IT Does Matter

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Abstract

Literatures in the late 1990s and early 2000s have convincingly demonstrated IT's contribution to productivity. Recently, much of the attention has shifted to a new debate raised by Nicholas G. Carr's article "IT Doesn't Matter." Carr argues that IT, while important, has been commoditized and lost its strategic value in differentiating one company from the pack. This paper seeks to test his hypothesis by measuring the contribution of IT stock to the productivity and profitability volatility in 62 industry sectors from 1987 to 2001. My results indicate that IT has contributed significantly to productivity and profitability volatility, and find no evidence that IT's strategic value has eroded.

1. INTRODUCTION

The decade of the 90s has witnessed dramatic, unparalleled growth of information technology. Companies were aggressively embracing IT to gain competitive advantages. Questions such as whether investments in IT can increase productivity (Solow, 1987) were centers of debates among academics and practitioners. Many studies in the late 90s (Hitt and Brynolfsson, 1996) and early 2000s (Brynolfsson, Hitt and Yang, 2002) demonstrated convincingly that IT did increase productivity and create substantial value for consumers. Recently much of the attention has shifted to a new debate raised by Nicholas G. Carr's article "IT Doesn't Matter" (2003). Carr argues that as IT's core functions – data processing, storage, and transmission – continue to be more standardized and more replicable, IT, as a commodity input, has lost its strategic value. Despite many criticisms from academic scholars (McFarlan and Nolan, 2003; Hittleman and Strassman, 2003) and practitioners (Pisello, 2003; Pike, 2003) on Carr's view, none of the studies to date has provided convincing evidence.

This paper seeks to provide an answer to this debate by quantitatively testing the strategic value of IT over years. The value of IT can be measured by productivity, business profitability and consumer surplus. Hitt and Brynjolfsson (1993) point out that these three measures, while related, are ultimately distinct and have different implications for managers, researchers and policy makers. In this paper, I will focus on the first two measures. As Carr's central point is that IT, while important, has lost its ability to differentiate firm productivity and profitability, I will test the impact of IT stock on the volatilities of productivity and business profitability among firms in the same industry sector over years.

Hypothesis 1 (H1): The contribution of IT stock to the productivity volatility has declined over years.

Hypothesis 2 (H2): The contribution of IT stock to the profitability volatility has declined over years.

The rest of the paper is organized as follows. Section 2 discusses how IT can contribute to productivity and profitability volatility among firms. Section 3 describes the volatility measures I developed and the dataset I compiled for testing the hypotheses. Section 4 describes my regression models and reports the results from empirical analyses. Section 5 concludes.

2. VOLATILITIES

Productivity Volatility. According to the definition given by the Bureau of Economic Analysis (BEA), productivity is a measure of economic efficiency which shows how effectively economic inputs are converted into output. It is measured by comparing the amount of goods and services produced with the inputs which were used in production. The theory of production posits that firms will keep investing until the last unit of that input creates no more value than it costs. In other word, more IT input does not necessarily increase the productivity because firms will only employ an optimal level of IT input in equilibrium. As IT is available to every firm, IT itself alone cannot lead to productivity dispersion. The only way IT can help differentiate firm productivity is through developing technology or process that cannot be easily replicated in other firms. For example, innovative use of IT assets in research and development can lead to creation of proprietary knowledge in production. In addition, IT can also help redefine organizational process to meet companies' specific needs. As each organization often has unique needs and characteristics, commoditization of IT does not imply that the best IT implementation can be easily replicable.

Profitability Volatility. In a competitive market with free entry, no firm can earn sustainable supranormal profit, as if it were the case, new entrants would enter and eventually drive down the price until there is no supranormal profit in the market. That is, all firms should earn normal return in such market. IT can help differentiate firms' profitability through creating intangible assets such as brands, patents, economies of scales, product differentiation and preferential access to scarce resources that can reduce the production cost or differentiate products. The evidence of the impact of IT on firm profitability is mixed. Using firm-level data on IT spending by 370 large firms, Hitt and Brynolfsson (1996) conclude that there is no clear evidence that the business value of IT have resulted in supranormal profit. On the other hand, Devaraj and Kohli (2000) find that combining investments in IT with BPR (Business Process Re-engineering) initiatives has a positive impact on firm profitability.

3. DATA

According to BEA's definition of productivity, I use the standard deviation of sales per employee in a given industry sector to measure productivity volatility. For profitability volatility, as data on net income are subject to accounting rules, I use the standard deviation of the growth rates of market values. A high growth rate of a firm's market value is often correlated to great profitability.

Since my goal is to test the impact of IT on these volatility measures in each industry sector over years, I construct two datasets: a firm-level dataset which includes annual data on productivity measures, profitability measures and other firm-specific characteristics, and an industry sector-level data which includes annual data on the total number of employees, IT stock, other capital stock, labor compensation, R&D stock and advertising expenditure in each sector. All dollar values in these two datasets are converted to 2002 dollars.

The primary data source for firm-level data is Standard & Poor's CompuStat database. I compiled an unbalanced panel of all public firms over the period 1987-2001. These data include sales, labor compensation, capital expenditure, R&D expenditure, advertising expenditure, number of employees, standard industry classification (SIC) code, and other financial data for each individual firm. CompuStat only provides data on annual R&D expense for each firm. Data on R&D stock are constructed following the method outlined in Hall (1990). I also exclude those firms that principally produced computers or software (SIC = 73) because the nature of computers as both a production input and output makes these firms very different from the rest. Panel A of Table 1 summarizes all firm-level variables.

I then compute the standard deviations of sales per employee, growth rate of market value and debt to equity ratio for each industry sector at the two-digit SIC level. As my dataset is unbalanced, that is, some data such as sales data of a particular firm may not be available across all years. To mitigate the potential volatility caused by random occurrences of some firms with values well beyond or below the industry average, I restrict my analysis to industry sectors in which I have at least fifteen observations for a given measure. I also examine these standard deviations and remove the data if I determine that their inconsistence from year to year is largely caused by random occurrences of some firms.

At the industry level, data on IT stock and non-IT related capital stock are obtained from BEA. These data are available for 62 industries at roughly the two-digit SIC level. IT stock comprises of computer hardware (mainframes, personal computers, storage devices, printers, terminals, tape drives, and integrated systems), computer software (prepackaged, custom and own-account), and telecommunication equipment. Ideally IT stock should also include investments in complementary assets such as training, support and maintenance of IT assets. These detailed data are often difficult to gather and are generally not available.

Data on total labor compensations and number of employees are obtained from the Bureau of Labor Statistics (BLS) and the Statistics of U.S. Business (SUSB). Since 1997, the North American Industry Classification System (NAICS) has replaced the Standard Industrial Classification (SIC) system. Some of the data on labor compensation and number of employees from BLS and SUSB are only available under NAICS. In such cases, I use the Annual Survey of Manufacturers and the Service Annual Survey published by the Census Bureau to fill in part of the data, and convert these data based on the correspondence table between NAICS and SIC from the Census Bureau. As the match between NAICS and SIC sometimes are not perfect, the converted data are used only if they are consistent from year to year.

As the data on R&D stock at the industry sector level is not available, I compute the average R&D per employee in each industry sector using firm-level data from CompuStat and use it to proxy the R&D stock per employee in the industry sector. Similar approach is also used to compute sector-level annual advertising expenses per employee.

Panel B of Table 1 summarizes all variables at the industry-sector level. Finally, I match volatilities measures in each industry sector with sector-level data based on the two-digits SIC code.

4. REGRESSION MODEL AND RESULTS

For each volatility measure, I proceed in two parts. First, I regress volatility measures on IT stock per employee, labor compensation, which includes wages and benefits, non-IT capital stock per employee, R&D stock per employee and year dummies to control for year-specific effects. I also include advertising expense per employee as an explanatory variable for two reasons. First, sales data are used to proxy firms' real output and they are often correlated with advertising expense. Thus, I need to control its effect on productivity volatility. Second, advertising expenditure can allow firms to build their brands and differentiate their products. Likewise, I need to control for its effect on profitability volatility.

The standard deviation of debt to equity ratio in each sector is also used. Debt to equity ratio represents how leveraged an average firm in the sector is. High debt to equity ratio implies high risk for a firm. Its effect on productivity and profitability volatility depends on how the money is used. When the money is used to resolve a temporary financial difficulty, the more outstanding debt a company has, the more earnings must go to debt payments. Consequently, this will limit the amount of capital that can go to core business, or paying dividends to shareholders. On the other hand, if a firm borrows money to finance its new business, up to a certain extent, the more leverage a firm is, the more market will value the firm. Therefore, dispersion in debt to equity ratios can potentially lead to dispersion in productivity and profitability if in an industry sector firms use the money for different purposes.

In the second part, I address the question whether the strategic value of IT has eroded recently by adding interaction variables between IT stock per employee and dummies for year 2000 and 2001. The full specification of my regression model for both productivity volatility and profitability volatility is as follows:

Volatility = β_0 + β_1 IT Stock Per Emp + β_2 IT Stock Per Emp * Dummy(Year 2000) + β_3 IT Stock Per Emp * Dummy(Year 2001) + β_4 R&D Stock Per Emp + β_5 Advertising Expense Per Emp + β_6 Capital Stock Per Emp + β_7 Labor Compensation Per Emp + β_{7-20} Dummies(Year 1988 to 2001) + ε

According to Carr's argument, if IT's role for differentiating productivity or profitability has declined recently, the coefficients β_2 and β_3 should be negative.

The left panel of table 2 reports the result for productivity volatility. The result indicates the following. First, IT stock exerts a much bigger impact on productivity volatility than labor compensation and non-IT related capital stock.

Second, contrary to Carr's viewpoint, the significance of IT stock has not declined after 1999. The two coefficients, though not significant, are positive. This implies IT's ability to differentiate productivity may have become even greater.

The result also indicates that higher debt to equity ratio indeed translates into high productivity volatility. Note that the amount of advertising expenditure also shows up as a significant factor. However, this may simply imply that advertising contributes to sales volatility, instead of output volatility.

The right panel of table 2 reports the result for profitability volatility. IT stock once again exhibits significant contribution to profitability volatility, much more than that of labor or non-IT capitals. Similar to the case of productivity volatility, I do not observe any decline in IT's role in differentiating profitability.

Therefore, both H1 and H2 are rejected. Note that R&D stock does not show up as a significant factor in both cases. It is probably due to the fact that most data on R&D expense and number of employees are missing in CompuStat. Only 1.38% of observations have both R&D expense and number of employees. Although Hall's approach allows us to construct part of the missing values, the number is still too low to be a true representation for the R&D stock at the industry sector level.

5. Conclusions

My study indicates that contrary to Carr's argument, IT investment has played an important role in differentiating productivities and profitability in the 1990s and continued to serve as a critical factor after 1999. The commoditization of IT equipment has not eliminated IT's strategic value.

As mentioned earlier, just as any input to production, IT, if used in its isolation, cannot lead to productivity and profitability dispersion. The fact that a greater amount of IT stock tends to cause larger dispersions in productivity and profitability is most likely due to variations in firms' ability in adopting new IT practices. Successful IT implementation often involves integrating IT with organizational structure, culture and process. As organizations differ from each other, there is no single best solution for IT implementation. Therefore, even firms with identical IT stock may display vastly different productivity and profitability. In addition, the growing importance of IT's strategic value in 2000s may result from the fact that new technologies are becoming obsolete at an ever faster rate.

6. References

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Table 1. Variable Definitions and Sources

A. Firm Level Data

Variable	Computation	Source
Sales	Gross sales	CompuStat
No. of Employees	Number of employees on the payroll	CompuStat
Debt to Equity	Book value of total debt divided by book value of total equity	CompuStat
Market Value	The value of common stock at the end of fiscal year plus the value of preferred stock plus total debt	CompuStat
R&D Stock	An accumulation of annual R&D expense calculated by a procedure used by Hall (1990)	CompuStat
Net Income	Deflated profit (loss) in a given year	CompuStat
Advertising Expense	The amount of advertising expenses	CompuStat
R&D Expense	The amount of R&D expenses	CompuStat

B. Industry Sector-Level Data

Variable	Computation	Source
Labor Compensation	Total wages and benefits	BLS & SUSB
No. of Employees	Total number of employees on payroll	BLS & SUSB
IT Stock	Real value of IT-related assets	BEA
Non-IT Stock	Real value of Non-IT related assets	BEA
Average R&D Stock	Proxyed by average R&D stock computed using firm-level data	CompuStat
Average Ad Expense	Proxyed by average advertising expense computed using firm-level data	CompuStat
Average Debt/Equity	Proxyed by average debt to equity ratio computed using firm-level data	CompuStat

Table 2. Impact of IT Stock on Profitability Volatility and Profitability Volatility

	Std. of Sales Per Employee		Std. of Growth of Market Value	
IT Stock Per Emp	6.3324485 (13.20)***	5.1008254 (5.80)***	26.8420170 (3.60)***	16.7521763 (1.84)*
IT Stock Per Emp * Year 2000		1.6663135 (1.45)	0.0011675 (0.44)	0.0010378 (0.40)
IT Stock Per Emp * Year 2001		1.6944253 (1.53)		80.4183710 (4.35)***
Std. of Debt /Equity	0.0003672 (3.03)***	0.0003769 (3.12)***		-19.769786 (1.14)
Labor Cost Per Emp	2.0649369 (6.31)***	1.957893 (5.90)***	-0.0003912 (0.02)	-0.0005806 (0.04)
Capital Stock Per Emp	0.1131878 (0.58)	0.0921325 (0.47)	-1.0042009 (0.79)	-0.9223630 (0.75)
R&D Stock Per Emp	-0.5137522 (2.65)***	-0.3399295 (1.55)	2.8553518 (0.63)	2.1396913 (0.49)
Ad Exp. Per Emp	5.1716492 (2.21)**	4.8952820 (2.10)**	63.9427092 (1.62)	60.3332101 (1.58)
Year Dummies	Yes	Yes	Yes	Yes
N	116	116	333	333
R^2	0.79	0.80	0.13	0.20

Absolute value of t statistics in parentheses
* significant at 10%; **significant at 5%; *** significant at 1%