Value Implications of Relative Investments in Information Technology

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Abstract

In this study, we investigate how divergence from the industry level of investment in information technology (IT) affects firm value. Theoretical arguments suggest that greater investment in IT relative to industry peers may positively affect firm value and that smaller relative investment may negatively affect firm value, but these arguments have not been empirically tested. We perform our analysis using data obtained from disclosures of IT spending in preparation for the year 2000. During this period, firms had options to replace legacy applications with enterprise applications that could improve internal business processes and enhance external coordination with other members of the industry value chain. We document a positive relation between firm value and the amount by which a firm's IT spending in preparation for the year 2000 exceeded the industry median level and a negative relation between firm value and the amount by which the firm's IT spending lagged behind the industry median level. We also find a positive relation between firm value and the industry median level of IT spending, consistent with value creation through the development of IT infrastructure for the industry value chain.

Keywords: Information Technology, Relative Investment, Valuation, Y2K, Enterprise Systems, Productivity Paradox

1. Introduction

Within and across industries, firms differ along many dimensions including internal processes and resources and external relations with suppliers, customers, and other firms and agencies. Clemons and Row (1991) observed that while acquiring information technology (IT) that could be easily replicated would not by itself provide a sustainable competitive advantage, new IT could add value if it complemented resource or structural advantages of a firm. This implies that firms with greater opportunities to leverage resource or structural advantages by investing in new IT would spend more than their industry peers and firms that were unusually disadvantaged would spend less than their industry peers on new IT. Clemons and Row (1991) also noted that "above average profits are the result of having acquired (or produced) the resources necessary to implement a particular strategy at less than the true current economic value of those resources." Since the stock price increases with the firm's ability to earn above average profits, firm value would be positively related to greater investment in IT that leveraged competitive advantages over industry peers and negatively related to a shortfall in investment in new IT due to competitive disadvantages. While previous empirical research has investigated relations between firm value and levels of IT spending or IT capital, it has not considered the question of how divergence from the industry level of investment in new IT affects firm value.

To empirically evaluate how relative investment in IT affects firm value, we relate firm value to differences in IT expenditures made in preparation for Y2K. At first glance, it may appear that Y2K expenditures would have a negative relation with firm value. Mere remediation of legacy systems drained resources and did not provide any change in business functionality. However, if Y2K made it easier to justify expenditures on enterprise applications to replace non-Y2K-compliant legacy systems, then Y2K expenditures may represent investments in IT that

could provide competitive advantage. 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." At SunAmerica (June 7, 1999 press release), Scott Robinson, senior vice president and controller, said, "We launched our systems integration strategy to prepare for Y2K issues, but compliance wasn't our sole concern. Sun also needed to realize increased efficiencies enterprise-wide, especially within the accounting areas and our customer service center."

By implementing enterprise systems, including enterprise resource planning (ERP), supply chain management (SCM), and customer relationship management (CRM) applications, firms use IT to accommodate modifications to internal business processes and external relations with suppliers and customers that may provide competitive advantage. Porter (1999) remarked:

> *The essential core of strategy is cross-functional or cross-activity integration. It's the capacity to link and integrate activities across the whole value chain. To have a sustainable advantage, a company has to integrate across many activities to create a unique positioning involving trade-offs with rivals.*

Greater Y2K spending than industry peers may reflect greater investment in enterprise systems that are used to cultivate competitive advantage. Therefore, we test for a positive relation between firm value and Y2K spending relative to industry peers.

While obtaining competitive advantage relative to industry peers may create individual firm value, improving the overall efficiency and effectiveness of the industry supply chain may create collective value for participants in the industry. In this vein, higher Y2K spending across firms in an industry may reflect development of an industry-wide IT infrastructure that enhances

coordination throughout the supply chain and enables development of new goods or markets. Liebman (1999) observed:

> *Nearly all drug and medical-supply companies have turned to enterprise resource planning packages, e-commerce systems, and consolidation of network and systems infrastructure to drive costs out of their business processes. They're also using information services to help their customers improve their own cost efficiencies – creating additional value for users and building stronger market relationships.*

We test whether firm value varied positively with the median level of Y2K spending by firms in an industry.

The Y2K case offers an unusual opportunity to examine cross-sectional differences in IT investment because the Securities and Exchange Commission (SEC) required companies to report their total spending on Y2K preparations, including amounts spent on new IT. An interpretative guideline issued by the SEC during June of 1998 mandated disclosure of planned total spending on Y2K initiatives including amounts spent to remediate existing systems and amounts spent to purchase new IT if acquisitions were accelerated to achieve Y2K compliance. This is the first time that firms have been required to separately disclose information about IT costs in publicly distributed financial reports. The data we use in our analysis were extracted directly from Y2K disclosures made in annual and quarterly filings with the SEC.

The remainder of this paper proceeds as follows. In section 2, we review empirical studies that relate productivity or firm value to investment in IT. In section 3, we develop our hypotheses. In section 4, we specify the empirical models. In section 5, we describe the data and present the results of estimating the models. In section 6, we provide concluding comments.

2. IT Productivity Paradox

The performance impact of IT has been evaluated at macroeconomic, industry, and firm levels. Observed performance has been measured in terms of productivity, profitability, market

share, and intermediate performance measures. Expected long-term performance has been measured using stock prices. The IT inputs have been depicted in terms of specific investments in IT, the level of periodic IT spending, and the estimated value of IT assets. Data on IT inputs has typically been obtained second-hand through reports or surveys gathered by information intermediaries. Inferences drawn from various studies have been sensitive to the specification of the performance-IT relationship and the data used. Results of these studies may also be time-sensitive as performance-IT relations have changed with the rapid development of new technology (Clemons, Reddi, and Row 1993). In this section, we review these prior studies to motivate our research. We organize this brief review by the type of performance measure that was used in the analysis.

Productivity or Profitability

Macro-level studies conducted during the 1980s and early 1990s (Baily and Chakrabarti 1988, Roach 1987, 1991) found negative relations between productivity and IT investment. Roach (1991), for example, observed that while the capital investment per information worker had increased between the mid-1970s and 1986, output per information worker decreased by 6.6%. Industry-level studies of productivity and IT capital produced similarly disturbing results. Morrison and Berndt (1990) found that each dollar spent on IT capital increased marginal output by only 80 cents and Berndt and Morrison (1991) found a statistically significant negative relationship between productivity growth and high-tech capital intensity.

At the firm level, Cron and Sobol (1983) looked at 138 medical supply wholesalers and found that high IT investment was associated with either very good or very poor firm performance. Harris and Katz (1988), using data for 40 insurance companies, found weak positive relations between investments in IT and various performance ratios. Strassman (1990),

using survey information for 38 companies, found no correlation between IT ratios and performance. Loveman (1994), using the Management Productivity and Information Technology (MPIT) data collected by the Strategic Planning Insitutute for sixty strategic business units at 20 firms during the 1978-1982 period, found that investments in IT showed no contribution to total output.

This inability of empirical research to document a positive impact on productivity of investments in IT was dubbed as the productivity paradox.[1] Since there were data problems with the macro-level and industry-level studies (Siegal and Griliches 1991) and the firm-level analyses relied on small samples concentrated in select industries, Brynjolfsson and Hitt (1996) observed a need to analyze firm-level data for a large cross-section of firms. Using data collected by the International Data Group (IDG) in a survey that targets *Fortune 500* manufacturing and *Fortune 500* service firms, they estimated production functions and evaluated the marginal products of IT and other capital. In their analysis, the measure of IT capital was the market value of central processors as estimated by the respondents plus an estimate of the market value of PCs and terminals based on the number of PCs and terminals the company reported to be in use. They cleared up the IT productivity paradox by comparing the marginal returns to IT capital with the marginal returns to other capital finding that the marginal returns to IT capital were much higher.

A recent study by Bharadwaj (2000) takes a different tact using information from the *InformationWeek* surveys for 1991 through 1994. Bharadwaj identifies 56 firms that were ranked as IT leaders by *InformationWeek* during two or more of these four years. Using a

[1] Weill (1992), using data from 33 strategic business units in the valve manufacturing industry, did find some positive impacts for investments in certain categories of IT (such as data processing) but no improvements for other categories (such as sales support). However, Weill's research had limited external validity because the units analyzed had just $2 billion in total sales.

matched sample approach, she compares various accounting measures, including return on assets, profit margin on sales, and expense to sales ratios, for the IT leader and control groups. Bharadwaj argues that the *InformationWeek* rankings provide information about the company's overall success in their IT programs, not only the money spent on IT. Her findings indicate that the IT leaders achieve better return on assets and profit margin on sales. She expresses some concern that the IT leaders sample may be tainted by the company's performance (that the selection of IT leaders is biased by their current operating performance).

Intermediate Performance Measures

Early research linking intermediate performance measures to IT investments was more successful. Banker and Kaufmann (1988) and Dos Santos and Peffers (1995) found evidence of positive impacts of ATM adoption on banks' market share. Dos Santos and Peffers also found income benefits that were sustained for a long period of time. Banker and Johnston (1994) found evidence of a positive impact of IT on market share in their studies of computerized reservation systems in the airline industry. Similarly, Kaufmann and Kriebel (1988) found evidence linking treasury management workstations to increases in demand balances. Banker et al. (1990) found direct impact of IT on users in their study of IT deployment at Hardee's. Kekre and Mukhopadhyay (1992) found that electronic data interchange systems had a positive influence on quality improvement and inventory reduction programs.

The fact that research was able to link specific investments in IT to specific performance parameters led Barua, Kriebel and Mukhopadhyay (1995) to reexamine the data used by Loveman (1994). They observed that firm-level output measures such as net income aggregate the impact of IT over many applications and activities. Based on the value-chain framework of Porter (1985), they examined first-order effects on operational level variables, such as capacity

utilization, inventory turnover, and quality. They found significant positive effects of IT for three of the five measures that they looked at.

Market Value Measures

Relations between performance and IT may be difficult to detect using contemporaneous accounting-based output measures because accounting tracks short-term performance whereas benefits from IT investments may be realized over the long-term (Brynjolfsson 1993). Since stock prices impound investor expectations about future earnings, they may be used to measure the expected influence of IT investments on long-term performance. Dos Santos, Peffers, and Mauer (1993) used an event study methodology to measure the impact on stock returns of announcements of IT investments. Because announcements of IT investments are rare and the events study methodology requires that the data be cleansed for contemporaneous announcements, Dos Santos et al. obtained a final sample of 97 firms. They separated the sample announcements into three categories based on whether the investment was considered innovative for the industry. Announcements of innovative investments made up one group, announcements of investments that clearly replicated IT used by other firms in the industry made up a second group, and announcements that could not be classified as either innovative or replicative made up a third group. Dos Santos et al. (1993) found a positive stock price effect for the announcements in the innovative group but not for the other announcements. This result is consistent with a first-mover advantage to IT innovators and with IT resources not being constrained in the sense that they may be easily replicated.

Recent research has related information in stock prices to measures of IT intensity. Bharadwaj, Bharadwaj, and Konsynski (1999) related Tobin's *q*, the ratio of the market value of firm assets to their accounting value, to the level of IT spending obtained from the

InformationWeek survey of 500 firms. The IT spending figure represents the corporate-wide capital and operating budget for information systems and services (staff, hardware, software and data communications). The spending figure does not include telecommunications hardware and software costs and spending on IT by departments other than the IS department. Bharadwaj et al. (1999) found a strong positive relation between *q* and the IT spending variable.

Brynjolfsson and Yang (1999) derived an economic model that uses the market value of the firm to estimate the intangible costs and benefits of IT capital. They obtained data on computer capital from the Computer Intelligence Infocorp database that details IT spending by site for *Fortune 1000* companies. The database is compiled from telephone surveys that detail the ownership of computers and related products (central processors, personal computers and peripherals). The data does not include all types of information processing or communication equipment. They found that each dollar of computer capital installed by a firm was associated with an increase of 5 to 20 dollars in the financial market valuation. This documented a *new IT productivity paradox* of the marginal value impact of IT being far in excess of the marginal cost. Brynjolfsson and Yang (1999) attributed the high valuation multiples to intangible assets created by organizational transformations that accompany computer investments.

Brynjolfsson, Hitt, and Yang (2000) provided additional analysis and evidence with respect to the high valuation multiples observed by Brynjolfsson and Yang (1999). They explicitly linked high market capitalization values for IT to investments in organizational assets, including greater use of teams, broader decision making authority, and increased worker training. They found that firms that are high IT users are more likely to adapt these work practices, that firm value increases with this cluster of organizational characteristics, and that in firms that have

these organizational characteristics, computer assets have a disproportionately higher market valuation.

3. Research Hypotheses

Data problems have been a major deterrent to work investigating performance-IT relations. Many early studies had limited external validity because they were based on observations for a small set of firms, often in the same industry. Macro-level and industry-level studies were hampered by difficulties in obtaining either proper output or proper input measures. More recent studies have utilized survey data to measure IT inputs. Researchers conducting these studies have cautioned that survey data is subject to self-selection and self-reporting problems and that the surveys are limited in their coverage of IT spending or IT capital. Surveys of IT spending, for example, may cover central spending but not individual business unit spending and surveys of IT capital may cover computers and peripherals but not software, communications, and embedded applications. The Y2K case provides an opportunity to obtain another perspective on firm performance and IT investment because Y2K spending information was gathered and disclosed through the rigorous financial reporting process and the reported amounts cover Y2K-related spending on hardware and applications throughout the firm.

Previous research has not investigated the effects of relative investments in IT (within industries) on firm value and recent research has not investigated the effects of broader industry investment in IT. These intra-industry and inter-industry effects are particularly important because IT may only affect firm value if it affects the competitive profile of the industry (division of the industry pie) or if it enables creation of value for the industry as a whole (size of the industry pie). The Y2K case provides an exceptional opportunity to investigate relative investments in IT because of the migration from legacy systems to enterprise systems firms made

in preparation for Y2K. 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 (SCM), 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 applications budgets.

A variety of sources link Y2K preparation to implementation of enterprise applications. In a survey conducted by Benchmarking Partners of Fortune 500 firms that implemented enterprise systems, year 2000 concerns topped the list of technology motivations for 42 per cent of the sample (Manchester 1999). 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." Press releases by individual firms cite 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 1requirements," 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).

In developing our empirical analysis, we use total planned Y2K spending (incurred plus projected) as a measure of IT investment during the Y2K preparation period. Since the Y2K spending disclosures do not distinguish between remediation costs for in-place IT and investments in new enterprise systems, we provide empirical validation of a positive relation between Y2K spending and investment in enterprise systems. The data for our study were drawn

from Y2K disclosures made by *Fortune 1000* companies. SAP AG was the premier provider of enterprise resource planning systems to *Fortune 1000* companies during the Y2K period. We performed a logit analysis of *Fortune 1000* companies based on whether they were included in SAP's best customer list at the SAP AG website in early 2000. The dependent variable was set at one if on the SAP list and zero otherwise. The independent variable was Y2K spending intensity, defined as planned Y2K spending divided by sales revenue. There was a significantly positive relation (p-value = 0.0040) between being on the SAP list and the Y2K spending intensity, supporting the claim that Y2K spending is informative about investment in enterprise systems during the Y2K period.

The publicity and the specter of potential disaster associated with Y2K raised concern about Y2K solutions to top management levels of large corporations. The convergence of the need to achieve Y2K compliance with the opportunity to invest in enterprise systems provided an opportunity for all large firms to make IT investment decisions that could affect their competitive status. Buchner (1999) observed:

> *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.*

Since Y2K provided a justification to invest in enterprise systems and SEC rules mandated disclosure of Y2K costs (including expenditures on new IT accelerated to achieve Y2K compliance), the Y2K period makes an ideal setting for evaluating the effects on firm value of differences across firms in IT investment. Because relations between firm value and the amounts by which IT investment exceeds or falls short of industry peers are not necessarily symmetrical,

we make separate hypotheses for positive and negative differences from the industry level of Y2K spending.

Hypothesis 1a: Firm value was positively related to the amount by which the level of a firm's Y2K spending exceeded that of its industry peers.

Hypothesis 1b: Firm value was negatively related to the amount by which the level of a firm's Y2K spending lagged that of its industry peers.

In addition to affecting the division of value within an industry, investments made in enterprise systems, including ERP, SCM, and CRM applications, may create value for all firms in an industry by helping build an IT infrastructure that increases efficiency in the supply chain and provides opportunities to develop new markets. Whiting (1999) described IT-enabled changes in the chemical industry:

> *IT is creating opportunities for chemical companies, such as the ability to leverage new supply-chain management systems to bring chemical makers closer to their customers… To that end, a number of companies are in the midst of large domestic and even global implementations of ERP systems. Chemical manufacturers are taking steps to implement supply-chain management technology, both as a means of controlling cost and of adding value to increasingly commoditized products.*

Our second hypothesis considers the extent to which IT investment across firms in an industry group during the Y2K preparation period affected the value of all firms in these groups.

Hypothesis 2: Firm value was positively related to the industry level of Y2K spending.

We would not find a positive relation between firm value and Y2K spending if Y2K spending were deemed to be a non-productive drag on firm resources. In fact, to the extent that the amount of planned Y2K spending represented an unrecorded liability, there would be a negative relation between firm value and Y2K spending (Amir 1993). Thus, our tests of hypotheses 1a, 1b, and 2 will also provide evidence whether Y2K spending was viewed as an investment in IT rather than a burden on firm profitability.

An unexplored issue in the empirical literature on IT productivity is whether IT has a greater impact at the industry level or at the individual firm level. This question is particularly interesting in the Y2K setting because enterprise applications may affect both internal and external interactions. In addition to the fact that innovative IT may be replicated by other firms (reducing the ability of individual firms to make relative gains using IT), adoption of enterprise systems by firms up and down the supply chain contributes to an IT infrastructure that may be used to create value for all firms in an industry. Porter (1999) observed the importance of creating value at the industry level, "Increasingly, leading companies won't just optimize within an industry, they will actually reshape and redefine their industry." Since Y2K forced virtually all companies to inventory and evaluate their IT resources, it provided an opportunity for a concerted effort by firms within specific industries to upgrade the IT that powers information-processing along industry value chains. We test a hypothesis that firm value was affected more by the industry level of Y2K spending than it was by relative Y2K spending.

Hypothesis 3: An observed positive relation between firm value and the industry level of Y2K spending is greater in magnitude than an observed positive relation between firm value and relative Y2K spending (the amount by which Y2K spending exceeds the industry level).

4. Empirical Model

Our aim is to measure the association between firm value and relative investment in IT made during the Y2K preparation period. We cannot use the short window event study methodology employed by Dos Santos, Peffers, and Mauer (1993) because information about Y2K preparations was not discretely disclosed at identifiable dates.[2] The market capitalization models, used by Bharadwaj et al. (1999) and Brynjolfsson and Yang (1999), measure the relation

[2] 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.

of the market value of the firm's assets to their accounting book value but do not incorporate information about the value of existing IT assets that is reflected in current earnings. Since we are interested in the value associated with incremental investment in IT, we employ an empirical model that relates the market value of the firm to a combination of the current book value and the current earnings of the firm (Ohlson 1995). The model admits information beyond book value and earnings that is value-relevant in terms of future expected earnings. Including the value of Y2K spending in the model provides a means of measuring the association between expected future earnings changes and investments in IT made during the Y2K period.

Amir (1993) provides the following empirical specification of the Ohlson model that controls for heteroskedasticity by scaling the model by $book\ value_{t-1}$:

$$market\ value_t / book\ value_{t-1} = \tilde{a}_0 + \tilde{a}_1 * book\ value_t / book\ value_{t-1} + \tilde{a}_2 * earnings_t / book\ value_{t-1} + \hat{a} * other\ value\ relevant\ information / book\ value_{t-1} + e_t$$

In the model, the unamortized cost of existing IT assets is reflected in the book value and the value-in-use of existing IT assets is reflected in the current earnings. This alleviates a potential omitted correlated variable problem if the amount of Y2K spending is correlated with the overall investment in IT or other assets.

To test our hypotheses, we need a broad-based measure of the industry level of Y2K spending to provide a reference point for determining a firm's relative Y2K spending and to measure the overall industry level of Y2K spending. We use the *industry median Y2K spending*, rather than the mean level of Y2K spending, because the median is not skewed by extreme observations. In the first model that we estimate, we include $relative\ Y2K\ spending_t$ (the firm's level of Y2K spending minus the industry median level) and the $industry\ median\ Y2K\ spending_t$ as our variables of interest, and $R\&D\ spending_t$ to control for other intangible assets. The *firm*

Y2K spending$_t$ represents the planned amount of Y2K spending throughout the Y2K preparation period as projected at time *t*.[3]

$$\begin{aligned} \textit{market value}_t / \textit{book value}_{t-1} &= \alpha + \hat{a}_1 * \textit{relative Y2K spending}_t / \textit{book value}_{t-1} \\ &+ \hat{a}_2 * \textit{industry median Y2K spending}_t / \textit{book value}_{t-1} \\ &+ \tilde{a}_1 * \textit{book value}_t / \textit{book value}_{t-1} \\ &+ \tilde{a}_2 * \textit{earnings}_t / \textit{book value}_{t-1} \\ &+ \tilde{a}_3 * \textit{R\&D spending}_t / \textit{book value}_{t-1} + \varepsilon \end{aligned} \qquad \text{(Model 1)}$$

Hypotheses 1a and 1b relate firm value to positive and negative deviations from the industry level of Y2K spending and to the industry level of Y2K spending. We specify a second model where the *relative Y2K spending* is split into two variables, one for positive deviations and one for negative deviations from the *industry median Y2K spending*. The positive and negative deviations, *positive relative Y2K spending* and *negative relative Y2K spending*, are defined by crossing a dummy variable that denotes whether the deviation from the industry median for a specific firm observation is negative or positive with the magnitude of the deviation.

$$\begin{aligned} \textit{market value}_t / \textit{book value}_{t-1} &= \alpha + \hat{a}_1^{+} * \textit{positive relative Y2K spending}_t / \textit{book value}_{t-1} \\ &+ \hat{a}_1^{-} * \textit{negative relative Y2K spending}_t / \textit{book value}_{t-1} \\ &+ \hat{a}_2 * \textit{industry median Y2K spending}_t / \textit{book value}_{t-1} \\ &+ \tilde{a}_1 * \textit{book value}_t / \textit{book value}_{t-1} \\ &+ \tilde{a}_2 * \textit{earnings}_t / \textit{book value}_{t-1} \\ &+ \tilde{a}_3 * \textit{R\&D spending}_t / \textit{book value}_{t-1} + \varepsilon \end{aligned} \qquad \text{(Model 2)}$$

The empirical forms of the hypotheses are:

Hypothesis 1a: $\hat{a}_1^{+} > 0$

Hypothesis 1b: $\hat{a}_1^{-} < 0$

Hypothesis 2: $\hat{a}_2 > 0$

Hypothesis 3: $\hat{a}_2 > \hat{a}_1^{+}, \quad \hat{a}_2 > |\hat{a}_1^{-}|$

[3] The standard deviation in planned Y2K spending over the five quarters from the fourth quarter of 1998 to the fourth quarter of 1999 was on average just 9% of the mean planned Y2K spending.

5. Data and Estimation Results

The Y2K spending data for our analysis were obtained from Y2K disclosures in the Management Discussion and Analysis (MD&A) section of annual 10K and quarterly 10Q reports filed with the SEC beginning in August, 1998. The SEC interpretation (August 4, 1998) mandating disclosure of Y2K costs 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 disclosed amount which we refer to as *planned Y2K spending* includes all expenditures in all years prior to the financial statement reporting date and all anticipated remaining expenditures between the reporting date and completion of the Y2K projects.

Our sample was drawn from companies included in the 1998 *Fortune 1000*. The 10K and 10Q reports were accessed through the EDGAR database maintained by the SEC and the planned Y2K spending amounts (including actual spending to date and anticipated future spending) were hand collected. We use, as the basis for our analysis, disclosures made in 10K and 10Q reports issued during the first quarter of 1999. This period was selected because companies with December 31 year-ends release their annual reports during the first quarter.[4] Disclosure information in annual reports is typically of better quality than disclosure information in quarterly reports because companies are more cautious in preparing annual reports and annual reports are subject to more detailed audit review. Accounting variables were obtained from Standard and Poors' Compustat database or from the Value-Line Investment Survey. These

[4] Over 90% of Fortune 1000 companies release their annual report during the first quarter. Data were also collected from filings made in the fourth quarter of 1998, the remaining three quarters of 1999 and the first quarter of 2000. Estimation results for these quarters are provided as robustness checks.

variables included net sales revenue (Compustat item #12), income before extraordinary items (#18), the book value of common equity (#60), the number of common shares outstanding (#25) and R&D expenditures (#46).

Information about Y2K spending was not obtained for all firms in the 1998 *Fortune 1000*. From the 1,000 companies, 124 were not used because the companies did not make 10K or 10Q filings during the first quarter of 1999. This non-filing occurred because some *Fortune 1000* companies, such as mutual insurance companies, do not make 10K filings and other companies had been acquired or merged during 1998. Of the firms that did make 10K or 10Q filings, 145 did not report their planned Y2K spending, leaving a sample of 731 firms. An SEC review of 400 corporate filings made in the fourth quarter of 1998 revealed that a number of companies were not including information about their planned Y2K expenditures (Hoffman and Stedman 1999). Companies' reluctance to make detailed disclosures of their Y2K preparations may be due to uncertainty about the total cost of Y2K or fear that the disclosures may be used in litigation against the company.[5] The SEC did not aggressively enforce compliance with the guideline and penalties for non-disclosure are fines ranging from $5,000 to $50,000.[6]

Table 1 provides information about planned Y2K spending for 18 industry groups formed by aggregating similar industries from the initial sixty-one industry groups in the *Fortune 1000*. The industry groups are presented in ascending order based on the industry median Y2K spending intensity (Y2K spending normalized by sales revenue). A review of the information presented in table 1 indicates that there are large differences across industry groups in their

[5] 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.

[6] The lack of enforcement by the SEC to ensure Y2K disclosures by all firms does not call into question the credibility of the disclosures that were actually made by 731 of the *Fortune 1000* firms because disclosures made are subject to the laws governing accountability for financial reports.

median Y2K spending intensity. The leading industries in terms of Y2K spending intensity are telecommunications, pharmaceuticals, and banks and financial services. This is congruent with spending on enterprise applications during the Y2K preparation period described by AMR Research. An AMR Research press release (August 23, 1999) reported, "High Tech, Pharmaceuticals, and Finance are the three vertical markets with the largest budgets for enterprise applications, and are increasingly spending more on enterprise applications." The table 1 data also shows large ranges within industry groups between the lowest and highest Y2K spending intensity.

Results of Estimation

Results of ordinary least squares (OLS) estimation of models 1 and 2 for Y2K data disclosed during the first quarter of 1999 are provided in table 2. Of the 731 firms making Y2K spending disclosures, 84 observations were not used because financial variables were missing. Influential observations were identified resulting in the exclusion of 11 firms from the analysis, leaving 636 firms.[7] To control for scaling effects and heteroskedasticity, all of the variables were deflated by the lagged book value per share. White's (1980) test indicates that the null hypothesis of homoskedasticity cannot be rejected at the 5% level of significance after the transformation. The Shapiro-Wilk (1965) test does not reject the hypothesis that the residuals are normally distributed. Multicollinearity was checked by computing the condition number of the moment matrix as suggested by Belsley, Kuh, and Welsch (1980). Belsley et al. (1980) indicate that values exceeding 20 may be a symptom of high correlation among regressors. This

[7] 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.

condition number does not exceed 11 in any of the estimations that we report, indicating that our analysis is not highly influenced by multicollinearity.

The model 1 results provide strong support for a positive association between the market value of the firm at the end of the first quarter and the planned Y2K spending (actual spending to date plus projected future spending) reported during the first quarter. The significantly positive coefficient of 21.319 (one-sided p-value = 0.0001) on *relative Y2K spending* and the significantly positive coefficient of 123.331 (one-sided p-value = 0.0001) on *median Y2K spending* indicate that firm value was positively related to both the difference between firm spending on Y2K and industry spending on Y2K and to the overall level of industry spending on Y2K. These strong positive relations would not be observed if Y2K spending had been primarily devoted to remediation of existing IT since current earnings already reflect the productive influence of existing IT.

Results of estimating model 2 provide further support for the empirical hypotheses. The significantly positive coefficient of 20.287 (one-sided p-value = 0.0001) on *positive relative Y2K spending*, supports hypothesis 1a and indicates that firm value is positively associated with incremental investment in IT relative to industry peers. Similarly the significantly negative coefficient of –40.523 (one-sided p-value = 0.0042) on the *negative relative Y2K spending* coefficient supports hypothesis 1b, consistent with a negative relation between firm value and the amount by which a firm's Y2K spending lagged behind its industry peers.

The significantly positive coefficient of 123.484 (one-sided p-value = 0.0001) on the *industry median level of Y2K spending* provides support for hypothesis 2, that firm value is positively related to the industry median level of Y2K spending. This result is consistent with Y2K spending being systematically related to opportunities to increase productivity and develop

new markets through investment in new IT. Clemons, Reddi, and Row (1993) observed that "lower relationship-specificity of IT investments and a better monitoring capability imply that firms can more safely invest in information technology for interfirm coordination … Moreover, rapid reduction in the cost of IT and reduction in the transactions risk makes possible substantially more use of explicit coordination with suppliers."

The positive coefficient on the *industry median level of Y2K spending* of 123.484 is significantly greater in magnitude than the positive coefficient on the *positive relative Y2K spending* variable of 20.287 (p-value of test of differences = 0.0006) and is also significantly greater in magnitude than the negative coefficient on the *negative relative Y2K spending* variable of –40.523. These results are consistent with hypothesis 3 that the relation between firm value and industry spending dominates the relation between firm value and spending relative to firms within an industry. This evidence supports an argument that the widespread adoption of enterprise systems by firms within an industry provides an IT infrastructure that enables greater coordination throughout the value chain.

Since our hypotheses were developed in terms of relative effects, we did not make specific predictions about the magnitudes of the coefficients. Brynjolfsson, Hitt, and Yang (2000) suggested that the coefficient on IT capital in a regression relating firm value to IT and other types of capital may be many times greater than one because complementary investments in unrecorded assets are made when investments are made in IT. These include the costs of reorganization efforts required in conjunction with investment in IT. This may be particularly salient for Y2K spending because reorganization costs are especially high for investments in enterprise systems. Laughlin (1999) observed that the opportunity costs of implementing ERP applications were more important than the direct costs, "The effort represents a significant

investment of capital, time, human resources, and management focus." Gormley et al. (1998) estimated that less than 20% of the total cost of the installation of an SAP R/3 system is for hardware and software. The coefficient on *relative Y2K spending* may also be magnified because it picks up the effects of increases in firm value attributable to combinations of new IT and complementary resources. In addition, greater relative spending on Y2K may signal opportunities for greater future investment in IT, the effects of which are anticipated by investors in the capital markets.

As new IT emerges, its potential impact is likely to differ substantially across industries. For instance, technology that enhances interactions in the value chain might have a large influence in the pharmaceutical industry where it could enable delivery of customized drug combinations to specific patients. In situations where IT innovations may add substantially to industry value, the effect on firm value of investments in IT may be many times greater than the actual cost of implementing the new IT by firms in the industry.[8] To the extent that the median level of Y2K spending represents greater opportunities by firms in an industry to leverage investments in enterprise systems, the coefficient on the industry median Y2K spending will be magnified. The coefficient on the industry median Y2K spending may also reflect complementary investment in unrecorded assets and anticipation of future investments.

Robustness

There is a possibility that industry Y2K spending proxies for other characteristics of industries that affect firm value. One might question whether growth is driving Y2K spending and the Y2K spending variable is reflecting the impact of growth on market value. To address this issue, we added sales growth and assets growth variables to the model 1 and model 2 specifications. Results of estimating these models, labeled model 1a and model 2a, using the

first quarter 1999 data are presented in table 3. The sales growth variable is significantly positive in both models and the coefficients on the *positive relative Y2K spending variables* are slightly reduced, but the positive outcomes of the tests of the hypotheses are sustained.

The Y2K data used for the table 2 estimations were derived from disclosures made during the first quarter of 1999. We also collected data from disclosures made during the fourth quarter of 1998, other quarters of 1999, and the first quarter of 2000. Table 4 presents results of the estimations of models 1 and 2 using data from all quarters. In each case, the *market value* is based on the closing stock price at the end of the quarter in which the disclosures were made. For the first quarter of year 2000, the Y2K spending variables are based on actual spending whereas for all other quarters the Y2K spending variables were the total planned Y2K spending. The number of firms in the sample declined somewhat over time due to mergers and acquisitions and the number reporting Y2K costs dropped appreciably in the first quarter of 2000 as the disclosures were no longer required.

There is a decline in the magnitude of the coefficients on the Y2K spending variables over time. This may be due to the effects of the new IT-resource combinations being partially manifest in book value as the investments were recorded and in earnings realizations as the competitive benefits were starting to be realized. Hypothesis 1a, that firm value is positively related to positive deviations from the industry median level of Y2K spending is supported in all quarters. Hypothesis 1b, that firm value is negatively related to negative deviations from the industry median level of Y2K spending, is supported in four of the six quarters at a 5% level of significance. Hypothesis 2 that firm value is positively related to the industry median level of Y2K spending is strongly supported in all quarters. And hypothesis 3 that relations between firm

[8] The developer of an IT innovation will not capture the whole surplus if the IT can be imitated.

value and industry Y2K spending dominate relations between firm value and Y2K spending relative to industry peers is supported in all quarters.

Simultaneous Equations Model

There is a potential issue of endogeneity with respect to changes in the market value of the firm and investment in IT. While our analysis considers the influence of investment in IT on the market value of the firm, it is possible that unexpected increases in the market value of the firm would lead to greater investment in IT. Brynjolfsson and Yang (1999) and Brynjolfsson, Hitt, and Yang (2000) 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 significantly 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 (2000) 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.

To address potential endogeneity, we specified and estimated a system of simultaneous equations with *firm Y2K spending* and *market value* as endogenous variables.

$$\begin{aligned} \textit{market value}_t / \textit{book value}_{t-1} &= \acute{a} + \hat{a} * \textit{firm Y2K spending}_t / \textit{book value}_{t-1} \\ &+ \tilde{a}_1 * \textit{book value}_t / \textit{book value}_{t-1} \\ &+ \tilde{a}_2 * \textit{earnings}_t / \textit{book value}_{t-1} \\ &+ \tilde{a}_3 * \text{R\&D spending}_t / \text{book value}_{t-1} + e \end{aligned} \qquad \text{(Equation 1)}$$

$$\begin{aligned} \textit{Y2K spending}_t / \textit{book value}_{t-1} &= a + b * \textit{market value}_t / \textit{book value}_{t-1} \\ &+ c_1 * \textit{net sales revenue}_t / \textit{book value}_{t-1} \\ &+ c_2 * \textit{fixed assets}_t / \textit{book value}_{t-1} \\ &+ c_3 * \textit{number of employees}_t / \textit{book value}_{t-1} + e \end{aligned} \qquad \text{(Equation 2)}$$

Equation 1 is the model 1 equation and equation 2 relates *firm Y2K spending* to *market value* and other variables that are likely to influence the amount of *Y2K spending* across firms. Since remediation costs and investments in new IT are likely to increase with the volume of transactions processed by the firm, *net sales revenue* is included as an exogenous variable. Similarly, IT costs are likely to increase with the value of assets governed by the firm and the number of employees whose efforts are coordinated by the firm. Therefore, the value of *fixed assets per share* and the *number of employees per share* are also included as independent variables. The presence of different exogenous variables in each equation ensures that each equation is identified (Greene 1997, p. 729).

We estimated the equations using both two-stage and three-stage least squares estimation procedures (Zellner and Theil 1962). In table 4, we present the three-stage least squares estimation of the system of equations because the magnitude of the correlation between the disturbance terms of the two equations of 0.43 exceeds the limit of 0.33 for using two-stage estimation suggested by Kennedy (1987). We also present results of estimating a second specification (corresponding to model 1a) that includes the sales growth and assets growth rate variables in equation 1. In both the model 1 and model 1a versions of equation 1, the coefficients on the *relative Y2K spending* variables are significantly positive and the coefficients on the *industry median Y2K spending* variables are significantly positive and of significantly greater magnitude than the coefficients on the *relative Y2K spending*. These results are consistent with the main results of our study.

In the estimations of equation 2, the exogenous variables are significantly positive as predicted but the endogenous *market value* variable is significant only at the 11.38% level in the model 1 version and not significantly greater than zero in the model 1a version. Hausman tests

of endogeneity, however, cannot reject simultaneity between *relative Y2K spending* and *market value*. Tests of Granger (1969) causality are precluded because there is no time series of distinct observations of Y2K spending and firm value. Nevertheless, the findings that Y2K spending significantly influences market value but that Y2K spending was not strongly influenced by firm value are consistent with the results obtained by Brynjolfsson, Hitt and Yang in their study of Granger causality.

Stock Return Models

The evidence presented to this point relates the market value of firms to Y2K spending. We observed earlier that it was not possible to perform a short window event study like that of Dos Santos, Peffers, and Mauer (1993) because information about firms' Y2K activities was not discretely disclosed at identifiable dates but was revealed throughout the Y2K preparation period. Previous financial research has related stock returns to earnings, changes in earnings, and other information over time periods of one year or more (e.g. Amir and Lev 1996). As an additional robustness test, we estimated models that relate stock returns to earnings, changes in earnings, R&D spending and Y2K spending over time periods when information about Y2K preparation was disclosed. Table 6 provides results of estimating single equation and simultaneous equations models for the four-year time period ending December 31, 1998. Results of estimations of these models are generally consistent with those of the corresponding valuation models.[9]

[9] The results are also generally similar for three-year return models.

6. Conclusion

The Y2K period provides an opportunity for observing relative investment in IT because firms were forced to evaluate their IT and make decisions whether to remediate existing systems or move to new platforms. Davenport (1998) contrasted legacy systems that were pervasive in many large firms prior to Y2K with enterprise systems that were implemented by many companies during the Y2K period. He observed that while the direct costs of maintaining legacy systems were high, the indirect costs were more important – "if a company's sales and ordering systems cannot talk with its production scheduling systems, then its manufacturing productivity and customer responsiveness suffer." Since the strength of enterprise systems is their ability to collect and process data from virtually all of a company's business activities, their acquisition may enable firms to leverage structural or resource advantages (Clemons and Row 1991). Our finding that firm value was positively related to the amount by which a firm's spending on IT for Y2K exceeded that of its industry peers provides empirical support for the theory that firms may use IT to complement other strengths and obtain competitive advantage.

Recent research by Brynjolfsson and Yang (1999) and Brynjolfsson, Hitt, and Yang (2000) suggest a new IT productivity paradox – that the marginal returns to investments in IT far exceed the marginal costs. Our study provides further evidence of this phenomenon. In contrast to the Brynjolffson et al. studies that examine relations between firm value and in-place IT, our study uses an IT metric that represents spending during a specific time period. If Y2K spending reflects investments in enterprise systems and measures improvements in IT infrastructure that complement changes in business processes and organization structure, then the high valuation multiples on the Y2K spending variables are consistent with the results of Brynjolfsson et al.

In the models that we estimate, firm value is indirectly associated with spending on enterprise systems through the Y2K spending variables. This makes our study the first empirical study that we are aware of to provide evidence of an association between firm value and investment in enterprise systems. We also document a strong positive association between firm value and industry spending on Y2K. This result suggests a powerful role for IT in the redefinition of industries. Ken Sharma, vice-president of i2 Technologies, a logistics software company observed, "We are moving to a world where companies no longer compete with each other – but supply chains do. This means business needs more responsive and adaptable systems to support a multi-enterprise supply chain" (Manchester 1999).

Estimates of worldwide spending on Y2K range from $280 billion to $600 billion, with spending in the U.S. reaching at least $100 billion (Kong and Seipel 2000). Total planned Y2K spending for the 731 firms in our sample was $34.8 billion. Whether the massive Y2K effort was worthwhile has been a controversial subject. 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, contended 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). Our analysis supports the view that Y2K preparation was more about investment in IT infrastructure than remediation of legacy systems.

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Table 1 – Distribution of Y2K Spending Intensity by Industry*

Industry Description	Total Number Of Firms	Number Of Sample Firms	Low	First Quartile	Median	Third Quartile	High
Wholesale & Specialty Retail	101	77	0.008	0.114	**0.178**	0.344	2.002
Merchandising	55	39	0.016	0.094	**0.249**	0.354	0.989
Extraction (Mining, Crude Oil)	39	26	0.009	0.170	**0.335**	0.650	1.953
Building Materials & Construction	53	40	0.034	0.230	**0.355**	0.702	3.434
Chemicals and Petroleum Refining	61	49	0.058	0.246	**0.379**	0.813	6.199
Manufacturing, Auto. & Equip.	87	66	0.033	0.260	**0.428**	0.667	5.478
Hotels, Restaurants & Services	35	27	0.037	0.145	**0.474**	0.725	2.454
Transportation	33	31	0.039	0.180	**0.483**	0.839	2.323
Consumer (Non-Food)	29	26	0.027	0.116	**0.530**	1.489	3.198
Healthcare	32	24	0.078	0.377	**0.550**	1.346	4.936
Insurance	84	35	0.046	0.278	**0.568**	1.130	2.042
Consumer (Food & Beverages)	49	35	0.029	0.250	**0.631**	0.951	9.574
Electronics and Aerospace	110	73	0.089	0.432	**0.712**	1.219	4.477
Utilities	73	61	0.109	0.492	**0.733**	1.244	4.805
Media Services	26	24	0.220	0.527	**0.795**	1.286	2.102
Banks & Financial Services	79	62	0.028	0.661	**1.081**	1.547	3.269
Pharmaceuticals	14	12	0.063	0.866	**1.123**	1.508	2.176
Telecommunications	40	24	0.208	0.595	**1.321**	1.767	4.135
All Firms	**1000**	**731**	**0.008**	**0.243**	**0.512**	**1.019**	**9.574**

*Y2K spending intensity is measured as planned Y2K spending divided by net sales revenue. Planned Y2K spending is obtained from disclosures made in the first quarter of 1999 and net sales is revenue is obtained from the 1998 financial statements.

Table 2 – Regression of *Market Value of Firm Equity*
on Y2K Spending Variables
(1st Quarter 1999 Disclosures with March 31, 1999 Market Values)

Model 1

$$\text{market value}_t / \text{book value}_{t-1} = \acute{a} + \hat{a}_1 * \text{relative Y2K spending}_t / \text{book value}_{t-1} + \hat{a}_2 * \text{industry median Y2K spending}_t / \text{book value}_{t-1} + \tilde{a}_1 * \text{book value}_t / \text{book value}_{t-1} + \tilde{a}_2 * \text{earnings}_t / \text{book value}_{t-1} + \tilde{a}_3 * \text{R\&D spending}_t / \text{book value}_{t-1} + e$$

Model 2

$$\text{market value}_t / \text{book value}_{t-1} = \acute{a} + \hat{a}_1^{+} * \text{positive relative Y2K spending}_t / \text{book value}_{t-1} + \hat{a}_1^{-} * \text{negative relative Y2K spending}_t / \text{book value}_{t-1} + \hat{a}_2 * \text{industry median Y2K spending}_t / \text{book value}_{t-1} + \tilde{a}_1 * \text{book value}_t / \text{book value}_{t-1} + \tilde{a}_2 * \text{earnings}_t / \text{book value}_{t-1} + \tilde{a}_3 * \text{R\&D spending}_t / \text{book value}_{t-1} + e$$

			Model 1	**Model 2**
variable[a]		**predicted sign**	**coefficient (p-value**[b]**)**	**coefficient (p-value**[b]**)**
intercept	$\acute{a}$		-1.390 (0.0174)	-1.373 (0.0187)
***relative Y2K spending**$_t$*	$\hat{a}_1$	+	21.319 (0.0001)	
***positive relative Y2K spending**$_t$*	$\hat{a}_1^{+}$	+		20.287 (0.0001)
***negative relative Y2K spending**$_t$*	$\hat{a}_1^{-}$	-		-40.523 (0.0042)
***industry median Y2K spending**$_t$*	$\hat{a}_2$	+	123.331 (0.0001)	127.484 (0.0001)
book value$_t$	g_1	+	1.527 (0.0001)	1.519 (0.0001)
earnings$_t$	g_2	+	5.539 (0.0001)	5.370 (0.0001)
R&D spending$_t$	g_3	+	11.987 (0.0001)	12.015 (0.0001)
			n = 636 adj. R^2 = 0.3685	n = 636 adj. R^2 = 0.3692

[a] All variables are scaled by *book value$_{t-1}$*

[b] All p-values, except for the intercept terms, are for one-sided tests

Table 3 – Regression of *Market Value of Firm Equity*
on Y2K Spending Variables and Growth Variables
(1st Quarter 1999 Disclosures with March 31, 1999 Market Values)

Model 1a

$$\text{market value}_t / \text{book value}_{t-1} = \alpha + \hat{a}_1 * \text{relative Y2K spending}_t / \text{book value}_{t-1} + \hat{a}_2 * \text{industry median Y2K spending}_t / \text{book value}_{t-1} + \tilde{a}_1 * \text{book value}_t / \text{book value}_{t-1} + \tilde{a}_2 * \text{earnings}_t / \text{book value}_{t-1} + \tilde{a}_3 * \text{R\&D spending}_t / \text{book value}_{t-1} + g_4 * \text{sales growth rate}_t / \text{book value}_{t-1} + g_5 * \text{assets growth rate}_t / \text{book value}_{t-1} + e$$

Model 2a

$$\text{market value}_t / \text{book value}_{t-1} = \alpha + \hat{a}_1^{+} * \text{positive relative Y2K spending}_t / \text{book value}_{t-1} + \hat{a}_1^{-} * \text{negative relative Y2K spending}_t / \text{book value}_{t-1} + \hat{a}_2 * \text{industry median Y2K spending}_t / \text{book value}_{t-1} + \tilde{a}_1 * \text{book value}_t / \text{book value}_{t-1} + \tilde{a}_2 * \text{earnings}_t / \text{book value}_{t-1} + \tilde{a}_3 * \text{R\&D spending}_t / \text{book value}_{t-1} + g_4 * \text{sales growth rate}_t / \text{book value}_{t-1} + g_5 * \text{assets growth rate}_t / \text{book value}_{t-1} + e$$

			Model 1a	**Model 2a**
variable[a]		**predicted sign**	**coefficient (p-value**[b]**)**	**coefficient (p-value**[b]**)**
intercept	α		-0.975 (0.1107)	-0.890 (0.1485)
relative Y2K spending$_t$	$\hat{a}_1$	+	14.948 (0.0001)	
positive relative Y2K spending$_t$	$\hat{a}_1^{+}$	+		13.028 (0.0002)
negative relative Y2K spending$_t$	$\hat{a}_1^{-}$	-		-53.598 (0.0014)
industry median Y2K spending$_t$	$\hat{a}_2$	+	111.509 (0.0001)	118.809 (0.0001)
book value$_t$	g_1	+	1.151 (0.0084)	1.080 (0.0077)
earnings$_t$	g_2	+	5.597 (0.0001)	5.500 (0.0001)
R&D spending$_t$	g_3	+	12.720 (0.0001)	12.644 (0.0001)
sales growth rate$_t$	g_4	+	6.958 (0.0094)	5.352 (0.0518)
assets growth rate$_t$	g_5	+	1.473 (0.2543)	2.537 (0.1745)
			n = 628 adj. R^2 = 0.3244	n = 627 adj. R^2 = 0.3290

[a] All variables are scaled by *book value*$_{t-1}$

[b] All p-values, except for the intercept terms, are for one-sided test

Table 4 – Regression of *Market Value of Firm Equity* on Y2K Spending Variables (Quarterly Disclosures with End of Quarter Market Values)

		4th qtr. 1998	1st qtr. 1999	2nd qtr. 1999	3rd qtr. 1999	4th qtr. 1999	1st qtr. 2000
variable[a]		**coeffecient (p-value**[b]**)**	**coeffecient (p-value**[b]**)**	**coeffecient (p-value**[b]**)**	**coeffecient (p-value**[b]**)**	**coeffecient (p-value**[b]**)**	**coeffecient (p-value**[b]**)**
Panel A – Model 1							
intercept	$\acute{a}$	-1.652 (0.0032)	-1.390 (0.0174)	0.148 (0.7669)	0.581 (0.2122)	0.637 (0.0804)	0.968 (0.1007)
relative Y2K spending$_t$	b_1	23.564 (0.0001)	21.319 (0.0001)	12.322 (0.0001)	7.819 (0.0008)	9.333 (0.0009)	0.800 (0.4159)
industry median Y2K spending$_t$	b_2	140.004 (0.0001)	123.331 (0.0001)	68.954 (0.0035)	79.044 (0.0005)	80.490 (0.0005)	101.678 (0.0002)
book value$_t$	g_1	1.300 (0.0002)	1.527 (0.0001)	0.215 (0.2592)	-0.355 (0.1368)	-0.427 (0.0598)	-1.311 (0.0016)
earnings$_t$	g_2	7.860 (0.0001)	5.539 (0.0001)	10.053 (0.0001)	8.966 (0.0001)	7.948 (0.0001)	10.781 (0.0001)
R&D spending$_t$	g_3	15.970 (0.0001)	11.987 (0.0001)	14.080 (0.0001)	9.304 (0.0001)	9.578 (0.0005)	9.568 (0.0001)
		n = 660 adj. R^2 = 0.5024	n = 636 adj. R^2 = 0.3685	n = 637 adj. R^2 = 0.5591	n = 625 adj. R^2 = 0.4543	n = 598 adj. R^2 = 0.4123	n = 402 adj. R^2 = 0.4240
Panel B – Model 2							
intercept	$\acute{a}$	-1.658 (0.0055)	-1.373 (0.0187)	0.154 (0.7573)	0.514 (0.2678)	0.589 (0.1896)	1.056 (0.0718)
positive relative Y2K spending$_t$	b_1	20.580 (0.0002)	20.287 (0.0001)	11.813 (0.0001)	7.922 (0.0007)	6.913 (0.0060)	7.724 (0.0389)
negative relative Y2K spending$_t$	$\hat{a}_1^+$	-95.154 (0.0001)	-40.523 (0.0042)	-27.592 (0.0170)	-3.918 (0.3850)	-19.164 (0.1055)	-35.467 (0.0006)
industry median Y2K spending$_t$	$\hat{a}_1^-$	165.533 (0.0028)	127.484 (0.0001)	73.832 (0.0022)	76.945 (0.0007)	76.895 (0.0008)	106.791 (0.0001)
book value$_t$	g_1	1.297 (0.0001)	1.519 (0.0001)	0.217 (0.5154)	-0.226 (0.4876)	-0.418 (0.1240)	-0.631 (0.1434)
earnings$_t$	g_2	7.213 (0.0001)	5.370 (0.0001)	9.803 (0.0001)	8.616 (0.0001)	8.927 (0.0001)	4.481 (0.0001)
R&D spending$_t$	g_3	13.462 (0.0001)	12.015 (0.0001)	13.935 (0.0001)	9.352 (0.0001)	9.269 (0.0001)	11.886 (0.0001)
		n = 658 adj. R^2 = 0.4402	n = 636 adj. R^2 = 0.3692	n = 637 adj. R^2 = 0.5594	n = 624 adj. R^2 = 0.4313	n=598 adj. R^2 = 0.4119	n= 400 adj. R^2 = 0.3325

[a]All variables are scaled by *book value*$_{t-1}$

[b]All p-values, except for the intercept terms, are for one-sided tests

Table 5 – Results of Three-Stage Least Squares Estimation of Simultaneous Equations Relating *Market Value of Firm Equity* and Y2K Spending Variables (1st Quarter 1999 Disclosure with March 31, 1999 Stock Prices)

Equation 1

$$\text{market value}_t / \text{book value}_{t-1} = \acute{a} + \hat{a}_1 * \text{relative Y2K spending}_t / \text{book value}_{t-1} + \hat{a}_2 * \text{industry median Y2K spending}_t / \text{book value}_{t-1} + \tilde{a}_1 * \text{book value}_t / \text{book value}_{t-1} + \tilde{a}_2 * \text{earnings}_t / \text{book value}_{t-1} + \tilde{a}_3 * \text{R\&D spending}_t / \text{book value}_{t-1} + e$$

Equation 2

$$\text{relative Y2K spending}_t / \text{book value}_{t-1} = a + b_1 * \text{market value}_t / \text{book value}_{t-1} + c_1 * \text{relative net sales revenue}_t / \text{book value}_{t-1} + c_2 * \text{relative fixed assets}_t / \text{book value}_{t-1} + c_3 * \text{relative number of employees}_t / \text{book value}_{t-1} + e$$

variable[a]		predicted sign	Model 1 coefficient (p-value[b])	Model 1a coefficient (p-value[b])
Equation 1				
intercept	$\acute{a}$		-0.513 (0.3818)	-0.557 (0.3673)
relative Y2K spending$_t$	$\hat{a}_1$	+	56.343 (0.0001)	52.337 (0.0001)
industry median Y2K spending$_t$	$\hat{a}_2$	+	121.726 (0.0001)	116.492 (0.0001)
book value$_t$	g_1	+	0.495 (0.0852)	0.5314 (0.1119)
earnings$_t$	g_2	+	5.327 (0.0001)	5.382 (0.0001)
R&D spending$_t$	g_3	+	11.932 (0.0001)	12.026 (0.0001)
sales growth rate$_t$	g_4	+		3.154 (0.3289)
assets growth rate$_t$	g_5	+		1.017 (0.1493)
Equation 2				
intercept	a		0.004 (0.0385)	0.005 (0.0143)
market value$_t$	b_1	+	0.001 (0.1138)	0.000 (0.2675)
relative net sales revenue$_t$	c_1	+	0.002 (0.0001)	0.002 (0.0001)
relative fixed assets$_t$	c_2	+	0.005 (0.0001)	0.005 (0.0001)
relative number of employees$_t$	c_3	+	43.915 (0.0566)	46.908 (0.0042)
			n = 601 system weighted R^2 = 0.3191	n = 597 system weighted R^2 = 0.3260

[a] All variables are scaled by *book value$_{t-1}$*

[b] All p-values, except for the intercept terms, are for one-sided tests

Table 6 – Regression of *Average Stock Return* for Four Year Period Ending December 31, 1998 on Y2K Spending Variables (1st Quarter 1999 Disclosure)

Model 3

$$\begin{aligned} \textit{average stock return} = {} & \acute{a} + \hat{a}_1 * \textit{relative Y2K spending}_t / \textit{book value}_{t-4} \\ & + \hat{a}_2 * \textit{industry median Y2K spending}_t / \textit{book value}_{t-4} \\ & + \tilde{a}_1 * \textit{average earnings / book value}_{t-4} \\ & + \tilde{a}_2 * \textit{average Ä earnings / book value}_{t-4} \\ & + \tilde{a}_3 * \textit{R\&D spending}_t / \textit{book value}_{t-4} \end{aligned}$$

variable[a]		predicted sign	Ordinary least squares coefficient (p-value[b])	Three-stage least squares coefficient (p-value[b])
				Equation 1
intercept	$\acute{a}$		-23.114 (0.0001)	-22.905 (0.0001)
relative Y2K spending$_t$	$\hat{a}_1$	+	33.283 (0.0001)	39.364 (0.0262)
industry median Y2K spending$_t$	$\hat{a}_2$	+	67.030 (0.0459)	61.352 (0.0615)
average earnings	g_1	+	10.523 (0.0001)	9.735 (0.0001)
average Ä earnings	g_2	+	36.463 (0.0001)	34.620 (0.0001)
R&D spending$_t$	g_3	+	4.525 (0.0020)	5.151 (0.0405)
				Equation 2
intercept	a			0.0175 (0.0213)
average stock return	b_1	+		0.0005 (0.0850)
relative net sales revenue$_t$	c_1	+		0.0006 (0.0015)
relative fixed assets$_t$	c_2	+		0.005 (0.0001)
relative number of employees$_t$	c_3	+		99.155 (0.0001)
			n = 600 adj. R^2 = 0.2286	n = 579 system R^2 = 0.3145

[a] All variables are scaled by *book value$_{t-4}$*

[b] All p-values, except for the intercept terms, are for one-sided tests