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Technology Investment and Business Performance

This article examines the relationships between measures of information technology (IT) investment and facets of corporate business performance. The results of our study suggest that IT investments have begun to show results in proving they can make a positive contribution to firm output and labor productivity. However, various measures of IT investment do not appear to have a positive relationship with administrative productivity, showing inconsistent results in terms of business performance. Our analysis suggests that while IT is likely to improve organizational efficiency, its effect on administrative productivity and business performance might depend on such other factors as the quality of a firm's management processes and IT-strategy links, which can vary significantly across organizations.

TRYING TO CALCULATE THE RETURN ON CORPORATE IT INVESTMENT ON THE THE BOTTOM LINE? FOCUS ON THE LINKS BETWEEN IT, BUSINESS STRATEGY, AND COMPETITIVE CONTEXT.

Measurement of the business value of IT investment has been the subject of considerable debate by academics and practitioners. The term *productivity paradox* is gaining increasing notoriety as several studies point toward falling productivity and rising IT expenditure in the service sector. Loveman [9] summarizes the research that provides evidence suggesting IT investment produces negligible benefits. Other studies [3] take the position that the "shortfall of evidence" is not "evidence of a shortfall" [3]. Brynjolfsson [3] argues that lack of positive evidence is due to mismeasurements of outputs and inputs, lags in learning and adjustment, redistribution and dissipation of profits, and mismanagement of IT. Our first objective was to reexamine the performance effects of IT investment in light of data collected up to 1994 (see the sidebar, "How the Study Was Done"). We are uncomfortable making such a statement as we have not conducted similar systematic scientific analysis with data later than 1994.

We included three measures of IT investments: aggregate IT, client/server systems, including Internet-related systems, and IT infrastructure. We studied firm performance in terms of firm output, measured using value added by the organization and total sales; business results, assessed using return on assets (ROA) and return on equity (ROE) measures of financial performance; and intermediate performance, assessed using labor productivity and administrative productivity.

Older studies examining the value of IT investment treat such investment as a monolithic entity. It is reasonable to argue that how investment dollars are differentially allocated among various elements of the IT infrastructure should be examined in tandem with how many dollars are spent cumulatively. Our second objective was to examine the relationships between investments in

different elements of the IT infrastructure and multiple measures of firm performance.

Distributed and client/server computing investments have recently been the subject of much interest. Proponents of client/server systems argue that a shift from centralized to distributed computing can improve system openness, customizability, and upgradability. Others suggest that client/server computing has the potential to improve IT productivity, enhance customer service, and provide better return on investment. However, most evidence in this regard has been anecdotal. Our third and final objective was to examine the value of investing in client/server systems.

Appropriate Measures

Several researchers have questioned the appropriateness of the research methodologies used, reliability and validity of datasets, and measurement of benefits in IT investment research [3]. In various studies, there is no uniform conceptualization of IT investment or identification of appropriate performance measures. For instance, if IT investments are conceptualized at the firm level, the value of IT needs to be measured at the firm level as well. On the other hand, if IT investments are conceptualized at the activity or department level, performance should be measured at these lower levels [2]. In addition to the unit of analysis, Brynjolfsson [3] noted that investment in IT may fail to show performance benefits—as many studies are cross-sectional in nature and do not account for the lagged effects of an investment. Lagged effects of IT investment could occur because of learning and readjustment in an organization. In contrast, it can be argued that lagged effects may not be significant in the case of IT investments, as they behave differently from traditional forms of capital investment. The effect of lag in obtaining value from IT investments may be much lower than other types of investment because of the accelerated rate of IT obsolescence. Furthermore, Strassman [11] argues there is no evidence to indicate that the decline in information-worker productivity can be attributed to time lags in obtaining benefits from IT investments, observing that:

More than 80% of any company's information systems cost is in support of current operations and in maintenance. Less than 20% of IT costs can be considered as investments. In the case of hardware investments it is even less because new computer equipment is either depreciated or leased. The cumulative size of the invested application software and hardware, estimated to be at least 20 times the current annual budget, dwarfs current investment funds by a ratio of 100 to 1. Consequently delay in realizing payoffs from new investments cannot possibly explain the lack of current performance.

Therefore, we incorporated multiple performance measures at the firm level, including both IT budget and IT capital. We further decomposed the IT budget into hardware, software, telecommunications, and IS staff expenditure.

IT Investment Dimensions
IT Budget Harris and Katz [6] Weill [12]
IT Capital Hitt and Brynjolfsson [7]
IT Infrastructure Weill [12]
Client/Server Consulting

IT Target	Research Perspective
Firm Output	***Production function approach*** Hitt and Brynjolfsson [7], Loveman [9]
Business Performance	***IT (firm business value)*** Harris and Katz [6], Weill [12]
Intermediate Performance	***IT (firm intermediate performance)*** Barua, Kreibel, and Mukhopadhyay [2], Rai, Patnayakuni, and Patnayakuni [10]

Table 1. Framework for our study

IT Investment Returns. Table 1 shows the dimensions of IT investments and performance-related variables we examined. Other studies at the organizational level of analysis have examined the relationship of IT investment with some indicator(s) of financial performance, such as operating costs, ROA, and ROE. IT is said to enhance organizational capabilities, resulting in improved product variety, quality, and customer satisfaction, while enabling the streamlining of administrative processes and facilitating improved labor and management productivity. However, such improvements are often not reflected in improved financial performance, as benefits may be redistributed within or across organizations or passed on to consumers. As a result, the emphasis in IT investment research has shifted to the study of intermediate and activity-based measures of performance, because these measures are more likely to provide

confirmation of IT payoffs [1, 2].

Breaking Down IT Investments. It has been suggested that rather than treating IT investments as monolithic entities, the nature of IT investments that create business value should be explicated [4, 5, 12].

Both IT capital stock and IT budgets represent aggregate spending on IT. Examining IT budgets is important in an environment of accelerating technological obsolescence and in which current expenditure has a significant role in producing short-term business benefits. Examining the relationships of these aggregate IT investments with business and intermediate performance allows us to assess whether or not IT investments are producing any positive effects on organizations and enables us to specifically identify where such value is accrued.

	Firm Output		Business Performance		Intermediate Performance	
Variables	Value	Sales	ROA	ROE	Labor Productivity	Administrative Productivity
IT Capital	+	+	+		+	
IT Budget	+	+			+	
Client/Server Expenditure	+	+	+		+	
IS Staff Expenditure	+	+			+	–
Hardware Expenditure	+	+			+	–
Software Expenditure	+	+				–
Telecom Expenditure	+	+				–

Figure 1. Our survey results at a glance

Following from our second objective, we moved to a finer level of granularity by examining the effects of investments in key elements of IT infrastructure. IT infrastructure has generally been defined as including hardware, software, development environments, shared databases, common applications, and human skills and expertise. The deployment of IS budgets by business organizations can reflect deliberate management strategies to influence firm performance. We broke down IT budget into key elements of IT infrastructure: hardware, software, telecommunications, and IS staff.

Shifting from centralized to client/server computing can result in efficiency gains for an organization. In client/server environments, the client needs to formulate only the request for data and, subsequently, process the reduced dataset returned by the server. Thus, cost reductions due to improvements in the use of computing resources by the client may be observed. If properly designed, the client/server architecture moves substantially less data through the network. In environments in which larger legacy systems are being replaced, the aggregate costs of network-based servers are often less than the cost of the operating system, application software, and hardware and maintenance costs of their big-iron cousins. The incremental of expanding the networks can also take place in smaller steps. Client/server systems can often be built with off-the-shelf tools that take advantage of up-to-date graphical user interfaces. Such systems can mean quicker response time to user requests, faster completion of system projects, and reduced need for overtime.

Further, client/server systems are viewed as being able to deliver the requisite information to empower users—a central tenet of business process redesign. Such systems can yield improved organizational effectiveness due to an environment of openness and trust in the organization and can result in enhancement of user productivity and firm performance. For end users, client/server computing can present a seamless computing environment. However, it also means systems administrators have to deal with increased complexity and change. Moreover, many processors may have to be upgraded and a stable and reliable communications infrastructure needs to be available for client/server computing. And training and other costs associated with human resources can be significant. Given the radical shift represented by client/server and Internet-based systems as an IT architecture, we examined the association between investments in client/server systems and firm performance.

Interesting Patterns

Our analysis found some interesting patterns (see Figure 1). IT investments are positively associated with firm output; less clear is their relationship with business performance. The lack of a clear association

How the Study Was Done

We obtained data for our study from two sources: *InformationWeek*, a weekly magazine for business and information technology managers, and Compustat, a database of financial and market information on public companies. In 1994, *InformationWeek* surveyed Computstat's top 500 firms for data on IT budgets, replacement costs of computers, client/server expenditure, and a breakdown of IT budget in terms of hardware, software, telecommunications, and IS staff expenditure. Corresponding financial data for these firms were obtained from the Compustat database. The process resulted in minor attrition and a usable sample of 497 firms. Besides, all firms did not respond to all the items in the *InformationWeek* survey. For instance, only 231 firms reported data on IT budgets, and only 192 firms reported data on replacement costs.

The validity and reliability of secondary data is often debated in the literature [3]. Data obtained from secondary sources may be problematic due to inconsistencies in definitions and, consequently, the data reported. This problem is further accentuated when multiple secondary sources are considered. The data reported by *InformationWeek* has been found comparable to data from International Data Group (IDG), a leading IT media, research, and exposition company [8]. The same study also found that the total annual values from IDG data were comparable to those reported by the Bureau of Economic Analysis (BEA), a division of the U.S. Dept. of Commerce providing various economic and statistical data. The *InformationWeek* data is thus consistent with data from other secondary sources, such as IDG and BEA.

Table 1 presents the study variables, their sources, definitions, and descriptive statistics. Replacement cost of computers was taken as a measure of IT capital [7]. Breakup of IT budget was reported by *InformationWeek* as expenditure on hardware, software, telecom, and IS staff. Client/server expenditure was reported separately as a range; the midpoint of this range was used as an estimate of an organization's expenditure on client/server computing. Client/server expenditure represents hardware, software, telecom, and IS staff expenditures devoted to client/server systems. Firms in the sample were categorized as one of two sectors: manufacturing and service. Primary Standard Industrial Classification (SIC) codes (published by the U.S. Dept. of Commerce) were not used to categorize firms into different sectors of the economy as this would have resulted in a too-small number of firms within each group to permit meaningful analysis.

We considered six performance variables: business output as measured by value added and by sales; financial business performance as measured by two accounting-based ratios (ROA and ROE); and intermediate performance as measured by labor productivity and administrative productivity. Administrative productivity is the ratio of value added to the total administrative costs of the firm (similar to Strassman's [11] concept of management productivity); labor productivity is the ratio of value added to the total number of employees.

Descriptive statistics show that average IT budgets are greater than IT capital, suggesting a high rate of obsolescence for IT. On average, 25% of organizational IT budgets are devoted to client/server computing.

We applied the production function approach (a methodology relating outputs to multiple inputs) to measures of firm output—an approach employed in earlier research in IT investments [7, 9]. For analysis, we used the natural logarithm form of the Cobb-Douglas production function:

$$\text{Log (Performance)} = \beta_0 + \beta_1 \textit{Sector} + \beta_2 \text{Log}(\textit{Capital}) + \beta_3 \text{Log}\,(\textit{Labor}) + \beta_4 \text{Log}(\textit{IT input}) + \epsilon$$

IT factor inputs considered individually were IT capital, IT budget, client/server investment, and IT infrastructure investment. Each component of IT infrastructure was entered in a separate regression equation, as dollar values of these investments are highly correlated. The IT input variables were entered after removing variances in firm output associated with differences in capital, labor, and sector.

The effect of IT investments on firm business and intermediate performance was analyzed in the tradition of earlier research on IT and business value [2, 7, 10, 12]. The association of IT inputs with business and intermediate performance was estimated using hierarchical regression. Both sector and size were used as control variables. IT inputs were entered after the variance due to size and sector was eliminated. As size and IT inputs were skewed positively, their natural logarithms were used. The estimated regression equations were:

$$\text{Financial Performance Ratio} = \beta_0 + \beta_1 \text{Log}\,(\textit{Size}) + \beta_2 \textit{Sector} + \beta_3 \text{Log}\,(\textit{IT inputs}) + \epsilon$$

$$\text{Intermediate Productivity Ratio} = \beta_0 + \beta_1 \text{Log}\,(\textit{Size}) + \beta_2 \textit{Sector} + \beta_3 \text{Log}\,(\textit{IT inputs}) + \epsilon$$

The results are summarized in Tables 2a, b, c, and d. There is a

strong association between both IT capital and IT budget and the two measures of firm output (see Table 2a). IT infrastructure investments and investments in client/server systems show positive associations with both measures of firm output (see Table 2b). The relationship of both IT budget and IT capital with business performance ratios is less consistent in nature (see Table 2c). IT capital is positively related to ROA, while neither IT capital nor IT budget shows significant association with ROE. No association is

Table 1. Variable definitions and descriptive statistics used in our study

Variable	Definition	Source	Mean ($ Millions)	Stand. Dev.
Investment				
IT Capital	Replacement cost	*InformationWeek*	115	158.4
IT Budget	Combined capital and operating budget of IS department directly controlled by the CIO	Computed from *InformationWeek* data (% IT budget x IT budget)	180.3	353.3
Client/Server	Percentage of IT budget devoted to client/server systems		45	86.5
Hardware	Percentage of IT budget devoted to each category of expenditure		39.3	77.4
Software			20.2	42.3
IS Staff			63.1	106.6
Telecom			21.8	42.7
Labor Investment				
Labor	Labor and Related Expenses. When not available, estimate based on industry[a] average labor costs x No. of employees.	Computed	1,662.3	2,693.8
Capital Investment				
Total Capital	Total Property, Plant, and Equipment	Compustat	6,456	10,958.3
Noncomputer Capital	Total Capital (IT capital)	Computed	5,530.4	7,984.1
Control Variables				
Size	Total No. of Employees (in thousands)	Compustat	44.9	72.6
Sector	The sector to which the firm belongs. Included in the base sample are 244 manufacturing firms and 253 service firms. Coded as dummy variables (manufacturing = 0; service = 1)			
Output Measures				
Value	Sales (labor expenses)	Computed	6,415	10,745.5
Sales	Total Sales	Compustat	7,738.8	12,207.6
Performance Ratios				
ROA	Pretax income/Total assets	Compustat	3.41	6.9
ROE	Pretax income/Total shareholder equity	Compustat	7.8	121.4
Productivity Ratios				
Labor Productivity	Value/Total Employees	Computed	238.9	364.2
Administrative Productivity	Value/Selling, General, and Administrative Expenses[b] (IT Budget)	Computed	1.35	78.4

Key:
[a] Industries were classified into 18 groups bused on BEA's 1994 table of income by industry.
[b] Selling, general, and administrative expenses (all commercial expenses not directly related to production in the course of regular business).

Table 2. IT investment and facets of corporate business performance

▼ **Table 2a.** Aggregate IT investment and firm output

Variables	Firm Output[a]	
	Value	Sales
IT Capital	0.23**	0.26**
R^2%	41.3	56.5
IT Buget	0.45**	0.42**
R^2%	55.1	68.3

▲ **Table 2b.** IT infrastructure investment and firm output

Variables	Firm Output[a]	
	Value	Sales
Client/Server Expenditure	0.24**	0.22**
R^2%	47.2	60.6
IS Staff Expenditure	0.35**	0.33**
R^2%	49.8	63.5
Hardware Expenditure	0.30**	0.30**
R^2%	47	62.2
Software Expenditure	0.16*	0.18**
R^2%	42.8	58.2
Telecom Expenditure	0.20*	0.21**
R^2%	47.1	60.2

▼ **Table 2c.** IT investment and firm performance ratios

Variables	Performance Ratios[b]			
	Business Performance		Intermediate Performance	
	ROA	ROE	Labor Productivity	Administrative Productivity
IT Capital	0.17*	n.s.	0.17**	n.s.
R^2%	5.1		40.3	
IT Buget	n.s.	n.s.	0.28**	n.s.
R^2%			39.5	

▼ **Table 2d.** IT infrastructure investment and firm performance ratios

Variables	Performance Ratios[b]			
	Business Performance		Intermediate Performance	
	ROA	ROE	Labor Productivity	Administrative Productivity
Client/Server Expenditure	0.23**	n.s.	0.18**	n.s.
R^2%	5.9		38.7	
IS Staff Expenditure	n.s.	n.s.	0.23**	−0.21*
R^2%			40.7	16.4
Hardware Expenditure	n.s.	n.s.	0.17**	−0.33**
R^2%			41.2	21.5
Software Expenditure	n.s.	n.s.	n.s.	−0.20*
R^2%				16.9
Telecom Expenditure	n.s.	n.s.	0.19**	−0.22*
R^2%			34.9	13.3

Key: [a]Production function estimated as hierarchical regression controlling for capital and labor and sector, pairwise deletion of data. N > = 144.
[b]Heirarichical regression controlling for size and sector, parwise deletion of data. N > = 124.
* p =< 0.05; ** p =< 0.01

observed between IT infrastructure investments and business performance ratios (see Table 2d). The association between client/server investment and business performance ratios is significant only for ROA.

IT capital, IT budget, and client/server expenditure are positively related to labor productivity, while insignificant results are observed for administrative productivity (see Table 2c and 2d). IT infrastructure investments, except for software expenditure, show positive association with labor productivity. All IT infrastructure investments, except client/server expenditure, are negatively related to administrative productivity (see Table 2d).

between aggregate IT investments and business performance is consistent with some earlier studies [7]. The presence of a relationship between IT capital and ROA and the lack thereof between IT capital and ROE is intriguing. ROE provides a measure of how effectively a firm uses financial capital [7]. Managers are increasingly examining this measure because it indicates how well the firm is managing resources invested by stakeholders. ROA may be a better indicator of the effectiveness of capital investments than ROE, as the latter combines the effects of capital investments as well as financial leverage employed by the firm. It is therefore likely that ROE may not be an appropriate criterion for judging the value of IT investments.

Hitt and Brynjolfsson [7] argue that IT has the capacity to lower and increase entry barriers and to intensify and reduce competitive rivalry. They also cite this equivocal effect of IT on competitive strategy and industry structure as an important reason for the lack of relationships between IT investment and measures of profitability, such as ROA and ROE. Our results also suggest that while various measures of IT investment can increase firm output and lower firm costs, their effect on financial measures of business performance is less consistent. Only IT capital and client/server expenditure are positively related to ROA. Variation in the links between IT, business strategy, and competitive context across firms may significantly influence financial performance. Incorporation of these contingencies may provide a better explanation of the relationship between IT investments and financial performance.

The two measures of aggregate IT investments—IT capital and IT budget—show a differential relationship with ROA. We found a positive association between IT capital and ROA and report it here for the first time. This finding may indicate that cumulative investments in IT capital have begun to reach a critical mass that can influence firm business performance. Improvements in business performance require accumulated competencies and periods of learning and adjustment arising from cumulative IT investments. Operational expenditure on IT can increase firm output and improve efficiency in the short run, but long-term investments in IT assets may be required to improve such business performance ratios as ROA.

IT budget allocation to IS staff indicates an organization's commitment to attracting, retaining, and developing high-quality IS human resources. Such development is becoming a critical component of IS capabilities due to the growing need for integrating IS with business operations, high turnover by IS staff, and an emphasis on timely systems delivery. IS staff expenses constitute the largest component of IS budgets, and the results suggest that investment in developing and sustaining IS staff has a positive association with firm output and labor productivity.

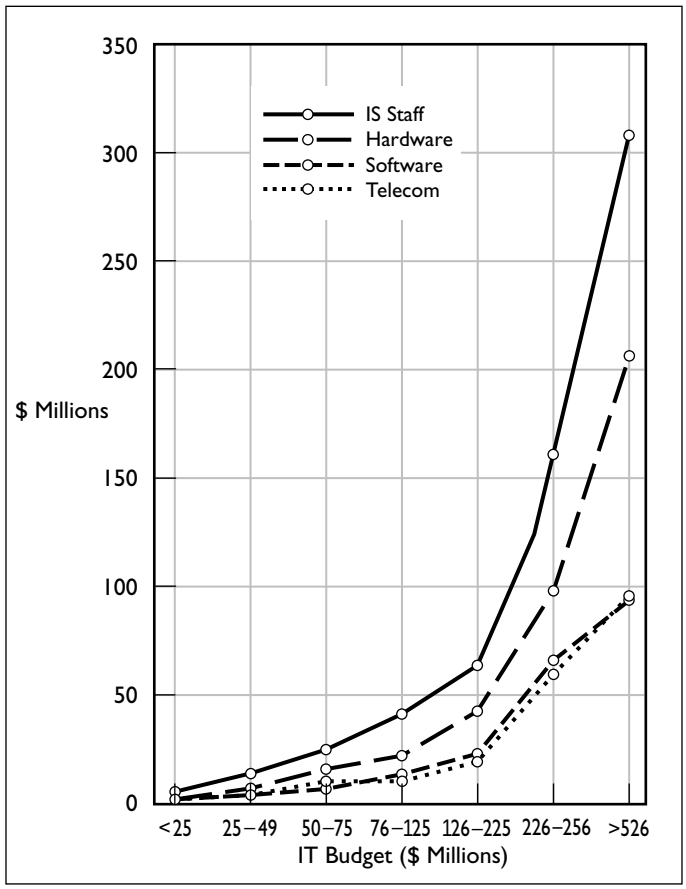

Figure 2. IT budget and infrastructure expenditure

As with IS staff, telecom and hardware investments are positively associated with firm output and labor productivity. Hardware, software, and telecommunication investments are critical to implementing new technological infrastructure and developing end-user computing applications in an environment of distributed and client/server computing. The lack of association between software investments and labor productivity and their weak relationships with other performance measures needs to be investigated further. Figure 2 shows the relationship between IT budgets and IT infrastruc-

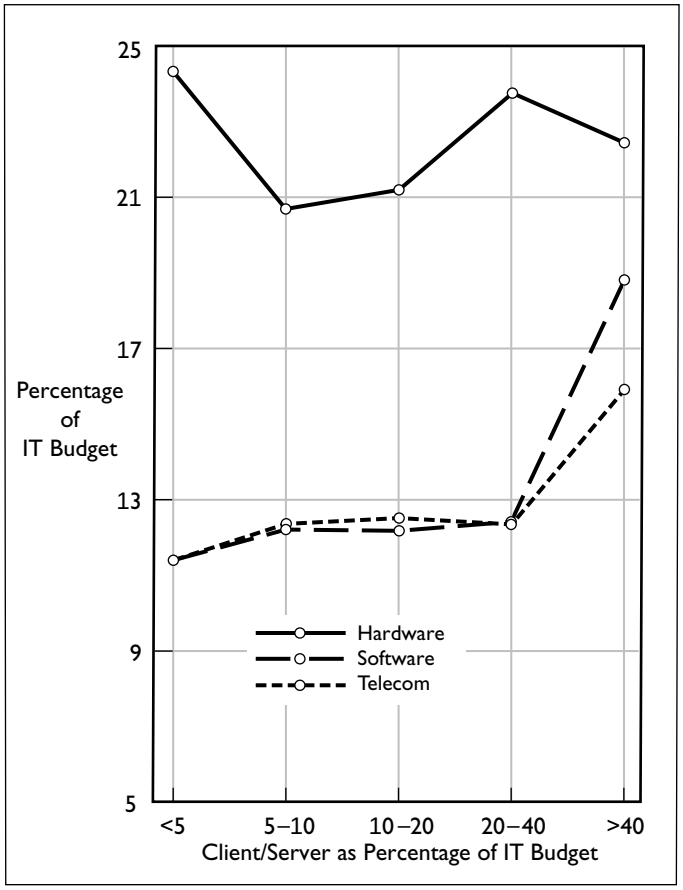

Figure 3. Infrastructure and client/server systems as a percentage of IT budgets

ture expenditures. Expenditures on IS staff and hardware show the greatest increase. As IT budgets increase, the proportion of expenditure on acquired software and telecom falls relative to other components of the IT budget.

Figure 3 shows the relationship between the proportion of an IT budget spent on client/server and the proportion spent on hardware, software, and telecom. When client/server expenditures are more than 40% of the IT budget, the proportion spent on software and telecom increases rapidly while hardware expenditures drop. It can be argued that organizations in the early stages of client/server computing invest steadily in their telecom infrastructures. The surge in the proportion of IT budgets spent on software, as the proportion spent on client/server goes beyond 40%, could be accounted for by increasing expenditures on client/server applications likely to replace legacy applications. A reasonable telecommunication infrastructure may need to be in place before investment can be directed at client/server applications. The critical threshold of networked infrastructure required by organizations to begin investing heavily in client/server applications may only be emerging. As a result, most organizations may not have invested sufficiently in client/server software. This lack of investment may be a possible reason for the lack of relationship between aggregate software expenditure and labor productivity, even though expenditures on client/server systems are positively associated with labor productivity.

Total investment in client/server computing shows a positive relationship with output measures, ROA, and labor productivity (see the sidebar's Table 2). The excitement surrounding client/server and Internet-based systems may actually be more than hype. These investments seem to create business value directly. ROA is positively associated with client/server investments, whereas no significant relationship is observed between these investments and IT budgets. A positive relationship with ROA indicates that institutional factors and imitative tendencies may not account for most investments in client/server computing. Investments in client/server computing may be better aligned with strategic corporate goals and business planning processes compared to IT operating expenditures.

The overall positive results for labor productivity suggest that IT has succeeded in reducing production costs and improving the productivity of all personnel. Increased efficiency of human resources may be the result of automating repetitive production and clerical processes.

The insignificant results for administrative productivity indicate that IT does not reduce the costs or increase the productivity of management to the extent it increases labor productivity throughout the business. Large investments in IT capital, budget, infrastructure, and client/server on its own may not improve administrative productivity. The results of our study suggest that the ratio of administrative expenses to value added is not improved by increasing IT investments. The results are largely consistent with Strassman's [11] discussion of "management productivity" in which he writes:

Computers will not make a badly managed business better. The expenses for computerization and the increased rigidity in computer managed procedures are likely to accelerate the decline of incompetent management.

IT investments may not benefit poorly managed organizations as they automate dysfunctional management processes, increase sunk costs, and reduce

management flexibility to respond to change. It can be argued that deriving administrative productivity from IT investments requires simplification of management tasks, reduction of administrative overhead, and redesign of business processes. Organizations failing to redesign management processes while increasing IT investment are likely to see administrative diseconomies of scale and rising overhead expenses without any concomitant increases in administrative productivity. Increasing diseconomies of scale as a result of superimposing IT on inefficient management processes might be responsible for the negative results in administrative productivity despite increased expenditures for IT infrastructure.

Conclusions

There is a need to improve the modeling and measurement of the performance effects of aggregate IT investments. Our study suggests that measures of IT investment have differential effects on the various measures of corporate business performance. A research strategy for modeling IT effects on firm output performance and labor productivity needs to be different from a research strategy for modeling IT effects on management effectiveness and strategic business performance.

Another significant issue is how IT's effects should be measured. Organizations measure value of IT investments to a very limited extent in terms of minimal benchmarks of time and cost schedules. Disaggregating IT investments in terms of specific activities and IS applications offers tremendous measurement advantages but suffers from two disadvantages: failure to examine the synergies between multiple IT investments and failure to give senior management a clear indication of how IT investments compare with a variety of other investments made by the organization. Modeling performance effects at the level of specific technologies and activities ignores the strategic and bottom-line effects of the portfolio of investments.

The justification processes for IT investments in organizations should consider the specific objectives of the proposed investments. Investment aimed at reducing labor costs or increasing firm output can be justified on the basis of cost savings and such quantitative measures of returns as net present value and internal rate of return. If the objective of proposed investments is to improve business performance, the justification should be closely tied to the organization's business planning processes and aligned with both short-term and long-term strategies. IT investments for improving the effectiveness of an organization's management require a simplification and redesign of management processes. In the absence of such redesign, IT investments may increase management expenses without concomitant increases in management productivity. C

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