} \text{market value}_t / \text{book value}_{t-1} = & \alpha_0 + \beta_{Y2K} * Y2K \text{ spending}_t / \text{book value}_{t-1} + \gamma_0 * \text{book value}_t / \text{book value}_{t-1} \\ & + \gamma_1 * \text{earnings}_t / \text{book value}_{t-1} + \gamma_2 * R\&D \text{ spending}_t / \text{book value}_{t-1} \\ & + \gamma_3 * \text{sales growth} / \text{book value}_{t-1} + \gamma_4 * \text{asset growth} / \text{book value}_{t-1} + \varepsilon \end{aligned}$$

To test hypotheses 2 and 3, we need to discriminate between the slope coefficients on Y2K spending by industry type (A for automate, I for informate, and T for transform). To do this, we expanded the specification of model (1) to include interaction variables for $Y2K \text{ spending}_t$ that identify the industry type for each of the firms in the sample. To control for other industry factors that might have influenced valuation, we also included intercept dummies for industry types I and T.

Model (2)

$$\begin{aligned} \text{market value}_t / \text{book value}_{t-1} = & \alpha_0 + \alpha_I * \text{type I} + \alpha_T * \text{type T} + \beta_A * \text{type A} * Y2K \text{ spending}_t / \text{book value}_{t-1} \\ & + \beta_I * \text{type I} * Y2K \text{ spending}_t / \text{book value}_{t-1} + \beta_T * \text{type T} * Y2K \text{ spending}_t / \text{book value}_{t-1} \\ & + \gamma_0 * \text{book value}_t / \text{book value}_{t-1} + \gamma_1 * \text{earnings}_t / \text{book value}_{t-1} \\ & + \gamma_2 * R\&D \text{ spending}_t / \text{book value}_{t-1} + \gamma_3 * \text{sales growth} / \text{book value}_{t-1} \\ & + \gamma_4 * \text{asset growth} / \text{book value}_{t-1} + \varepsilon \end{aligned}$$

To test hypothesis 4, we add the median value of Y2K spending by industry to model (2). We interact the industry median variable with the industry type (A, I or T) because both the positive and negative effect of this variable will depend upon the nature of the IT investments. For example, IT investments that are efficiency oriented may be more easily competed away while it may be difficult to imitate an IT investment that is related to innovation and may transform the business model.

Studies of the time-series properties of earnings (Mozes 1992, Watts and Leftwich 1977) have found that earnings in year t are informative about earnings in year $t+i$ and that past and future earnings growth is correlated so that year $t-1$ earnings may also be useful in predicting year $t+i$ earnings. Research has also 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, Sloan 1996). To test hypothesis 5 that there is a positive association between Y2K spending and earnings in future periods, we

add $Y2K\ spending_t$ to an earnings prediction model that relates earnings in period $t+i$ to earnings in periods t and $t-1$.

5. Data and Results of Estimation

We hand-collected the Y2K spending data from Y2K disclosures in the Management Discussion and Analysis (MD&A) section of annual 10K and quarterly 10Q reports filed electronically with the SEC beginning in the first quarter of 1999.⁸ Our sample was drawn from companies included in the 1998 *Fortune 1000*. We used, as the starting point for our analysis, disclosures made during the first quarter of 1999 because this was the first annual reporting season subsequent to the SEC guideline on Y2K reporting.⁹ Of the *Fortune 1000* companies, 124 companies did not make 10K or 10Q filings during the first quarter of 1999 and 145 did not report their planned Y2K spending, leaving 731 firms.¹⁰ The 1998 *Fortune 1000* list divided companies into 61 industries. We formed 18 broader industry groups by aggregating similar industries. In table 1, we provide descriptive information about Y2K spending for these 18 industry groups. The industry groups are presented in ascending order based on the industry median Y2K spending intensity (Y2K spending normalized by sales revenue). We identified our 18 industry groups as automate, informate, and transform industries using the classification of industries provided by Chatterjee, Richardson and Zmud (2001).¹¹ Five of the 18 industry groups were classified as automate, eight as informate, and five as transform industries. The four highest industry groups in terms of median Y2K spending intensity (Media Services, Banks and Financial Services, Pharmaceuticals and Telecommunications) were classified as transform industries, indicating greater spending on IT for Y2K by firms in these industries. An AMR Research press release (August 23, 1999) reported, “High Tech,

⁸ The disclosures do not separate Y2K spending expensed from Y2K spending capitalized. Failure to adjust earnings for the expensed portion may cause a small upward bias on the coefficient on Y2K spending.

⁹ Over 90% of *Fortune 1000* companies release their annual reports during the first quarter. Data were also collected from filings made in the remaining three quarters of 1999 and the first quarter of 2000.

¹⁰ We reviewed the names of non-filers for the purpose of considering whether they were more likely to be low or high Y2K spenders but found no reason to suspect that they would be biased in either direction. A number of prominent IT firms, including Microsoft, Oracle, IBM, and Hewlett Packard, were among the non-filers.

¹¹ We deviated from the Chatterjee et al. (2001) classification for one industry group. We classified pharmaceutical manufacturers as a T industry whereas they had classified it as an I industry. Liebmann (1999) observed that nearly all drug and medical-supply companies had turned to enterprise resource planning packages, e-commerce systems, and consolidation of network and systems infrastructure to transform their business processes.

Pharmaceuticals, and Finance are the three vertical markets with the largest budgets for enterprise applications, and are increasingly spending more on enterprise applications.”

We obtained accounting variables from Standard and Poors’ Compustat database. These variables include income before extraordinary items (Compustat item #18), the book value of common equity (#60), the number of common shares outstanding (#25), R&D expenditures (#46), net sales revenue (#12), and total assets (#6). The number of firms in the final sample is reduced because firms were not included in the Compustat data base or specific data items were missing.

We present results of our ordinary least squares (OLS) estimation of model (1) in table 2. We identified and removed influential observations.¹² White’s (1980) test indicated that the null hypothesis of homoskedasticity could be rejected at the 5% level of significance after the transformation. The Shapiro-Wilk (1965) test did not reject the hypothesis that the residuals are normally distributed. We checked for the influence of multicollinearity by computing the condition number of the moment matrix as suggested by Belsley, Kuh, and Welsch (1980). In no case did the condition number exceed 20, the value Belsley et al. (1980) suggest as a symptom of high correlation among regressors.

From table 2, we observe that the estimated coefficients on Y2K spending are significantly positive between the second quarter of 1999 and the fourth quarter of 2000 and are not significantly negative in any of the quarters reported between 1999 and 2003.¹³ These results are consistent with hypothesis 1 and indicate that there was not an erosion of shareholder value associated with Y2K spending by the firms in our sample. With respect to the control variables, the estimated coefficients on the book value, earnings and R&D spending of firms are similar to those reported in previous research (Amir 1993, Lev and Sougiannis 1996).

¹² We identified influential observations using recommended cutoffs for leverage points, Studentized residuals, the DFFITS measure, and standard influences of observations on the covariance of estimates (Belsley, Kuh and Welsch 1980, Krasker, Kuh and Welsch 1983). Observations were excluded from the analysis if any one of the four cutoffs were exceeded. We also controlled for outliers by trimming 5% of the observations (Chen and Dixon 1972), based on Y2K spending normalized by book value in the previous period. Results of estimation for the trimmed sample were qualitatively similar to those presented.

¹³ We estimated our models for all quarters between 1999 and 2003 but only present two quarters for 2000 and 2001 and the fourth quarter only for 2002 and 2003. In all of the tables 2 through 7, the results for the quarters presented are representative of the results obtained in all quarters.

In the estimation of model (1), the coefficient on Y2K spending is constrained to a single value across all types of industries. This restrictive constraint is relaxed in the estimations of model (2) where different coefficients on Y2K spending are estimated for firms in type A, type I, and type T industries. We present the results of estimating model (2) in table 3. The estimated coefficients on Y2K spending for firms in type A industries are not significantly positive in any of the quarters between 1999 and 2003 and the coefficients on Y2K spending for firms in the type I industries are only significantly positive in a couple of quarters between 1999 and 2003.¹⁴ The coefficients on Y2K spending for firms in the transform industries are, however, significantly positive in nine of the ten quarters presented, providing strong support for hypothesis 3 that the association between the market value of firms and Y2K spending is highest for firms in the transform industries (see comparisons provided in table 6).

The magnitude of the estimated coefficients on Y2K spending for the transform industries ranges from 13.997 (second quarter of 1999) to 231.294 (fourth quarter of 2000). Caution must be exercised in interpreting this coefficient. Just as the coefficient on R&D spending reflects the complementarity of R&D with other firm resources, the coefficient on Y2K spending for type T industries reflects the complementarity of investments in IT with other organizational assets. This complementarity may be with pre-existing organizational assets, contemporaneous investments in organizational assets, or anticipated future investments in IT and other organizational assets. Firms that had organizational structures in place that enabled them to take better advantage of new IT would likely have invested more and realized greater increases in firm value than other firms (Clemons and Row 1991). Firms that made contemporaneous investments in organizational assets to complement investments in IT would have increased the returns to both investments (Milgrom and Roberts 1995). Anticipated future investment could also have affected the shareholder value of current investment in IT. For example, by investing in enterprise systems and making complementary investments that changed internal processes and external

¹⁴ The fact that the type A and type I coefficients on Y2K spending are not significantly different from zero in most cases may mean that investment in new IT did not have a significant impact on firm value or that Y2K spending in these industries was primarily corrective in nature.

interactions, firms opened the way to make complementary investments in such applications as supply chain management (SCM) or customer relationship management (CRM) systems.

We tested the relative investment hypothesis (hypothesis 4) by adding industry median Y2K spending (interacted with the three industry types) as a measure of peer spending for each of the eighteen industries described in table 1 to the model (2) specification. Results of estimations of model (3) with these additional variables are presented in table 4. With the exception of one quarter for firms in the automate industries, the estimated coefficients on industry median Y2K spending are not significantly negative in any quarter where there is a significantly positive coefficient on firm Y2K spending across the three industry types. These results do not support the relative investment hypothesis.¹⁵

Simultaneity

There is a potential issue of endogeneity with respect to the market value of the firm and investment in IT. For example, firms with higher market values (relative to their book values) are more likely to anticipate greater growth and may have more aggressive investment strategies. Brynjolfsson and Yang (1999) and Brynjolfsson, Hitt, and Yang (2002) recognized this possibility. Brynjolfsson and Yang (1999) dealt with potential simultaneity by estimating a two-stage least squares model that included the market value of the firm and computer capital as endogenous variables. Their results for this estimation were not qualitatively different from the results obtained using a single equation model that related the market value of the firm to computer capital. Brynjolfsson, Hitt, and Yang (2002) used current and lagged values of IT and market value to perform an analysis of Granger (1969) causality. They found that changes in current and lagged market values did not affect computer investment but that the current increase in the market value of the firm was significantly influenced by past investment in computer capital.

We do not have the time-series data to perform a test of Granger (1969) causality. Therefore, as a robustness check, we specified and estimated a system of simultaneous equations with firm *Y2K spending*_{*t*} and the *market value*_{*t*} of the firm as endogenous variables. The results of estimating this simultaneous

¹⁵ The results for the relative investment hypothesis are sustained in the model (4) 3SLS analysis described below.

equations model (4) are presented in table 5. Equation 1 (panel A) is the model (3) specification described above. Equation 2 (panel B) relates firm Y2K spending to various factors that were likely to have influenced spending on IT for Y2K. Because remediation costs and investments in new IT would likely have increased with the volume of transactions processed by the firm, *net sales revenue_t* is included as an exogenous variable in the second equation. Similarly, the value of *fixed assets_t* and the *number of employees_t* are included as independent variables because IT costs would likely have increased with the value of assets managed by the firm and the number of employees whose efforts are coordinated by the firm. We also included *sales growth_t* and *asset growth_t* in the second equation because current growth would have influenced firm's decisions to make new investments in IT.

In table 5, we present the three-stage least squares estimation (Zellner and Theil 1962) because the magnitude of the correlation between the disturbance terms of the two equations (0.54 in the first quarter of 1999) exceeds the limit of 0.33 suggested by Kennedy (1987) for using two-stage estimation. The coefficients on the market value variable in equation 2 are significantly positive (p-value < 0.10) in nine of the ten quarters estimated, providing support for two-way relations between Y2K spending and the market value of firms.¹⁶ From panel A of table 5, we observe that the estimated coefficients on the Y2K spending variable for the informate firms are significantly positive in eight of ten quarters reported between 1999 and 2003. This finding of more significant coefficients on Y2K spending for the informate firms is the most striking difference between the results presented in the OLS estimation in table 3 and the 3SLS estimation and indicates a higher association between the market value of firms and Y2K spending for firms in the informate industries when endogeneity is considered. The estimated coefficients on the Y2K spending variable for the transform industries are significantly positive in all quarters and significantly greater than the coefficients on Y2K spending for the informate firms making these results robust to the simultaneous equations estimation.

¹⁶ The strength of a simultaneous equations analysis is limited by the availability of appropriate instruments. Hausman (1978) tests of endogeneity provide mixed evidence of simultaneity between *Y2K spending* and *market value*.

Results of estimating the earnings prediction model are presented in table 7. The first column presents our basic earnings model. The dependent variable is net income deflated by total assets pooled over the four years subsequent to 1999. The coefficients on the Y2K spending terms are significantly positive for firms in the informate and transform industries and significantly negative for firms in the automate industries. However, the estimated coefficient for the type T firms of 3.487 (p-value = 0.0085) is a couple of orders of magnitude greater than the coefficient for the type I firms of 0.021 (p-value = 0.0003) and an order of magnitude larger than the negative coefficient for the type A firms of -0.512 (p-value = 0.0001). The large, significantly positive coefficient for the type T firms provides evidence that future earnings were positively impacted by Y2K spending for firms in these industries. This result directly links higher future earnings to Y2K spending and supports the implicit assumption that higher stock price values associated with higher Y2K spending are informative about future performance. The joint observation of higher stock price values and higher future earnings associated with Y2K spending by firms in transform industries provide complementary evidence that higher Y2K spending did help firms create value.

Following Hitt, Wu and Zhou (2002) who evaluated the impact of ERP systems on company performance for companies that implemented SAP during this time period, we included a number of alternative earnings-based performance measures. Type T firms that spent more on Y2K apparently realized greater improvements in profit margin on sales (Net income / Sales) and asset turnover (Sales / Total Assets) than other firms. The increase in profitability is primarily seen in the reduced ratio of cost of goods sold to sales. This indicates that firms in the transform industries that spent more on Y2K were able to increase their gross profit margins on sales, possibly because they were able to add more value for customers by connecting more closely with their needs. The increase in asset turnover is primarily seen in the higher inventory turnover (COGS / average inventory). This indicates that firms in the transform industries that spent more on Y2K were better able to coordinate their inventory needs with suppliers.

6. Conclusion

Managers face difficult decisions about IT investments because implementation of new IT is costly, disrupts business activities, puts strain on employees and has uncertain payoffs. In addition, there are strong incentives to put off investing in IT because a better solution may come out and it is easier to wait while others bear the costs and risks of innovating (Carr 2003). It is also difficult to quantify the expected benefits of new IT implementations that alter the way companies do business. Y2K was an intersection of opportunities to invest in innovative IT and the requirement to deal with potentially nasty problems in existing IT.

Some critics believe that managers got carried away by the Y2K bug and made unnecessary and unwise investments (Kong and Seipel 2000). John Gantz, chief research officer at International Data Corporation, remarked, “There has been a lot of spin doctoring to try and find benefits but the fact is that we fixed more than we needed to” (Bowen 2000). On the other hand, Lawrence Kudlow, chief economist at Schroder & Co. Inc. in New York, argued that “the Y2K-spurred information upgrade by businesses will yield productivity, profit and rate-of-return increases that may not be officially recognized and reported for years. In particular, business-to-business and business-to-supplier information improvements are going to be a huge plus for cost control, price-cutting and inventory management” (Kudlow 2000).

Porter (1999) observed that the essential core of strategy is cross-functional or cross-activity integration, the capacity to link and integrate activities across the whole value chain. When we expanded the specification of the Y2K spending variable to evaluate the value implications across industry types, we found strong positive value implications of Y2K spending in those industries where IT was playing a transforming role. This result counters claims based on isolated anecdotal evidence that ERP and other integrated systems are not paying for themselves and suggests the need for more research on the performance effects of enterprise systems.

Our finding of overall positive value implications of investments in IT by firms in the transform industries, in the face of observed failures in some situations, illustrates the importance of differences in firms’ abilities to utilize new IT (Bharadwaj 2000). Our failure to find support for the relative investment

hypothesis indicates that the competitive dynamics of IT investing are complex. While the ease of replication of IT makes it tempting to think that abnormal returns to investment in IT are likely to be wiped out by competitors making similar investments, this is not necessarily the case. Our analysis shows that companies that spent more during the Y2K period increased in value and improved their earnings performance.

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Table 1
Distribution of Y2K Spending Intensity by Industry^a

Industry Description	Industry Type^b	Total Number of Firms	Number of Sample Firms	Low	First Quartile	Median	Third Quartile	High
Wholesale & Specialty Retail	I	101	77	0.008	0.114	0.178	0.344	2.002
Merchandising	I	55	39	0.016	0.094	0.249	0.354	0.989
Extraction (Mining, Oil)	A	39	26	0.009	0.170	0.335	0.650	1.953
Building Materials & Construction	I	53	40	0.034	0.230	0.355	0.702	3.434
Chemicals & Petroleum Refining	I	61	49	0.058	0.246	0.379	0.813	6.199
Manufacturing, Auto. & Equip.	A	87	33	0.033	0.260	0.428	0.667	5.478
Hotels, Restaurants & Services	I	35	27	0.037	0.145	0.474	0.725	2.454
Transportation	A	33	31	0.039	0.180	0.483	0.839	2.323
Consumer (Non-Food)	I	29	26	0.027	0.116	0.530	1.489	3.198
Healthcare	T	32	24	0.078	0.377	0.550	1.346	4.936
Insurance	A	84	35	0.046	0.278	0.568	1.130	2.042
Consumer (Food & Beverage)	I	49	35	0.029	0.250	0.631	0.951	9.574
Electronics and Aerospace	I	110	73	0.089	0.432	0.712	1.219	4.477
Utilities	A	73	61	0.109	0.492	0.733	1.244	4.805
Media Services	T	26	24	0.220	0.527	0.795	1.286	2.102
Banks & Financial Services	T	79	62	0.028	0.661	1.081	1.547	3.269
Pharmaceuticals	T	14	12	0.063	0.866	1.123	1.508	2.176
Telecom	T	40	24	0.208	0.595	1.321	1.767	4.135

^a Y2K spending intensity is total Y2K spending divided by net sales revenue. Total Y2K spending is obtained from disclosures made in the first quarter of 1999 and net sales revenue is obtained from the 1998 financial statements.

^b Industry type is based on the strategic role of IT during 1995 to 1998 as determined by a panel of experts surveyed by Chatterjee, Richardson and Zmud (2001): A = automate, I = informate and T = transform.

Table 2
Results of OLS Estimation of Model (1) relating Market Value of Firm Equity to Y2K Spending
(Quarterly Disclosures of Y2K Spending with End of Quarter Market Values)

		1 st qtr. 1999	2 nd qtr. 1999	3 rd qtr. 1999	4 th qtr. 1999	2 nd qtr. 2000 ^a	4 th qtr. 2000 ^a	2 nd qtr. 2001 ^a	4 th qtr. 2001 ^a	4 th qtr. 2002 ^a	4 th qtr. 2003 ^a
variable ^b	predicted sign ^c	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)
<i>Intercept</i>		-0.096 (0.8534)	-1.056 (0.0604)	-2.583 (0.0001)	-2.418 (0.0008)	-1.939 (0.0113)	-1.803 (0.1238)	-0.283 (0.6309)	0.536 (0.3360)	2.055 (<0.0001)	0.324 (0.5064)
<i>Y2K spending_t</i>	+	2.629 (0.2640)	9.585 (0.0160)	8.463 (0.0366)	10.365 (0.0586)	49.228 (0.0001)	82.282 (0.0001)	1.017 (0.4216)	2.590 (0.2940)	5.156 (0.0956)	1.928 (0.3000)
<i>book value_t</i>	+	1.299 (0.0084)	2.210 (0.0001)	3.611 (0.0001)	3.352 (0.0001)	2.491 (0.0001)	1.176 (0.1452)	1.995 (0.0004)	1.273 (0.0094)	-0.764 (0.0418)	0.916 (0.0548)
<i>earnings_t</i>	+	10.166 (0.0001)	11.959 (0.0001)	9.581 (0.0001)	11.416 (0.0001)	5.317 (0.0001)	12.571 (0.0001)	5.549 (0.0001)	7.111 (0.0001)	8.319 (0.0001)	9.063 (0.0001)
<i>R&D spending_t</i>	+	13.420 (0.0001)	11.941 (0.0001)	16.480 (0.0001)	11.759 (0.0001)	17.074 (0.0001)	11.199 (0.0005)	10.186 (0.0001)	12.459 (0.0001)	4.051 (0.0001)	9.792 (0.0001)
<i>sales growth_t</i>		2.191 (0.6031)	3.937 (0.3904)	3.155 (0.5147)	5.785 (0.3401)	-3.061 (0.6816)	3.377 (0.6930)	-3.214 (0.5433)	-12.782 (0.0070)	2.577 (0.2718)	1.018 (0.5351)
<i>assets growth_t</i>		1.196 (0.7053)	-2.758 (0.4531)	-4.749 (0.2161)	-6.046 (0.2178)	6.374 (0.4371)	6.396 (0.2741)	-4.172 (0.1820)	5.940 (0.0269)	-4.045 (0.4061)	1.950 (0.1979)
		N = 421 adj. R ² = 0.446	N = 420 adj. R ² = 0.490	N = 425 adj. R ² = 0.533	N = 407 adj. R ² = 0.449	N = 286 adj. R ² = 0.287	N = 286 adj. R ² = 0.525	N = 292 adj. R ² = 0.359	N = 296 adj. R ² = 0.463	N = 290 adj. R ² = 0.464	N = 272 adj. R ² = 0.645

^a Y2K spending amount for quarters after the 1st quarter of 2000 are the actual amounts of Y2K spending disclosed in the 1st quarter 2000 reports.

^b All variables are scaled by *book value_{t-1}*.

^c All p-values are for one-tailed tests when the coefficients have the predicted signs and for two-tailed tests otherwise.

Table 3
Results of OLS Estimation of Model (2) relating Market Value of Firm Equity to Y2K Spending
(Quarterly Disclosures of Y2K Spending with End of Quarter Market Values)

		1 st qtr. 1999	2 nd qtr. 1999	3 rd qtr. 1999	4 th qtr. 1999	2 nd qtr. 2000 ^a	4 th qtr. 2000 ^a	2 nd qtr. 2001 ^a	4 th qtr. 2001 ^a	4 th qtr. 2002 ^a	4 th qtr. 2003 ^a
variable ^b	predicted sign ^c	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	Coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)
<i>intercept</i>		-0.259 (0.6275)	-1.572 (0.0056)	-2.835 (0.0001)	-2.838 (0.0001)	-2.078 (0.0042)	-1.062 (0.2356)	-0.236 (0.6742)	0.059 (0.9130)	1.392 (0.0028)	-0.197 (0.6970)
<i>type I</i>		0.466 (0.0979)	1.313 (0.0006)	0.741 (0.0338)	1.250 (0.0059)	0.778 (0.0612)	0.673 (0.0850)	1.076 (0.0012)	1.119 (0.0005)	0.718 (0.0047)	0.660 (0.0055)
<i>type T</i>		1.288 (0.0054)	1.156 (0.0115)	0.511 (0.1702)	-0.739 (0.1244)	-2.513 (0.0001)	-2.672 (0.0001)	0.982 (0.0171)	0.768 (0.0416)	0.118 (0.7188)	0.029 (0.9221)
<i>type A * Y2K spending_t</i>	+	-17.901 (0.1278)	11.744 (0.2782)	-9.801 (0.3816)	-8.950 (0.5261)	1.562 (0.4705)	-10.430 (0.6122)	7.729 (0.1688)	7.685 (0.1338)	3.538 (0.2811)	1.572 (0.3991)
<i>type I * Y2K spending_t</i>	+	17.407 (0.0832)	-11.485 (0.1716)	10.717 (0.1976)	0.348 (0.4914)	-5.798 (0.4044)	-4.594 (0.4220)	-19.813 (0.0298)	-20.982 (0.0267)	-5.363 (0.5053)	-7.184 (0.3498)
<i>type T * Y2K spending_t</i>	+	34.281 (0.0198)	13.997 (0.1718)	45.344 (0.0028)	135.178 (0.0001)	220.147 (0.0001)	231.294 (0.0001)	40.577 (0.0066)	42.013 (0.0072)	45.063 (0.0004)	43.613 (0.0001)
<i>book value_t</i>	+	1.111 (0.0202)	1.991 (0.0001)	3.528 (0.0001)	3.254 (0.0001)	2.652 (0.0001)	1.968 (0.0180)	1.540 (0.0030)	1.035 (0.0588)	-0.480 (0.1327)	1.106 (0.0162)
<i>earnings_t</i>	+	9.461 (0.0001)	11.197 (0.0001)	8.9572 (0.0001)	10.402 (0.0001)	6.796 (0.0001)	9.213 (0.0001)	4.728 (0.0001)	6.609 (0.0001)	7.657 (0.0001)	8.398 (0.0001)
<i>R&D spending_t</i>	+	14.274 (0.0001)	12.204 (0.0001)	17.074 (0.0001)	12.003 (0.0001)	15.268 (0.0001)	12.090 (0.0001)	10.97884 (0.0001)	12.672 (0.0001)	4.489 (0.0001)	9.846 (0.0001)
<i>sales growth_t</i>		3.584 (0.3798)	3.118 (0.4907)	2.554 (0.5908)	6.012 (0.2861)	0.857 (0.8928)	-2.688 (0.6719)	-2.851 (0.5992)	-8.725 (0.0541)	2.705 (0.2345)	1.578 (0.3198)
<i>assets growth_t</i>		0.942 (0.7575)	-1.994 (0.5828)	-4.885 (0.1937)	-4.805 (0.2895)	4.966 (0.4757)	3.323 (0.6719)	-0.611 (0.8454)	5.488 (0.0323)	-4.305 (0.3620)	1.7123 (0.2378)
		N = 421 adj. R ² = 0.489	N = 420 adj. R ² = 0.514	N = 425 adj. R ² = 0.558	N = 407 adj. R ² = 0.536	N = 286 adj. R ² = 0.492	N = 286 adj. R ² = 0.750	N = 297 adj. R ² = 0.439	N = 295 adj. R ² = 0.525	N = 290 adj. R ² = 0.511	N = 272 adj. R ² = 0.679

^a Y2K spending amount for quarters after the 1st quarter of 2000 are the actual amounts of Y2K spending disclosed in the 1st quarter 2000 reports.

^b All variables are scaled by *book value_{t-1}*.

^c All p-values are for one-tailed tests when the coefficients have the predicted signs and for two-tailed tests otherwise.

Table 4
Results of OLS Estimation of Model (3) relating Market Value of Firm Equity to Y2K Spending and Industry Median Y2K Spending
(Quarterly Disclosures of Y2K Spending with End of Quarter Market Values)

		1 st qtr. 1999	2 nd qtr. 1999	3 rd qtr. 1999	4 th qtr. 1999	2 nd qtr. 2000 ^a	4 th qtr. 2000 ^a	2 nd qtr. 2001 ^a	4 th qtr. 2001 ^a	4 th qtr. 2002 ^a	4 th qtr. 2003 ^a
variable ^b	predicted sign ^c	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)
<i>intercept</i>		0.637 (0.4312)	0.494 (0.6106)	-1.123 (0.1843)	-2.293 (0.0149)	-1.668 (0.1180)	0.099 (0.9336)	-0.071 (0.9342)	0.022 (0.9793)	0.870 (0.1862)	-1.142 (0.0977)
<i>type I</i>		0.912 (0.3740)	0.502 (0.6667)	-0.018 (0.9868)	-0.093 (0.9237)	0.563 (0.6774)	0.226 (0.8613)	0.458 (0.6533)	0.517 (0.5939)	-0.104 (0.8911)	0.773 (0.2803)
<i>type T</i>		0.158 (0.8769)	-1.697 (0.1203)	-1.797 (0.0703)	-1.938 (0.1176)	-1.152 (0.4515)	-0.462 (0.7522)	0.592 (0.6153)	0.146 (0.8956)	-0.001 (0.9998)	0.556 (0.4940)
<i>type A * Y2K spending_t</i>	+	13.614 (0.0654)	16.660 (0.0320)	-1.100 (0.4621)	-5.040 (0.3668)	5.081 (0.4079)	-1.773 (0.4663)	8.216 (0.1571)	7.693 (0.1347)	2.068 (0.7393)	-1.283 (0.8387)
<i>type I * Y2K spending_t</i>	+	12.521 (0.0836)	-15.631 (0.1005)	2.612 (0.2100)	-5.244 (0.3753)	-10.928 (0.3290)	-11.221 (0.3178)	-20.855 (0.0260)	-22.403 (0.0200)	-5.304 (0.5158)	-5.127 (0.5134)
<i>type T * Y2K spending_t</i>	+	28.815 (0.0147)	1.241 (0.2342)	30.773 (0.0144)	125.575 (0.0001)	219.597 (0.0001)	222.476 (0.0001)	39.581 (0.0110)	37.156 (0.0140)	43.827 (0.0004)	44.717 (0.0002)
<i>type A industry Y2K spending</i>	-	-89.481 (0.1418)	-193.822 (0.0055)	-165.955 (0.0027)	-59.082 (0.1854)	-46.344 (0.5621)	-119.992 (0.1179)	-28.495 (0.6293)	7.854 (0.8868)	49.068 (0.2781)	80.990 (0.0611)
<i>type I industry Y2K spending</i>	-	131.563 (0.2864)	103.360 (0.2844)	87.290 (0.3292)	121.981 (0.1291)	126.879 (0.2904)	50.436 (0.6602)	56.503 (0.5202)	55.753 (0.5079)	71.415 (0.2842)	-16.194 (0.4002)
<i>type T industry Y2K spending</i>	-	104.896 (0.3368)	260.791 (0.0034)	210.600 (0.0044)	109.172 (0.2528)	-82.546 (0.4655)	-116.956 (0.2826)	34.628 (0.6927)	45.318 (0.5812)	-4.581 (0.4772)	-59.888 (0.1656)
<i>book value_t</i>	+	1.094 (0.0057)	1.820 (0.0002)	3.455 (0.0001)	3.275 (0.0001)	2.705 (0.0001)	2.033 (0.0066)	1.540 (0.0016)	0.987 (0.0370)	-0.452 (0.2898)	1.241 (0.0037)
<i>earnings_t</i>	+	9.599 (0.0001)	11.597 (0.0001)	9.354 (0.0001)	10.536 (0.0001)	6.840 (0.0001)	9.000 (0.0001)	4.724 (0.0001)	6.708 (0.0001)	7.652 (0.0001)	8.356 (0.0001)
<i>R&D spending_t</i>	+	14.386 (0.0001)	13.545 (0.0001)	17.846 (0.0001)	11.705 (0.0001)	14.899 (0.0001)	12.921 (0.0001)	11.003 (0.0001)	12.316 (0.0001)	4.041 (0.0001)	9.226 (0.0001)
<i>sales growth_t</i>		4.090 (0.3216)	2.574 (0.5682)	2.387 (0.6126)	6.654 (0.2393)	0.017 (0.9979)	-5.451 (0.3893)	-3.112 (0.5701)	-9.046 (0.0468)	3.041 (0.1807)	1.465 (0.3540)
<i>assets growth_t</i>		1.005 (0.7425)	-1.237 (0.7315)	-4.322 (0.2466)	-4.791 (0.2921)	5.738 (0.4121)	4.145 (0.3266)	-0.485 (0.8778)	5.683 (0.0274)	-5.170 (0.2736)	1.147 (0.4336)
		N = 421 adj. R ² = 0.488	N = 420 adj. R ² = 0.522	N = 425 adj. R ² = 0.565	N = 407 adj. R ² = 0.535	N = 286 adj. R ² = 0.493	N = 286 adj. R ² = 0.758	N = 297 adj. R ² = 0.434	N = 294 adj. R ² = 0.523	N = 289 adj. R ² = 0.519	N = 271 adj. R ² = 0.682

^a Y2K spending amount for quarters after the 1st quarter of 2000 are the actual amounts of Y2K spending disclosed in the 1st quarter 2000 reports.

^b All variables are scaled by *book value_{t-1}*.

^c All p-values are for one-tailed tests when the coefficients have the predicted signs and for two-tailed tests otherwise.

Table 5
Panel A - Results of 3SLS Estimation of Equation 1 of Model (4) relating
Market Value of Firm Equity to Y2K Spending and Industry Median Y2K Spending
(Quarterly Disclosures of Y2K Spending with End of Quarter Market Values)

variable ^b	predicted sign ^c	1 st qtr. 1999	2 nd qtr. 1999	3 rd qtr. 1999	4 th qtr. 1999	2 nd qtr. 2000 ^a	4 th qtr. 2000 ^a	2 nd qtr. 2001 ^a	4 th qtr. 2001 ^a	4 th qtr. 2002 ^a	4 th qtr. 2003 ^a
		coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)
<i>intercept</i>		0.938 (0.2645)	-0.423 (0.6678)	-0.9566 (0.2729)	-2.250 (0.0280)	-1.282 (0.2455)	0.230 (0.8510)	0.160 (0.8555)	-0.787 (0.3653)	0.967 (0.1781)	-1.197 (0.0835)
<i>type I</i>		-1.157 (0.2769)	0.661 (0.5800)	0.398 (0.7282)	-0.076 (0.9410)	-1.823 (0.2030)	-0.326 (0.7965)	0.261 (0.7066)	0.108 (0.9112)	0.139 (0.8720)	1.058 (0.1693)
<i>type T</i>		-0.096 (0.9252)	-1.649 (0.1356)	-1.623 (0.1071)	-0.975 (0.4484)	-1.832 (0.2331)	-0.701 (0.6059)	0.261 (0.8191)	0.307 (0.7774)	-0.042 (0.9629)	0.671 (0.4043)
<i>type A * Y2K spending_t</i>	+	-15.598 (0.1561)	5.373 (0.3384)	-11.794 (0.2432)	-14.989 (0.2704)	-9.241 (0.3671)	-10.770 (0.3636)	4.582 (0.3710)	13.335 (0.1727)	-7.584 (0.3388)	-3.520 (0.4108)
<i>type I * Y2K spending_t</i>	+	24.953 (0.0001)	26.523 (0.0001)	17.441 (0.0061)	-4.926 (0.3059)	49.124 (0.0001)	27.634 (0.0059)	14.482 (0.0184)	9.830 (0.0724)	-1.579 (0.3872)	8.219 (0.0539)
<i>type T * Y2K spending_t</i>	+	33.953 (0.0004)	33.140 (0.0014)	34.453 (0.0015)	88.173 (0.0001)	276.991 (0.0001)	90.458 (0.0004)	81.192 (0.0001)	77.660 (0.0001)	47.549 (0.0001)	59.786 (0.0001)
<i>type A * industry Y2K spending</i>	-	-94.542 (0.0581)	-183.848 (0.0072)	-171.511 (0.0016)	-62.700 (0.1678)	-42.033 (0.3009)	-121.339 (0.0443)	-15.933 (0.3908)	16.106 (0.7677)	57.932 (0.2243)	104.297 (0.0153)
<i>type I * industry Y2K spending</i>	-	132.125 (0.1454)	119.568 (0.2160)	91.723 (0.3064)	118.908 (0.1433)	155.28 (0.2093)	44.817 (0.6804)	79.202 (0.3651)	58.439 (0.4867)	45.597 (0.5409)	-58.930 (0.3857)
<i>type T * industry Y2K spending</i>	-	101.826 (0.1770)	200.188 (0.0222)	173.405 (0.0171)	72.872 (0.4408)	-94.111 (0.2004)	60.064 (0.5581)	8.770 (0.9165)	27.704 (0.7280)	-11.037 (0.4345)	-87.429 (0.0722)
<i>book value_t</i>	+	0.873 (0.0368)	1.951 (0.0001)	3.476 (0.0001)	3.260 (0.0001)	2.519 (0.0001)	2.179 (0.0048)	1.437 (0.0026)	1.683 (0.0009)	-0.494 (0.1358)	1.123 (0.0074)
<i>earnings_t</i>	+	9.942 (0.0001)	11.769 (0.0001)	10.344 (0.0001)	12.160 (0.0001)	6.415 (0.0001)	8.557 (0.0001)	4.305 (0.0001)	5.744 (0.0001)	7.796 (0.0001)	8.049 (0.0001)
<i>R&D spending_t</i>	+	14.458 (0.0001)	13.144 (0.0001)	17.547 (0.0001)	11.475 (0.0001)	15.672 (0.0001)	13.646 (0.0001)	10.033 (0.0001)	12.259 (0.0001)	4.482 (0.0001)	9.219 (0.0001)
<i>sales growth_t</i>		3.2708 (0.3783)	2.772 (0.5432)	1.740 (0.7134)	5.700 (0.3166)	0.071 (0.9917)	-10.539 (0.0803)	0.085 (0.9881)	-3.480 (0.5504)	3.375 (0.1452)	0.495 (0.8149)
<i>assets growth_t</i>		1.991 (0.5201)	-1.278 (0.7217)	-3.767 (0.3106)	-4.129 (0.3603)	7.116 (0.3326)	4.026 (0.3140)	-1.130 (0.7357)	1.766 (0.6474)	-5.780 (0.2268)	1.700 (0.2623)

^a Y2K spending amount for quarters after the 1st quarter of 2000 are the actual amounts of Y2K spending disclosed in the 1st quarter 2000 reports.

^b All variables are scaled by *book value_{t-1}*.

^c All p-values are for one-tailed tests when the coefficients have the predicted signs and for two-tailed tests otherwise.

Table 5
Panel B - Results of 3SLS Estimation of Equation 2 of Model (4) relating
Market Value of Firm Equity to Y2K Spending and Industry Median Y2K Spending
(Quarterly Disclosures of Y2K Spending with End of Quarter Market Values)

variable ^b	predicted sign ^c	1 st qtr. 1999	2 nd qtr. 1999	3 rd qtr. 1999	4 th qtr. 1999	2 nd qtr. 2000 ^a	4 th qtr. 2000 ^a	2 nd qtr. 2001 ^a	4 th qtr. 2001 ^a	4 th qtr. 2002 ^a	4 th qtr. 2003 ^a
		coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)	coeff. (p-value)
<i>intercept</i>		0.0029 (0.3099)	0.0037 (0.1679)	0.0064 (0.0211)	0.0077 (0.0006)	0.0037 (0.1685)	0.0054 (0.0476)	0.0030 (0.4730)	0.0065 (0.1049)	0.0064 (0.1133)	0.0031 (0.4023)
<i>type I</i>		-0.0014 (0.7092)	0.0020 (0.5052)	0.0003 (0.9316)	-0.0001 (0.9950)	-0.0009 (0.7112)	-0.0010 (0.6621)	-0.0054 (0.0956)	-0.0055 (0.0865)	-0.0041 (0.2180)	-0.0027 (0.4408)
<i>type T</i>		0.0075 (0.0463)	0.0111 (0.0027)	0.0087 (0.0239)	0.0056 (0.0714)	0.0045 (0.1409)	0.0044 (0.1626)	0.0008 (0.8543)	-0.0002 (0.9623)	-0.0024 (0.5904)	-0.0008 (0.8532)
<i>market value_t</i>	+	0.0020 (0.0003)	0.0010 (0.0207)	0.0013 (0.0014)	0.0007 (0.0183)	0.0005 (0.1748)	0.0007 (0.0717)	0.0021 (0.0095)	0.0018 (0.0113)	0.0022 (0.0135)	0.0024 (0.0018)
<i>net sales revenue_t</i>	+	0.0012 (0.0010)	0.0012 (0.0002)	0.0013 (0.0004)	0.0011 (0.0002)	0.0018 (0.0001)	0.0016 (0.0001)	0.0019 (0.0001)	0.0014 (0.0020)	0.0015 (0.0015)	0.0014 (0.0064)
<i>fixed assets_t</i>	+	0.0016 (0.0476)	0.0028 (0.0007)	0.0010 (0.1626)	0.0010 (0.1008)	0.0023 (0.0231)	0.0013 (0.1207)	0.0023 (0.0573)	0.0014 (0.1588)	0.0022 (0.0727)	0.0030 (0.0095)
<i>number of employees_t</i>	+	0.2373 (0.0001)	0.2206 (0.0001)	0.2175 (0.0001)	0.1585 (0.0001)	0.0882 (0.0199)	0.0735 (0.0393)	0.1134 (0.0006)	0.1322 (0.0001)	0.0640 (0.1894)	0.0386 (0.3138)
<i>sales growth_t</i>		-0.0948 (0.0432)	-0.1135 (0.0114)	-0.1043 (0.0304)	-0.0769 (0.0645)	-0.0695 (0.0899)	-0.0536 (0.1781)	-0.1655 (0.0075)	-0.2723 (0.0001)	0.0201 (0.5527)	0.0941 (0.0003)
<i>assets growth_t</i>		0.0096 (0.7416)	0.0213 (0.4709)	0.0117 (0.7080)	0.0216 (0.4467)	-0.0189 (0.6575)	0.0024 (0.9281)	0.0487 (0.1723)	0.1433 (0.0001)	-0.0319 (0.6467)	-0.0427 (0.0462)

^a Y2K spending amount for quarters after the 1st quarter of 2000 are the actual amounts of Y2K spending disclosed in the 1st quarter 2000 reports.

^b All variables are scaled by *book value_{t-1}*.

^c All p-values are for one-tailed tests when the coefficients have the predicted signs and for two-tailed tests otherwise.

Table 6
Panel A - Tests of Coefficients on Y2K Spending for Automate (A), Informate (I) and Transform (T) firms based on the Model (2) Estimation in Table 3

	1 st qtr. 1999	2 nd qtr. 1999	3 rd qtr. 1999	4 th qtr. 1999	2 nd qtr. 2000	4 th qtr. 2000	2 nd qtr. 2001	4 th qtr. 2001	4 th qtr. 2002	4 th qtr. 2003
Tests of Coefficients	(p-value)	(p-value)	(p-value)	(p-value)	(p-value)	(p-value)	(p-value)	(p-value)	(p-value)	(p-value)
I ≥ A	0.9176	0.9621	0.8755	0.2374	0.7125	0.1863	0.0791	0.0494	0.7313	0.2274
T ≥ A	0.0684	0.0104	0.0005	0.0001	0.0001	0.0001	0.0007	0.0003	0.0001	0.0001
T ≥ I	0.0956	0.0251	0.0033	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Panel B - Tests of Coefficients on Y2K Spending for Automate (A), Informate (I) and Transform (T) firms based on the Model (4) Estimation in Table 5

	1 st qtr. 1999	2 nd qtr. 1999	3 rd qtr. 1999	4 th qtr. 1999	2 nd qtr. 2000	4 th qtr. 2000	2 nd qtr. 2001	4 th qtr. 2001	4 th qtr. 2002	4 th qtr. 2003
Tests of Coefficients	(p-value)	(p-value)	(p-value)	(p-value)	(p-value)	(p-value)	(p-value)	(p-value)	(p-value)	(p-value)
I ≥ A	0.0444	0.1253	0.0738	0.2562	0.6266	0.6063	0.3060	0.1035	0.3468	0.7558
T ≥ A	0.0001	0.0001	0.0001	0.0001	0.0001	0.0585	0.0023	0.0001	0.0028	0.0034
T ≥ I	0.0005	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Table 7
Results of OLS Estimation of Prediction Models relating Earnings-based Performance Measures
in 2000 to 2003 (pooled) to Y2K Spending in 1999

Variable	predicted Sign	(1) <u>Net income</u> Total assets coeff. (p-value ^a)	(2) <u>Net income</u> Sales coeff. (p-value ^a)	(3) <u>COGS</u> Sales coeff. (p-value ^a)	(4) <u>SG&A cost</u> Sales coeff. (p-value ^a)	(5) <u>Sales</u> Total assets coeff. (p-value ^a)	(6) <u>COGS</u> Inventory coeff. (p-value ^a)	(7) <u>Sales</u> Net PP&E coeff. (p-value ^a)
<i>Intercept</i>		1.752 (0.1933)	0.031 (0.0370)	0.096 (0.0001)	0.010 (0.3127)	0.069 (0.6778)	2.481 (0.4817)	-0.648 (0.2961)
<i>type I</i>		0.213 (0.5161)	-0.023 (0.1912)	-0.012 (0.3222)	0.001 (0.7635)	0.034 (0.5356)	-0.002 (0.5143)	0.2375 (0.7254)
<i>type T</i>		0.449 (0.3792)	0.011 (0.5398)	-0.025 (0.3291)	0.001 (0.2610)	-0.047 (0.4101)	-6.744 (0.2730)	-0.919 (0.4739)
<i>type A * Y2K spending_t / total assets_t</i>	+ except columns (3) and (4) - for columns (3) and (4)	-0.512 (0.0001)	-0.003 (0.6014)	0.001 (0.7975)	0.005 (0.5042)	-0.001 (0.7620)	0.485 (0.0195)	-0.001 (0.9510)
<i>type I * Y2K spending_t / total assets_t</i>	+ except columns (3) and (4) - for columns (3) and (4)	0.021 (0.0003)	0.008 (0.0001)	-0.003 (0.0336)	0.005 (0.1603)	-0.001 (0.6223)	0.1151 (0.2422)	0.001 (0.4342)
<i>type T*Y2K spending_t / total assets_t</i>	+ except columns (3) and (4) - for columns (3) and (4)	3.487 (0.0085)	0.024 (0.0811)	-0.039 (0.0005)	0.006 (0.2539)	0.075 (0.1121)	0.3474 (0.0002)	0.001 (0.2630)
<i>performance measure in 1999_t</i>	+	0.383 (0.0016)	0.193 (0.1168)	0.983 (0.0001)	1.258 (0.0001)	0.671 (0.0001)	0.825 (0.0045)	1.048 (0.0001)
<i>performance measure in 1998_t</i>		0.130 (0.1623)	0.128 (0.2642)	-0.088 (0.5143)	-0.319 (0.001)	0.197 (0.0221)	-0.078 (0.1623)	0.049 (0.2778)
		Avg. N = 405 Adj. R ² = 0.671	Avg. N = 402 Adj. R ² = 0.244	Avg. N = 407 Adj. R ² = 0.843	Avg. N = 312 Adj. R ² = 0.896	Avg. N = 401 Adj. R ² = 0.884	Avg. N = 351 Adj. R ² = 0.942	Avg. N = 396 Adj. R ² = 0.914

^a p-values are for one-tailed tests when the coefficients have the predicted signs and for two-tailed tests otherwise.