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The New Productivity Paradox

ECONOMIC studies conducted in the 1980s and early 1990s failed to find evidence of improved firm productivity corre-

sponding to greater IT investment. Because business firms expected performance to improve as a result of IT, the failure to observe higher productivity (more output from resources employed) was dubbed the “productivity paradox” [5]. The alleged implication was that they had overinvested in computers and other IT.

If firm productivity did improve with investment in IT, the shareholder value of publicly traded companies would increase with IT spending. When we studied the relation between shareholder value and IT spending by Fortune 1000 companies as they prepared for the Y2K date change we found that shareholder value associated with Y2K spending was in fact many times greater than the spending itself. We also found this strong positive relation between shareholder value and Y2K spending persisted through the market downturn of 2000–2002.

These results are surprising in light of conventional wisdom that companies overspent on Y2K. At face value, the relation between shareholder value and Y2K spending suggests that improved productivity due to Y2K initiatives far outweighed their costs. This could mean that businesses actually underinvested in new IT during this period, thus presenting a new paradox that is the reverse of the initial productivity paradox.

Financial Reporting on IT Investment

Although information management has assumed an increasingly important role in defining the strategic direction of businesses, there is no standard for

High valuation multiples on
IT spending suggest that companies
are underinvesting in IT.

reporting on IT initiatives under current accounting rules. The resulting inability to publicly observe firm spending on IT makes it difficult to measure IT influence on productivity or firm value. On the other hand, the relation between shareholder value and R&D spending (reported separately in accounting statements) has been studied extensively [10].

With respect to IT spending, the Y2K situation was exceptional because the U.S. Securities and Exchange Commission (SEC) instructed publicly traded companies to provide estimates of all IT costs associated with Y2K preparation in quarterly and annual reports beginning in the fall of 1998. Companies had to disclose estimates of all amounts that had been or would be incurred to correct existing IT or to acquire new IT if acquisitions were made or accelerated to achieve Y2K compliance.

Simple correction of existing IT would not add economic value because it would not improve firm productivity. Moreover, because profit-seeking companies are expected to make value-adding investments voluntarily, forced investment in IT would not be expected to increase firm value. These observations about Y2K make the finding of a large positive valuation multiple on Y2K spending particularly puzzling. Our objective in writing this article is therefore to identify and evaluate possible explanations for the high market valuation of Y2K spending.

Shareholder Value and Y2K Spending

Our valuation model relates a firm’s shareholder value (stock price multiplied by number of shares

outstanding) to its book value, current earnings, and Y2K spending:

$$\text{Market Value} = \alpha + \beta_{BV} * \text{Book Value} + \beta_E * \text{Earnings} + \beta_{Y2K} * \text{Y2K Spending} + \epsilon$$

The book value represents the net invested capital in the company; earnings represent the profit generated through the use of the firm's resources during the current period. Book value and earnings may be jointly informative about the firm's market value (the present value of expected future cash flows), because the amount of invested capital influences future earnings generation, and the amount of current earnings is a predictor of future earnings.

Other information, like Y2K spending, is value-relevant if it provides additional information about the market value of the firm beyond that conveyed by the book value and earnings. Previous research used similar models to investigate the value-relevance of information about firm activities (such as R&D spending) and resources (such as the potential service populations of cellular telephone companies) [1, 10].

We used our market-valuation model to determine the valuation multiple on Y2K spending, denoted β_{Y2K} , for our sample of Fortune 1000 firms on March 31, 1999. We obtained estimates of their Y2K spending from 10K reports filed during the first three months of 1999. We obtained accounting values from the 1998 financial statements included as part of these 10K reports. To control for potential scale effects, we deflated all variables by the accounting book value at the beginning of the 1998 financial reporting year.

An important statistical concern is that there may be a two-way relationship between a firm's market value and its Y2K spending [4]. While greater Y2K spending could have led to improved IT and increased productivity, other factors increasing a firm's market value could also have spurred more Y2K spending. To control for potential statistical bias caused by this relationship, we estimated a simultaneous-equations model allowing for the possibility that the market valuation of the firm and its Y2K spending were jointly determined.

We took other precautions to ensure the statistical validity of our results; for example, we removed observations with extreme values and performed appropriate statistical tests to rule out potential violations of assumptions underlying the regression model. (For a more complete exposition of the valuation model and its properties, as well as the value implications of IT investment, see [2].)

Table 1 lists the valuation multiples on Y2K spending and accounting variables obtained by estimating our model. In addition to the base analysis for March

31, 1999, we obtained values of the multiples for March 31, 2000, 2001, and 2002 by rolling forward the stock price and accounting variables. The valuation multiples on the book value and earnings variables are similar in magnitude to those found in previous studies [1, 10]. The fact that the book value multiple for March 31, 1999 was not statistically different from zero indicates that earnings dominated book value in the valuations for this period. The drop in the multiple on earnings from 10.15 for March 31, 1999 to 5.22 for March 31, 2002 is attributable to the market downturn from 2000 to 2002.

The multiple on Y2K spending of 62.10 for March 31, 1999 indicates that about \$60 of firm value was associated with each \$1 of Y2K spending. One might suspect that the Y2K spending multiple is magnified because it picked up the valuation effects of investment in IT made before 1999. This cannot be the case, however, because the influence of previous investments in IT on firm value would be picked up by the book value and earnings multiples, not the Y2K multiple.

Another possibility is that the high Y2K multiple for March 31, 1999 was due to irrational market exuberance for technology spending. If unwarranted market enthusiasm for such spending drove the high valuation multiple for that date, it would disappear with the market decline in technology stock values in 2000–2002.

	3/31/99	3/31/00	3/31/01	3/31/02
Y2K spending	62.10	26.53	32.16	30.00
Accounting book value	-0.03*	1.76	1.85	1.91
Current earnings	10.15	8.98	8.31	5.22

* not statistically different from zero

Table 1. Valuation multiples.

We found the valuation multiple on Y2K spending declined between 1999 and 2000 but was still a significant 26.53 for March 31, 2000 and remained at that level or higher in 2001 and 2002. The robustness of the Y2K multiples—despite the market downturn—indicates that investors' valuations were not simply caused by the technology bubble but driven by higher performance expectations for firms that spent more on Y2K.

Our findings of high valuation multiples on Y2K spending are consistent with findings in other recent studies that relate market values to IT assets or IT spending [3, 4]. In the old productivity paradox, there was no significantly positive effect from IT. The new paradox is that the strong positive valuation effect of IT spending in the 1990s suggests firms actually underinvested in IT.

Intangible Asset Value

A possible explanation for the high valuation multiple on Y2K spending is that Y2K spending functioned as a

surrogate for other innovative activities that increased intangible asset value. Firms that were innovative along other dimensions may also have been innovative in their response to Y2K. If this were the case, the observed effect of Y2K activities on intangible asset value would be overstated unless variables representing the other innovative activities were included in the model.

Table 2 lists the valuation multiples we obtained from estimating an expanded version of our model that included R&D spending. The valuation multiple on Y2K spending for March 31, 1999 dropped to 44.64 when R&D spending was included, compared to 62.10 in Table 1, when R&D spending is included. But the multiples for the remaining years (31.38 for March 31, 2000, 35.05 for March 31, 2001, and 32.65 for March 31, 2002) were similar to those found when R&D spending was not included. Both the multiple on Y2K spending and the multiple on R&D spending declined between March 31, 1999 and March 31, 2000, coinciding with the shift in the market's assessment of the effect IT would have on the economy.

In addition to improving the model statistically,

	3/31/99	3/31/00	3/31/01	3/31/02
Y2K spending	44.64	31.38	35.05	32.65
Accounting book value	-0.10*	1.77	1.57	2.04
Current earnings	8.85	8.55	7.81	4.69
R&D spending	13.70	7.32	6.78	9.98

* not statistically different from zero

inclusion of the R&D variable provided a new frame of reference for evaluating the multiple on Y2K spending. Ranging from 6.78 to 13.70 over the four years, it indicates the average amount of incremental firm value associated with each dollar of R&D spending. The values of the R&D multiple are of similar magnitude as those found in a previous study of R&D spending [10]. The fact that the multiples we found on Y2K spending were three or four times the multiples we found on R&D spending is noteworthy because it indicates investors gave a higher valuation to investment in IT than investment in R&D during the sample period.

While R&D spending represents a dimension of innovative activity, it may not capture all types of innovation that yield new market opportunities. Other innovative activities may be reflected in a firm's success exploiting new markets and investing in new business opportunities. Therefore, we included current sales growth and asset growth as additional variables in the valuation model. The high valuation multiples on Y2K spending were not diminished when we estimated the model with these growth variables.

Enterprise Systems and Y2K

Our sample included 476 Fortune 1000 companies. At many of them, the IT in place prior to the Y2K period was a cluster of legacy systems designed to facilitate specific business processes within individual business units or functional areas. Legacy systems were generally independent of one another and did not facilitate extensive information sharing across organizational divisions or across companies in a supply chain.

When preparing for Y2K, large companies had to choose between remediating their existing systems and acquiring new systems that were Y2K compliant. Due to the high costs of remediating and maintaining legacy systems, many companies used the Y2K opportunity to replace an existing cluster of legacy systems with an enterprise resource planning (ERP) system integrating various internal applications through a common database [8]. For instance, Y2K prompted Rayovac Corp., a worldwide manufacturer of batteries and other products based in Madison, WI, to set a goal of shutting down all legacy systems simultaneously and transferring all open transactions to its new Y2K-compliant enterprise system. Similarly, Mobil Corp. (now part of ExxonMobil, a leading producer and distributor of petroleum products based in Irving, TX) cited the need to comply with Y2K requirements as the primary driver for its decision to implement a companywide ERP system.

Numerous other sources portrayed a strong link between Y2K preparation and investment in ERP systems. Consultants reported phenomenal increases in the demand for their services fueled by massive ERP projects in advance of the 2000 date changeover [11]. In a survey of Fortune 500 companies by Benchmarking Partners, 42% of the respondents cited Y2K concerns as the most important technical reason for implementing an enterprise system. A 1999 AMR Research survey found that spending on ERP systems absorbed 43% of application budgets, while another 30% of these budgets went to supply chain management (SCM) applications and customer relationship management (CRM) applications. To verify that higher Y2K spending was related to investment in enterprise systems, we related the probability of companies appearing on the SAP best customer list in early 2000 to their Y2K spending and found the likelihood of being on the list increased significantly with Y2K spending.

Within companies, IT inertia results from the high organizational costs associated with changing from familiar systems. During the Y2K period, this inertia was countered by the high cost of remediating existing systems. In addition, Y2K elevated IT to the line of sight of top executives who paid attention to proposals that would simultaneously address the Y2K problem and provide other benefits. The ubiquitous nature of

Table 2. Valuation multiples with R&D spending.

Y2K also helped alleviate joint investment problems across firms. Linking to customers and other firms in the supply chain requires investment in IT infrastructure by all members of the chain. Unless there was common movement toward enterprise systems, the payoff structure for an individual firm in the supply chain would be incomplete.

The strong link between Y2K spending and enterprise systems gives a meaningful context for evaluating the apparent paradox of high market valuation of Y2K spending.

When implementing an ERP system, a company changes organizational processes and structures, worker knowledge and monitoring, and reporting and incentive systems [12]. Although resources, including time redesigning processes and training employees, are devoted to these changes, accounting conventions do not allow the investment to be recorded as an asset. Therefore, the related investment contributes to the firm's unrecorded asset value.

A 2000 survey relating the market value of firms to their IT and other assets found much higher market value multiples on computing assets than on other recorded assets [4]. The study also found that computing assets had a disproportionately higher value in firms exhibiting certain organizational characteristics (such as greater use of teams, broader decision-making authority, and worker training), supporting the notion that unrecorded investment in organizational resources complements investment in IT. Forrester Research estimated the non-IT costs associated with implementing ERP systems are as much as four times greater than IT costs [7]. But if this ratio were applied to Y2K spending, investment in complementary assets would only partially explain the observed Y2K multiple of about 30.

Value Creation

IT investment plays a role in value creation if it enables a firm to mobilize other resources. Leading IT innovators almost uniformly cite quicker response time and deeper knowledge of customers as key benefits from their IT investments [6]. IT innovators are also more likely than other companies to share information with strategic partners. Investment in ERP systems is considered the price of entry for connecting to other companies in today's globally networked economy [9].

The intangible benefits of ERP systems are difficult to isolate and quantify because they depend on the broader effects of enterprise resource management on supply-chain economies, customer loyalty, application interoperability, and business cycles. Mandated disclosure of Y2K costs in 1999 allowed investors in the capital market to evaluate IT spending like they evaluate R&D spending. Our analysis indicates that, just as spending on

R&D creates value for the companies making the investment, spending on enterprise systems and related organizational changes during the Y2K period created value for the companies making the investment.

New IT Productivity Paradox

Our evidence of high valuation multiples on Y2K spending, both before and after 2000, refutes claims that Y2K was much ado about nothing. By demonstrating high market valuation of Y2K spending and linking Y2K spending to ERP systems, we provide evidence of a positive value effect of ERP investment not previously available. In fact, the valuation multiples on Y2K spending were so high and robust over time as to present a new IT productivity paradox.

Our evaluation suggests two parallel explanations for the paradox: Complementary investment in organizational assets accompanying implementation of ERP and related systems increased intangible asset value. And the interweaving of IT links throughout the supply chain created value by enabling each member of the supply chain to identify and respond to dynamic customer needs. ■

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