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The influence of information technology diffusion and business process change on perceived productivity: The IS executive's perspective

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Abstract

A hallmark of the emerging 'information age' is the dramatic rise in expenditures by modern business enterprises on information technologies (IT). On account of these investments, senior managers anticipate gains in productivity, which are commensurate with the cost of modern IT and Information Systems. While the evolving capabilities of emerging IT are evident, the association between technological diffusion and increased productivity has not been readily demonstrated in terms of corporate repositioning or scholarly research findings. One possible source of this paradox is the absence or presence of Business Process Redesign in positioning the organization to assimilate and leverage technological innovation. This study empirically examines the nature and magnitude of relationships between IT diffusion, perceived productivity improvement, and process redesign. The findings suggest that process redesign and IT have a complex relationship with productivity, and that these can be represented by a mediating or moderating model for different technologies. The data, while exploratory, do suggest alternate ways to examine the productivity paradox. © 1998 Elsevier Science B.V. All rights reserved

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1. Introduction

The measurable impact of information technology (IT) investments on productivity remains a topic of intense debate among managers and researchers. While modern organizations continue to invest heavily in advanced communications and computing technologies, research studies and practitioner surveys report contradictory findings on the effect of these expenditures on organizational productivity [2, 5, 21, 38]. Given the extraordinary improvement in speed, interconnectivity, and user-friendliness of emerging IT, ambiguity with respect to this asset's influence on productivity is particularly troublesome. Perhaps of even greater concern is the possibility that this 'productivity paradox' may create a wave of cynicism among top executives that may unfavorably bias technology-based investment decisions. Clearly, an important agenda within the area of IT management and

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research is the investigation of how, when, and to what extent investment in IT influences change in productivity.

This study takes an alternate view to this productivity paradox. Rather than examine IT investments and their impact on bottom line metrics, the study examines IT *diffusion* within the organization, and its impact on *perceived* productivity. By utilizing major IT decision makers as the frame of reference, the study attempts to provide a barometer of whether higher levels of IT diffusion result in a perception of increased productivity. Further, rather than using IT as a generic entity, it is refined into various types of IT, so that differential impacts on perceived productivity can be examined. The extent of business process change (or redesign) is empirically examined, as a potential intervening factor in the relationship between each type of IT diffusion and perceived productivity improvement. As noted in several recent studies [10, 14, 18, 19], investments in IT without a re-calibration of underlying process structures can lead to optimization of tasks and sub-optimization of larger inter-functional processes. This state of affairs can lead to incremental gains in productivity that fall well below managerial expectations. Through regression analysis, we examine two fundamentally different forms of intervention in the IT–productivity relationship. The first of these, *moderation*, suggests that the interaction of process change and IT diffusion is as important as either of its components (IT diffusion and process change) in predicting increases in perceived productivity. In essence, perceived process change is tested for its influence on the strength of the association between IT diffusion and perceived productivity improvement. The second effect, *mediation*, suggests that IT diffusion influences productivity primarily through its impact on process change. Through analysis of these relationships, it is hoped that further understanding of the nature and magnitude of these interactions can be gleaned, thereby providing a clearer frame of reference for IT decisions and associated changes in process structure, that are implied.

Therefore, the major questions addressed are: (1) is there a relationship between IT diffusion and productivity as perceived by senior IS executives? (2) what is the nature of the intervening effect (if any) of process redesign? and (3) Do these effects vary by type of IT? Collectively, through these questions we hope to get a different, albeit exploratory, perspective on IT's impact on productivity.

2. IT and organizational productivity

Through their direct impact on two important factors of production, *information* and *knowledge*, computing and communications technologies promise enormous gains in levels of organizational productivity [24]. As noted by Laudon and Marr [27], in advanced information economies where information and knowledge work account for 60% of GDP, it is only logical to conclude that revolutionary improvements in IT coupled with exponential increases in IT investment within factories and offices will most certainly lead to significant and widespread gains in organizational productivity. However, while spending on IT has surged, formal empirical evidence linking IT to gains in productivity has been mixed. The inconsistencies have caused some to question the value of IT investment, and others to suggest that the empirical association between IT and productivity is much more complex than the theoretical association. Those of the latter opinion suggest that measurement issues contribute to the apparent ambiguity among research findings. In Table 1 some studies are shown. These are organized according to their conclusions on the influence of IT on productivity.

In general, results of the first set of studies (where IT does not improve productivity) epitomize the productivity paradox. However, it has been suggested that data and methodological issues could confound the results. Panko [31] and Ho [22] point out weaknesses in the BLS (Bureau of Labor Statistics) data used by Roach [33] and other economists. Brynjolfsson [5] suggests that poor measurement of input and output variables and failure to consider time lags could be two important explanations for these results. Further evidence of these potential confounds is the contradictory result found in the second set of studies (where IT was found to increase productivity). Among these, a study by Hitt and Brynjolfsson [21] provides the most compelling evidence. Using a large data set and econometric models similar to prior studies, they found ROI for computer capital to be large and significant among the manufacturing and service firms in

Table 1
Studies on information technology and productivity

Study	Method	IT Measure	Productivity Measure	Conclusion
Studies that found IT does not improve productivity				
Loveman [28]	PIMS (Profit Impact of Market Strategy) data for 60 U.S. and European SBUs	IT capital investment	Performance ratios (ROI)	Productivity gain zero over a 5-year period
Strassman [38]	Survey of 38 service firms	IT budgets/investment/ratios	Profitibility ratios and return on management	No relationship between IT investments and returns
Berndt and Morrison [4]	BEA (Bureau of Economic Analysis) data from the U.S. Department of Commerce	Total IT capital investment	Labor productivity and profitability (IRR)	Incremental benefits since 1986 were 20% lower than incremental investments indicating IT overinvestment
Roach [33]	BLS (Bureau of Labor Statistics), BEA data for service sectors	Total IT capital investment	Output of production workers vs. information workers	Decline in information worker productivity. IT investments inefficient in service sector
Studies that found IT does improve productivity				
Osterman [30]	Data from 40 service and manufacturing industries	Number of mainframe CPUs	Clerical and managerial employment	Increase in computing stock decreases employment
Harris and Katz [20]	Data from 40 life insurance firms	IT expense as a percentage of operating expense	Operating expense as a percentage of premium income	Firms that are profitable have higher growth on IT expense ratios and lower growth on operating expense ratios. Positive but weak relationships
Alpar and Kim [1]	Data collected by the Federal Reserve Bank	IS expenses (along with time deposits, labor and capital expenses)	Multifactor (loans and demand deposits)	IT results in decrease in costs and increase in time deposits. However, findings are sensitive to the assessment approach used
Brynjolfsson and Hitt [6]	Data set on IS spending compiled by the International Data Group. Also, Compustat and BEA data	Computer capital/IS staff labor	Output dollars of firm in industry	Return on IT investments averaged 68% in manufacturing and services

the sample. They conclude that the productivity paradox was not evident in their sample, perhaps due to the recent time frame of the study and the more detailed data set used. They also suggest that radical organizational change may be a way to leverage high intensity of computer usage.

Given the contradictory conclusions regarding IT's impact on productivity, some studies have attempted to rationalize the observation through the presence of intervening variables. One of the first efforts to empirically examine this possibility was conducted by Cron and Sobol [9]. In a study of 138 medical supply wholesalers, they found a bi-modal performance distribution among high IT investors. Such a finding suggests that the presence of organizational factors may affect returns derived from IT spending. More recently, Weill [43], in a study of 33 valve manufacturing firms over a 6-year period, found that 'conversion effectiveness' or the quality of firm-wide management and commitment to be a significant moderator between IT investment and performance. Brynjolfsson [5] discuses the possibility that IT is not productive at the firm level because of mismanagement. More money spent on IT in automating inefficient processes will not help until the process by which products and services are delivered are radically redesigned [21].

In sum, the results of these studies indicate that the relationship between IT and productivity is unclear and confounded by methodological problems and intervening variables. Most analyses have been based on economic data aggregated across firms and industries. Typically, these studies measure the IT variable in terms of dollar investment in technology and attempt to gauge the productivity variable by profit and ROI. While there are obvious advantages in using objective measures, a number of intervening variables may influence the relationship and confound the results. For the independent variable, what really matters is the extent to which IT is *effectively utilized* in the organization, not the sheer amount of investment in that technology. Depending on how these technologies are implemented, the same amount of investment in two different organizations may lead to success in one organization and failure in another. For the dependent variable, it should be recognized that there is a complex array of factors influencing market success of a firm including strategy, economic, and competitive environment in addition to IT. In a study conducted by Kettinger et al. [26], a variety of factors was identified that influences the sustainability of strategic information systems, including environmental factors (e.g. unique industry characteristics, changes in regulatory environment), foundation factors (firm's IT infrastructure) and action strategies which initiate strategic IS applications. In fact, information systems that cannot sustain competitive impact have only transient strategic value or may offer negative value if matched by a superior response by competitors.

In this study, we attempt to take an alternate non-economic view of IT productivity. Three changes are made in the approach to this problem in contrast to prior studies:

1. For the independent variable we gauge actual IT utilization by assessing the extent of its diffusion in the organization. This diffusion resulted from the initial investment but may have experienced more or less success in the process of implementation.
2. For the dependent variable, *perceived* productivity improvement in the organization is assessed. Such productivity gain may or may not lead to eventual market success depending on many contingency factors. However, senior IT gatekeepers often make key decisions on their perceptions of IT effectiveness.
3. Rather than consider one generic IT, we refine it into specific technologies.

2.1. IT: Process change and productivity

Over the past several years, many organizations have attempted business process reengineering (BPR) as advocated by Hammer and Champy [19] and Davenport [10] with varying degrees of success. While the BPR concept of 'revolution' and 'obliteration' is appealing, its root may be traced to quality improvement techniques, systems analysis, and the socio-technical design theories [11]. BPR attempts to achieve dramatic performance improvements by breaking down outdated assumptions and rules. The role of IT in these changes is well documented [17, 41]. However, IT is just one of the enablers of process change. In addition to IT, success of process change also depends on organizational structural enablers, management systems enablers and human resource enablers [40]. With more experience accumulated, there is growing realization that IT is a critical enabler, but implementing reengineering involves complex socio-technical change in the organization [29, 36]. Results of a recent empirical field study reported by Grover et al. [16] indicate that among a number of reengineering implementation problems, change management was regarded as the most severe. The exaltation of 'business revolution,' which was advocated by BPR proponents at the beginning of the movement [19], has been tempered by evidence from the field pointing to the merits of evolutionary change [37].

The complex organizational contingencies of BPR success aside, certain precepts do suggest a fresh angle in examining the relationship between IT and productivity. Fundamental to the reengineering concept is the distinction between automation and redesign. Many of the early applications of IT in organizations focused on automating existing procedures: this approach may improve efficiency and reduce cost but lead to limited productivity impact. With reengineering, the business process is critically examined for redundant steps and opportunities for totally new ways of achieving the output. If successfully implemented, breakthrough performance gain in productivity can be achieved.

Of course, IT impacts can be gauged along many dimensions representing the depth of change. Process automation is the least deep and could result in efficiency gains. Effectiveness, in turn, requires changes in not only technology, but process skills, job roles and work flows [18, 37]. Davenport goes one step further in suggesting that process change is the "best hope we have for getting value out of our vast IT expenditures." He indicates that the productivity paradox can be explained by the mediating effect of process change between IT initiatives and economic return. Further, he suggests that managers seeking returns on IT investments must strive to ensure that process changes are realized or benefits will be minimal.

The significance of process change in enhancing the productivity impact of IT investment is well illustrated by the 'Orion' project at Federal Express. It effectively utilized imaging technology to store the massive employee documentation requirements of a growing worldwide workforce. Early use of the technology had very little effect, as it entailed scanning of paper documents into an image repository. This allowed faster document retrieval, but the old ways of work still remained. Quantum increase in benefits was obtained, however, when the process was changed. New work flow patterns that eliminated data entry, allowed simultaneous inputs from alternative sources and multiple parties instant access to documents, created major productivity improvements [7]. Similarly, the use of 'Case Managers' that provide interface between the customers and the organization, usually draw from an expert system (e.g. at Mutual Benefit Life) or integrated databases (e.g. at Pacific Bell) in order to provide complete management of a work process and resolve customer issues. In this case, the IT repositories would benefit little if the old sequential processing methods were not reengineered to accommodate the new case manager process [12].

Thus, process change seems to be an important intervening variable in the relationship between IT and productivity. It can be hypothesized as having two forms: a moderating one that captures the notion that IT will have a greater impact on productivity only if the process is changed and a mediating one that indicates that IT will cause process change which can lead to higher productivity. In the former case, process change is an *enabler*, while in the latter, leveraging IT *requires* process change.

3. IT and organizational productivity: The intervening role of process change

There are numerous models that examine the impact of technology on the organization. These are usually applied at the individual, work group, and organizational levels. Among these, the socio-technical model [35], the technological change model [42] and the independent effects model [15] have each proposed and examined the interdependence of technology and organizational initiatives (e.g. work redesign) in manufacturing units. However, to our knowledge, the study of process change as an intervening variable between IT and productivity has not been examined empirically. In this study, we will explore process change as an intervening mediating and moderating variable.

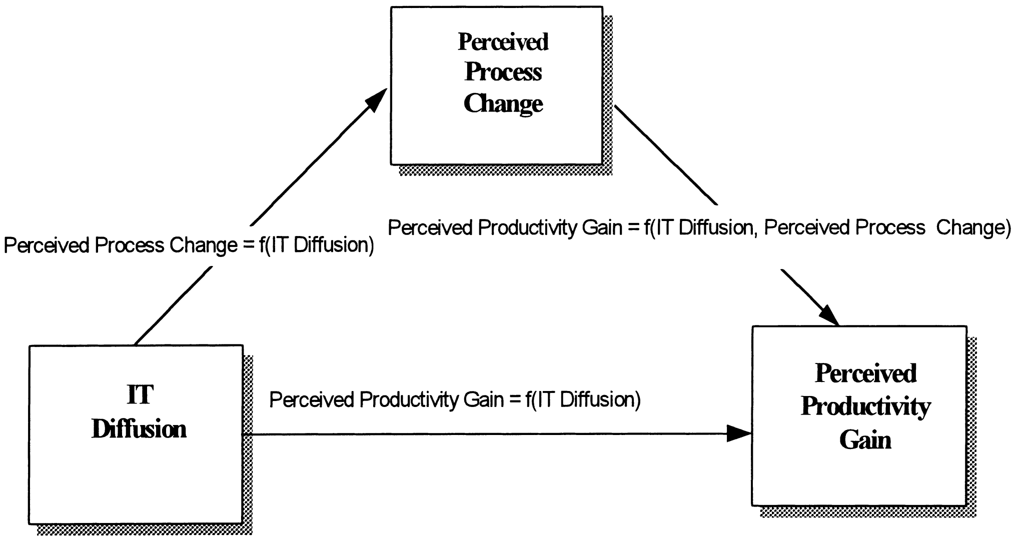

Fig. 1. A mediating effects model of IT diffusion, perceived process change, and perceived productivity gain.

3.1. The nature of mediating effects

A variable is said to function as a mediator when it accounts for a significant amount of the causality between a predictor and criterion variable [3]. A mediating model of perceived process change with respect to perceived productivity and IT diffusion[1] is illustrated in Fig. 1. As shown, the model assumes a three-variable system with two causal paths influencing the outcome variable (perceived productivity gain). Perceived process change mediates the association between IT diffusion and perceived productivity improvement when association between IT diffusion and perceived productivity improvement is significantly lessened with the introduction of perceived process change. Elimination of the association between IT diffusion and perceived productivity improvement would suggest that process change is a necessary and sufficient condition for IT-induced productivity. This relationship, stated in the form of a research proposition, is:

Proposition 1: *The relationship between IT and Perceived Productivity Improvement will be mediated by the extent of Perceived Process Change associated with the IT.*

[1]The penetration of IT in the organizational unit. The economic equivalent of this could be IT investment.

3.2. The nature of moderating effects

A moderating variable affects the direction and/or strength of the relation between an independent and dependent variable [3]: the strength and direction of association between IT diffusion and perceived productivity improvement is influenced by the level of perceived process change. This effect is illustrated in Fig. 2. This model has three causal paths. The moderating effect of perceived process change is supported through the significance of the interaction. This model, of course, is generally statistically symmetrical, that is, it also indicates that the relationship between perceived process change and perceived productivity gain will be moderated by IT. Stated in the form of an alternative proposition, this association is:

Proposition 1A: *The relationship between IT and Perceived Productivity Improvement will be moderated by the extent of Perceived Process Change associated with the IT.*

4. Methodology

In contrast to a prior study, our study uses primary firm-level non-economic data from a large sample. While many of the criticisms of survey research are

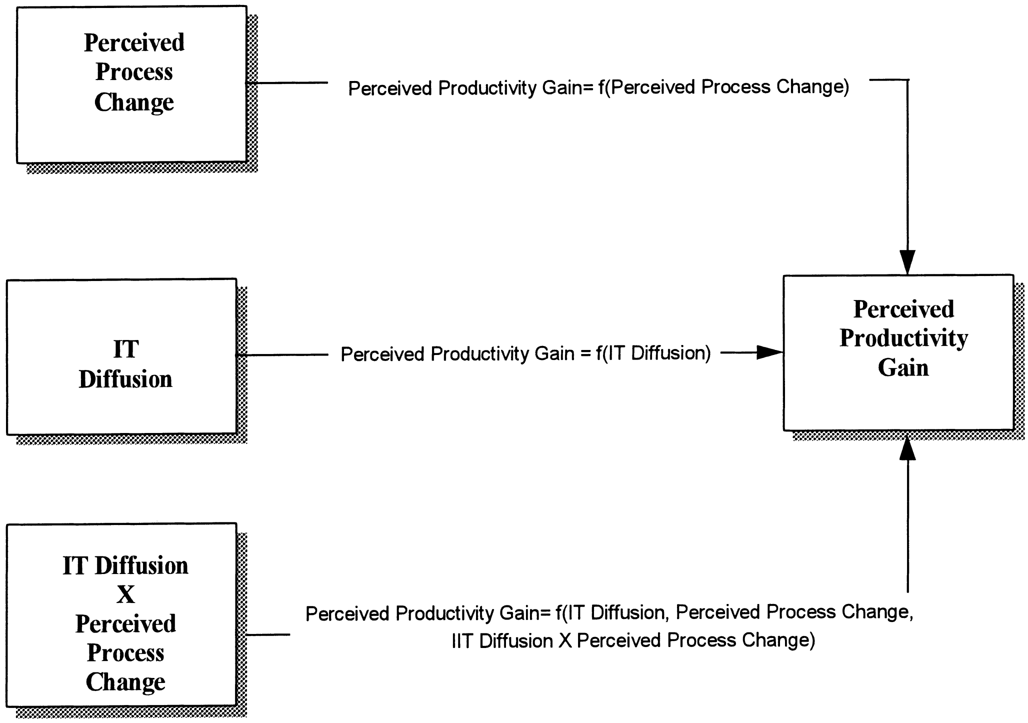

Fig. 2. A moderating effects model of IT diffusion, perceived process change, and perceived productivity gain.

acknowledged, we believe that this alternative method, albeit exploratory, is appropriate here. Further, given the diverse nature of technologies and process change efforts, it seems reasonable to suspect that some technologies will be enablers of reengineering efforts (a moderating effect) while others will depend on the existence of perceived process change to positively impact perceived productivity improvement (a mediating effect).

4.1. Measures

The unit of analysis within this study is the organization. In general, information technology is assessed in terms of its penetration or diffusion in the organizational unit. Eleven technologies are used to describe IT diffusion. These include a myriad of contemporary hardware and software technologies drawn from various technological studies [39]. Eleven specific technologies selected are: Electronic Mail, Expert Systems, Teleconferencing, EDI, EIS, Computer Aided Software Engineering (CASE), OOP (Object Oriented Programming), Client/Server Architecture, Large Scale Relational DBMS, Local Area Networks (LAN), and Imaging Technology.

Three variables are examined for each IT: (a) *IT diffusion* or penetration within the organization, (b) the perceived extent of process change associated with it, and (c) the perceived *productivity improvement* of the business processes as a result of IT. As a measure, IT diffusion is consistent with the organizational unit of analysis and is popular within the innovation–diffusion literature. While many innovation measures focus on the number of adoptions within the organization [13], it is important to normalize this number based on the number of potential adopters. For instance, CASE technology might not have significant penetration outside the IS group. Therefore, the following item assesses cumulative diffusion level item for each IT based on a ratio (percentage) scale.

For those employees who can benefit from this IT, what percentage are using it? —%
11 items, one for each IT

The extent of perceived process change associated with each IT is assessed using a 5-point Likert-type scale, ranging from 'strongly disagree' to 'strongly agree.' The difference in format for this item can reduce the problem of method bias. In each item, care was taken to emphasize structural change in the process.

	SD	D	N	A	SA
This IT has **radically changed** the nature of the					
business processes that it serves (e.g. by reducing redundant steps, changing work flow patterns).	1	2	3	4	5
11 items, one for each IT					

Finally, perceived productivity improvement (in terms of efficiency and effectiveness) of the business processes is assessed for all technologies on a similar Likert scale.

	SD	D	N	A	SA
This IT has significantly improved					
productivity of the business processes that it serves (i.e. process efficiency and/or effectiveness).	1	2	3	4	5
11 items, one for each IT					

4.2. Sample and administration

The survey instrument was iteratively refined through feedback from 12 IS executives in different metropolitan areas. Seven of them were interviewed face-to-face for over one hour. The feedback primarily resulted in the refinement of technologies and minor modification of the wording. The final instrument was administered to a population of 900 executives drawn from a database of over 5000 executives affiliated with a leading professional publishing and information service firm. This firm compiles and sells information of the subscriber base of the 14 information technology-related magazines it publishes. The sample frame requested was senior IS executives (Director or above) in unique U.S.-based for-profit organizations.

The primary objective of this study was to examine the influence of IT diffusion and perceived process change on perceived productivity improvement. Toward this end, data were gathered from a large statistically viable population by using a questionnaire. The target respondent was the senior IS executive. This is consistent with Huber and Power's [23] recommendation that when one respondent per unit is solicited, it should be the most informed person. It was presumed that the corporate senior IS executive would be the most informed respondent regarding the diffusion of IS innovation. The host organization was defined as the strategic business unit served by the IS group. From these, only businesses having over $50 million in revenue were randomly selected. To encourage response, a small monetary incentive was provided. Also, to reduce self-reporting bias, each executive was given the opportunity of receiving a report of their firm's position along the variables of interest with respect to firms of their industry, firms of similar size, and firms with similar patterns of IT diffusion.

Two mailings were sent out one month apart. Respondents were encouraged to phone with any questions about the instrument. Of the 900 initial mailings, 45 were returned because they did not reach the targeted individual. However, 313 usable responses were obtained, representing an effective response rate of 36.6%. The industry sector and size of responding firms is provided in Table 2. Over half the sample is from the financial and manufacturing sectors. Also, over half of the responding organizations have over 2500 employees, with about one-third having over 5000. While these descriptive statistics are similar to those observed in similar survey-based IS studies [32], the sample seems biased towards moderate-sized finance and manufacturing firms. Therefore, caution should be exercised in extending the results to all organizations and industry sectors.

4.3. Empirically testing mediation and moderation

As noted by Judd and Kenny [25] a series of regression models provides the best test of a mediating effect. To establish mediation, the following conditions must hold: first, the independent variable must affect the mediator in equation 1; second, the independent variable must affect the dependent variable in equation 2; and third, the mediator must affect the

Table 2
Industry profile and size of responding organizations

Industry profile

Industry	Frequency	Percentage
Finance/insurance	79	25.3
Manufacturing	78	24.9
Healthcare	37	11.8
Retailing/wholesale	33	10.5
Business/information services	22	7.0
Utility/transportation	20	6.4
Media	11	3.5
Other	20	6.4
Not indicated	13	4.2
Total	313	100

Size

Number of employees	Frequency	Percentage
<1000	66	21.1
1000–2500	84	26.8
2500–5000	58	18.5
5000–10,000	34	10.9
10,000–25,000	31	9.9
>25,000	21	6.7
Not indicated	19	6.1
Total	313	100

dependent variable in equation 3. If these conditions hold, then the effect of the independent variable on the dependent variable must be less in equation 3 than in equation 2.

The moderating effect of a third variable is tested by adding the product of the moderator and independent variable to the regression of the independent on the dependent variable [8]. Therefore, if the independent variable is denoted as X, the moderator as Z, and the dependent variable as Y, then Y is regressed on X, Z, and XZ. Moderator effects are indicated by a significant XZ coefficient.

5. Results

Table 3 contains the results of the regression equations estimated for a mediating effects model. As shown in the first column of Table 3, the regression equations for all technologies suggest that higher diffusion levels are associated with higher levels of perceived productivity improvement. The strongest associations are observed for E-mail, EIS, and EDI. The weakest associations are observed for teleconferencing, client/server, and RDBMS. Column 2 suggests that for all technologies perceived productivity improvement is strongly associated with perceived process change. The strongest associations are observed for CASE, EDI, and Expert Systems while the weakest associations are observed for RDBMS, OOP, and E-mail. In sum, the regression results seem to suggest that, to varying degrees, these technologies are perceived as positive contributors to productivity by the Chief Technology Officers. The results also strongly suggest that process redesign with respect to these technologies is directly associated with perceived productivity improvement, a first indication of mediating effects between IT diffusion and perceived productivity improvement.

For those technologies where IT diffusion significantly affects perceived process change (column 3), assessment of mediation can be made through comparison of the regression coefficients in column 1 (Productivity=*f*(IT diffusion), column 3 (perceived process change = *f*(IT diffusion), and column 4 (Productivity=*f*(IT diffusion, perceived process change). In the case of E-mail, the beta-coefficient of column 1 suggests that productivity is a function IT diffusion (beta=0.46). The coefficient of column 3 suggests that perceived process change is a function of IT Diffusion (beta=0.47) and the coefficients of column 4 suggest that Perceived Productivity Improvement is a function of IT diffusion (beta=0.17) and Perceived Process Change (beta=0.61). Since the coefficient associated with IT Diffusion is less in column 4 than in column 1, and columns 2 and 3 are both significant, a mediating effect is implied. This phenomenon is also observed for Imaging, RDBMS, Expert Systems, and LAN. In sum, the results suggest that, for these technologies, process change is a necessary and sufficient condition for improvements in productivity.

Table 4 contains the estimated regressions for assessing moderating effects between IT Diffusion, Perceived Productivity Improvement, and Perceived Process Change. As implied in column 4 of Table 4, moderating effects are observed for only Client/server technology (as indicated by the significance level of the interaction effect and the lack of mediating effect). Perceived process change does not moderate the relationship between IT Diffusion and Perceived

Table 3
Results of regression analysis: Testing for mediating effects

Technology	Perceived productivity=*f* (IT Diffusion)	Perceived productivity=*f* (Perceived process change)	Perceived process change=*f* (IT Diffusion)	Perceived productivity=*f* (IT diffusion, Perceived process change)		
E-mail						
R^2	0.21	0.47	0.22		0.50	
Adj. R^2	0.20	0.46	0.22		0.50	
SE	0.84	0.67	1.01		0.67	
f-Statistic	62.58[c]	216.84[c]	67.62[c]		119.17[d]	
Beta (s)	0.46	0.68	0.47	0.17		0.61
t-Statistic(s)	7.91[c]	14.72[c]	8.22[c]	3.24[b]		11.78[c]
df	238	248	237		236	
Expert systems						
R^2	0.13	0.66	0.15		0.66	
Adj. R^2	0.13	0.66	0.14		0.65	
SE	1.22	0.73	1.17		0.77	
f-Statistic	9.85[b]	160.99[c]	11.61[c]		63.53[c]	
Beta (s)	0.36	0.81	0.38	0.05		0.79
t-Statistic(s)	3.14[b]	12.68[c]	3.41[c]	0.75		10.10[c]
df	68	82	67		66	
Teleconferencing						
R^2	0.04	0.63	0.00		0.61	
Adj. R^2	0.03	0.62	0.00		0.61	
SE	0.95	0.63	1.08		0.60	
f-Statistic	4.66[a]	237.86[c]	0.04		98.07[c]	
Beta (s)	0.19	0.79	0.01	0.07		0.77
t-Statistic(s)	2.16[a]	15.42[c]	0.20	1.32		13.61[c]
df	125	142	125		123	
EDI						
R^2	0.17	0.73	0.01		0.72	
Adj. R^2	0.17	0.72	0.00		0.71	
SE	0.99	0.60	1.08		0.58	
f-Statistic	30.44[c]	417.50[c]	2.30		185.68[c]	
Beta(s)	0.42	0.85	0.12	0.07		0.82
t-Statistic(s)	5.52[c]	20.43[c]	1.52	1.35		16.79[c]
df	145	158	149		144	
EIS						
R^2	0.19	0.58	0.02		0.60	
Adj. R^2	0.18	0.57	0.01		0.59	
SE	1.04	0.73	1.22		0.74	
f-Statistic	22.46[c]	147.27[c]	2.00		69.92[c]	
Beta(s)	0.44	0.76	0.14	0.11		0.72.
t-Statistic(s)	4.73[c]	12.13[c]	1.42	1.51		9.80[c]
df	94	106	96		92	
CASE						
R^2	0.14	0.71	0.00		0.71	
Adj. R^2	0.13	0.71	0.00		0.71	
SE	1.09	0.62	1.28		0.63	
f-Statistic	16.53[c]	269.39[c]	0.59		126.42[c]	
Beta(s)	0.37	0.84	0.07	0.13		0.79
t-Statistic(s)	4.06[c]	16.41[c]	0.77	2.26[a]		14.27[c]
df	102	108	102		100	

Table 3 (*Continued*)

OOP						
R^2	0.08	0.41	0.01		0.47	
Adj. R^2	0.07	0.40	0.00		0.45	
SE	0.91	0.73	0.98		0.65	
f-Statistic	5.98[a]	51.70[c]	0.67		27.12[c]	
Beta(s)	0.29	0.64	0.10	0.21		0.63
t-Statistic(s)	2.44[a]	7.19[c]	0.82	2.21[a]		6.76[c]
df	63	74	62		61	
Client/Server						
R^2	0.05	0.64	0.02		0.62	
Adj. R^2	0.04	0.64	0.01		0.62	
SE	0.81	0.51	0.85		0.50	
f-Statistic	8.23[b]	310.68[c]	3.59		128.87[c]	
Beta(s)	0.22	0.79	0.15	0.09		0.77
t-Statistic(s)	2.87[b]	17.62[c]	1.89	1.93		15.42[c]
df	156	177	156		144	
RDBMS						
R^2	0.08	0.38	0.08		0.40	
Adj. R^2	0.07	0.37	0.08		0.39	
SE	0.91	0.74	0.93		0.74	
f-Statistic	12.80[c]	100.59[c]	13.35[c]		45.52[c]	
Beta(s)	0.29	0.62	0.30	0.12		0.57
t-Statistic(s)	3.57[c]	10.03[c]	3.65[c]	1.71		8.45[c]
df	138	163	137		138	
LAN						
R^2	0.09	0.57	0.07		0.53	
Adj. R^2	0.08	0.57	0.06		0.53	
SE	0.76	0.54	0.84		0.55	
f-Statistic	24.06[c]	366.05[c]	17.07[c]		140.56[c]	
Beta(s)	0.30	0.75	0.25	0.12		0.69
t-Statistic(s)	4.91[c]	19.13[c]	4.13[c]	2.62[b]		15.35[c]
df	251	280	248		248	
Imaging Technology						
R^2	0.14	0.54	0.07		0.52	
Adj. R^2	0.13	0.54	0.06		0.51	
SE	0.90	0.69	0.93		0.68	
f-Statistic	16.50[c]	146.14[c]	7.49[c]		53.06[c]	
Beta(s)	0.37	0.74	0.26	0.18		0.65
t-Statistic(s)	4.06[c]	12.09[c]	2.74[c]	2.53[b]		8.96[c]
df	103	123	101		101	

[a] $p<0.01$.
[b] $p<0.001$.
[c] $p<0.0001$.

Productivity Improvement for any other technology. In sum, the results seem to suggest a lack of an enabling effect with respect to Process Change for the majority of the technologies examined. Technologies which exhibited neither a moderating nor a mediating effect include teleconferencing, EDI, EIS, OOP, and CASE.

6. Discussion

The results of this study suggest that IT investment as manifested in its diffusion does lead to perceived improvement in productivity. In essence, the perceptual data inherent within this research design seem to corroborate the economic data characteristic of

Table 4
Results of regression analysis: Testing moderating effects

Technology	Perceived productivity=*f* (IT Diffusion)	Perceived Process change=*f* (IT Diffusion)	Perceived productivity=*f* (IT Diffusion, Perceived process change)		Perceived productivity=*f* (IT diffusion, Perceived process change, IT Diffusion×Perceived process change)		
E-mail							
R^2	0.21	0.22	0.50			0.51	
Adj. R^2	0.20	0.22	0.50			0.50	
SE	0.84	1.01	0.67			0.67	
f-Statistic	62.58[c]	67.62[c]	119.17[c]			80.29[c]	
Beta(s)	0.46	0.47	0.17	0.61	0.36	0.73	−0.27
t-Statistic(s)	7.91[c]	8.22[c]	3.24[b]	11.78[c]	2.37[a]	7.14[c]	−1.33
df	238	237	236			238	
Expert Systems							
R^2	0.13	0.15	0.66			0.66	
Adj. R^2	0.13	0.14	0.65			0.65	
SE	1.22	1.17	0.77			0.78	
f-Statistic	9.85[b]	11.61[c]	63.53[c]			42.42[c]	
Beta(s)	0.36	0.38	0.05	0.79	0.36	0.83	−0.32
t-Statistic(s)	3.14[b]	3.41[c]	0.75	10.10[c]	0.99	9.15[c]	−0.85
df	68	67	66			68	
Teleconferencing							
R^2	0.04	0.00	0.61			0.66	
Adj. R^2	0.03	0.00	0.61			0.65	
SE	0.95	1.08	0.60			0.57	
f-Statistic	4.66[a]	0.04	98.07[c]			80.01[c]	
Beta(s)	0.19	0.01	0.07	0.77	0.72	1.00	−0.75
t-Statistic(s)	2.16[a]	0.20	1.32	13.61[c]	4.42[c]	12.98[c]	−4.19[b]
df	125	125	123			125	
EDI							
R^2	0.17	0.01	0.72			0.72	
Adj. R^2	0.17	0.00	0.71			0.72	
SE	0.99	1.08	0.58			0.58	
f-Statistic	30.44[c]	2.30	185.68[c]			123.44[c]	
Beta(s)	0.42	0.12	0.07	0.82	0.19	0.85	−0.14
t-Statistic(s)	5.52[c]	1.52	1.35	16.79[c]	0.97	11.73[c]	−0.65
df	145	149	144			146	
EIS							
R^2	0.19	0.02	0.60			0.61	
Adj. R^2	0.18	0.01	0.59			0.60	
SE	1.04	1.22	0.74			0.74	
f- Statistic	22.46[c]	2.00	69.92[c]			47.69[c]	
Beta(s)	0.44	0.14	0.11	0.72	0.38	0.81	−0.34
t- Statistic(s)	4.73[c]	1.42	1.51	9.80[c]	1.81	8.18[c]	−1.37
df	94	96	92			94	
CASE							
R^2	0.14	0.00	0.71			0.72	
Adj. R^2	0.13	0.00	0.71			0.71	
SE	1.09	1.28	0.63			0.63	
f-Statistic	16.53[c]	0.59	126.42[c]			81.50[c]	
Beta(s)	0.37	0.07	0.13	0.79	−0.16	0.76	0.17
t- Statistic(s)	4.06[c]	0.77	2.26[a]	14.27[c]	−0.12	10.53[c]	0.95
df	102	102	100			102	

Table 4 (*Continued*)

OOP								
R^2	0.08	0.01		0.47			0.47	
Adj. R^2	0.07	0.00		0.45			0.44	
SE	0.91	0.98		0.65			0.66	
f-Statistic	5.98[a]	0.67		27.12[c]			17.79[c]	
Beta(s)	0.29	0.10	0.21		0.63	0.22	0.64	−0.02
t-Statistic(s)	2.44[a]	0.82	2.21[a]		6.76[c]	0.67	4.82[c]	−0.05
df	63	62		61			63	
Client/server								
R^2	0.05	0.02		0.62			0.64	
Adj. R^2	0.04	0.01		0.62			0.63	
SE	0.81	0.85		0.50			0.51	
f-Statistic	8.23[b]	3.59		128.87[c]			85.60[c]	
Beta(s)	0.22	0.15	0.09		0.77	−0.03	0.74	0.27
t-Statistic(s)	2.87[b]	1.89	1.93		15.42[c]	−0.12	10.05[c]	2.41[a]
df	156	156		144			156	
RDBMS								
R^2	0.08	0.08		0.40			0.42	
Adj. R^2	0.07	0.08		0.39			0.41	
SE	0.91	0.93		0.74			0.73	
f-Statistic	12.80[c]	13.35[c]		45.52[c]			32.73[c]	
Beta(s)	0.29	0.30	0.12		0.57	0.68	0.77	−0.65
t-Statistic(s)	3.57[c]	3.65[c]	1.71		8.45[c]	2.54[a]	7.09[c]	−1.46
df	138	137		138			138	
LAN								
R^2	0.09	0.07		0.53			0.54	
Adj. R^2	0.08	0.06		0.53			0.53	
SE	0.76	0.84		0.55			0.55	
f-Statistic	24.06[c]	17.07[c]		140.56[c]			94.47[c]	
Beta(s)	0.30	0.25	0.12		0.69	−0.13	0.58	0.30
t-Statistic(s)	4.91[c]	4.13[c]	2.62[b]		15.35[c]	−0.65	6.06[c]	1.26
df	251	248		248			248	
Imaging Technology								
R^2	0.14	0.07		0.52			0.52	
Adj. R^2	0.13	0.06		0.51			0.51	
SE	0.90	0.93		0.68			0.68	
f-Statistic	16.50[c]	7.49[c]		53.06[c]			35.69[c]	
Beta(s)	0.37	0.26	0.18		0.65	−0.18	0.58	0.39
t-Statistic(s)	4.06[c]	2.74[c]	2.53[b]		8.96[c]	−0.49	6.00[c]	0.99
df	103	101		101			101	

[a] $p<0.01$.
[b] $p<0.001$.
[c] $p<0.0001$.

Hitt and Brynjolfsson's work. However, like their work, the results of this work are inconsistent with many earlier studies. A possible implication of this state of affairs is that a time lag between IT investment and productivity exists, and that this may have led earlier studies to conclude that investment and productivity are unrelated while later studies conclude the opposite. Clearly, it is reasonable to believe that organizations vary in their ability to assimilate technology. Further, cycles of technology introduction and assimilation should shorten over time. Therefore, organizational learning coupled with more

Table 5
Summary of results

Technology	Raw relationship with perceived productivity	Mediating effect of perceived process change	Moderating effect on perceived process change
Communication technologies			
E-mail	Yes[a]	Yes (weak)	No
Teleconferencing	Yes[a]	No	No
EDI	Yes[c]	No	No
Shared Resource Technologies			
RDBMS	Yes[c]	Yes (strong)	No
Expert Systems	Yes[b]	Yes (strong)	No
Imaging	Yes[c]	Yes (strong)	No
EIS	Yes[c]	No	No
Infrastructural Technologies			
Client/server	Yes[c]	No	Yes
LAN	Yes[c]	Yes (strong)	No
System Building Technologies			
OOP	Yes[a]	No	No
CASE	Yes[c]	No	No

[a] $p<0.01$.
[b] $p<0.001$.
[c] $p<0.0001$.

user-friendly technology may reduce the lag between investment and benefit.

6.1. Alternative models of effects: Determined by technology-types

The focus of most research within this stream has been the determination of a relationship between IT investment and productivity; the drive has been to establish the association rather than understand the nature of the association. Table 5 summarizes the results of our study by categorizing the set of 11 technologies into 4 categories: (a) technologies that facilitate better communication, (b) technologies that allow common repositories of documents, data or knowledge, (c) technologies that provide an infrastructure for applications, and (d) technologies that enable system development and implementation. While the categories are not mutually exclusive, they provide a basis for interpreting the results.

6.1.1. Communication technologies

The results for communication technologies suggest a relationship with perceived productivity improvement that is not improved by perceived process change. These technologies improve the efficiency of information flow, but have apparently do not need process change. For instance, e-mail and teleconferencing systems are often used to facilitate formal and informal communication. However, the structure of processes may not have to be changed in order to achieve benefits of more efficient information flow. Teng et al. call this as *information coupling*, where communication technologies can improve collaboration among participants in a process, thereby allowing them to manage uncertainty. For instance, constant interaction between R&D and Production groups can enable each to understand the implications of change in requirements.

We suspect, however, that we may be observing a first-order impact of these technologies. As new communication structures and roles are defined, a second-order effect that requires process and structural change may become more apparent. For instance, network analysis can be used to assess information flows and communication technologies, and analyzing ways in which these flows can be improved by changing formal processes and structures [34].

6.1.2. Shared resource technologies

In contrast to communication technologies, shared resource technologies such as RDBMS, Expert Systems, and Imaging Systems require changes in process before a gain in productivity can be realized. These technologies benefit the most from hard changes in process structure. Many of the popular examples of reengineering, if examined closely, involve changes in sequential processing and hand-offs, to more parallel structures that allow simultaneous processing. Shared resource technologies allow repositories of information, data, images or knowledge to be shared among multiple participants, thereby facilitating a holistic understanding of the status and outcomes of the process.[2]

This study provides evidence for the importance of process change, particularly in the case of shared technologies. The only exception is EIS, which may be due to the fact that it typically draws from transactional databases, rather than having its own information resource. However, as information in organizations becomes more voluminous and complex, shared repositories allow for better cross-functional integration, parallel processes, flatter structures, and management of information as an organizational resource rather than as functional files.

6.1.3. Infrastructural technologies

Two infrastructural technologies, Client/server and LAN offer interesting insights. Client/server technology exhibits a moderating effect, suggesting that process change *enables the relationship* between this technology and perceived productivity improvement. In other words, it does not lead to process change. However, companies that institute process change with client/server implementation will gain more from the technology. While most of the other relationships are 'mediating,' indicating that process change *is a consequence* of greater technology diffusion, in the case of client/server technology it is not. However, the technology (or more accurately, architecture) does facilitate empowerment of users and allows for efficient distribution of information and applications. Changing process structure and roles to take advantage of this architecture would enhance productivity. This is true in the case of LAN also, albeit with a mediating effect. LAN implementations with more users require hard structural changes (i.e. team approaches, coordination, application sharing) in order to get productivity increase.

[2]As a classic example, Ford's accounts payable benefited tremendously from having receiving, accounts payable, and purchasing share in a common database.

6.1.4. System building technologies

OOP and CASE tools showed no support for either the moderating or mediating model. Probably they enhance developer productivity, primarily on the efficiency dimension (i.e. automated-flow diagrams, automatic code generation, modular programming, inheritance, etc.) but do not require process change. On the other hand, it is possible that these technologies are currently being superimposed on older ways of development (e.g. SDLC), and corporations have not yet effectively changed processes to further leverage them. Also, as these technologies evolve, it is probable that they will improve their support of group processes, thereby requiring changes in the development process.

Such results imply that maybe IT investment should be viewed as a portfolio consisting of technology classes which may exhibit significantly different tendencies. Therefore, the managerial approach in terms of technology introduction and assessment should also be varied.

6.2. Consideration of process in systems design

Perhaps the most significant finding of these results is that deployment of some IT must be accompanied by organizational redesign in order to reap productivity gains. Such findings have very direct implications for methods of system design. Designers and managers must first examine process structure before making investment decisions. The integration of new technologies with outdated or ill-structured processes is likely to result in only short-term gains and, in some instances, may only quickly make the process inefficient. In other words, process change is a necessary condition for the realization of productivity gain. This is particularly true for shared resource and infrastructure technologies where the results suggest that these particular technologies must certainly be preceded with careful evaluation and redesign of underlying process structure.

6.3. Interorganizational technologies

Another interpretation of the lack of significant findings for three of the technologies: teleconferencing, EDI, and EIS is the inter-organizational nature of many of the processes they support. They are often partly controlled by the firm and partly controlled by other organizations, such as suppliers, customers, and competitors; for example, EDI is most commonly shared between a firm and its suppliers or customers. Also, EIS typically supports enterprise needs for data and is increasingly being used to link geographically dispersed subsidiaries and share data with suppliers and customers. Teleconferencing also has many uses for sharing information across diverse coalitions of internal and external business partners. Given the complexities involved in coupling shared processes among these coalitions, technology may play more of a supporting role rather than the role of a stimulus for process renewal.

The results seem especially poignant with respect to system development technologies. As suggested by the results of this study, OOP and CASE do not seem to be rendering productivity through process change. A direct implication is that IS developers have yet to significantly reconfigure their processes to take advantage of emerging building tools. Clearly, all technologies may not be equal with respect to the organizational experience which may be required for deployment utilization in redesign of business network relationships.

7. Limitations

The study of technology's impact on organizational functioning will always be inherently complex due to the many influences on performance metrics. Unlike previous work, this study has attempted to deepen our understanding of the relationship between IT and productivity through non-economic assessments of IT diffusion, perceived process change, and perceived productivity gain, the examination of 'perceived process change' as an intervening variable, and assessment of individual technologies. Doing so adds richness to the economic analysis that precedes this study, as well as increased granularity in the treatment of IT. This approach enables us to separate the confounding influence of other factors such as strategy, market vagaries and quality of implementation effort and take us closer to the phenomenon itself. However, this approach also subjects the study to some limitations.

Perhaps the most significant limitation is the potential tendency of IS executives *to overrate the level of productivity realized from IT investment*. While financial incentives and 'tailored' research summaries were incorporated to reduce this bias, IS executives do have a vested interest in the relationship between IT investment and productivity and therefore, the results of the study should be interpreted with this bias in mind.[3]

A second potential limitation lies in the operationalization of the study's research variables. The objective of this study was to assess the association between IT usage, perceived process change, and perceived productivity improvement across a variety of technologies. Therefore, to reduce the complexity of the survey instrument, single-scale items were used to assess the variables of interest. While different scales were used to reduce method bias, the fact that a single respondent, albeit the most informed, was making assessments for all variables, is an issue of concern. Also, while the items used in this study were rigorously pre-tested, multiple measures and perhaps the combination of perceptual and financial measures may represent a stronger form of measurement. However, the utilization of complex scales and multiple informants tends to lengthen survey instruments and can place too great a burden on very limited executive time.

While IT diffusion was chosen as an arguably superior alternative to economic measures, it may not correspond to IT investment. For instance, inexpensive e-mail systems might incur extremely high levels of diffusion. To the extent that this is true, direct comparisons with the 'productivity paradox' studies might be misleading. May be this study provides an alternative way of looking at the purported paradox.

8. Conclusions

A major agenda of both practitioners and researchers within the area of IT management is the determi-

[3]The significant variation in the strength of the various relationships, might demand considerable care and scrutiny in the assessment of IT diffusion and productivity by the respondents. We also noticed that the relationship for OOP, a systems building technology under the control of the IS executives themselves, showed one of the lowest strength (R^2=0.08) and significance level. This provides some evidence that the bias, if it exists, is limited.

nation of value-added through investment in new technology. This critical link has not been consistently established due to a variety of methodological approaches, the existence of intervening variables, inconsistent operationalizations of productivity, and the treatment of IT investment as a 'lump sum.' This study has attempted to broaden the understanding of the relationship between IT and productivity through: (1) non-economic assessments of IT diffusion, perceived process change, and perceived productivity improvement by an informed source (2) examination of 'perceived process change' as an intervening variable (3) development of alternative operational models of effects, and (4) assessment of individual technologies. While certainly not a panacea in terms of modeling this complex relationship, the design of this study does provide an additional operational framework for further study. The results of this study suggest that the nature of outcomes *can be classified by technology-type*. Also, managerial and design approaches should be cognizant of potential discrepancies among technologies in terms of organizational learning. Future research in this area should attempt to determine causes of such discrepancies and managerial strategies to insure that IT investment and diffusion accompanies reorientation of supporting process structures.

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References

[1] P. Alpar, M. Kim, A microeconomic approach to the measurement of information technology value, Journal of Management Information Systems 7(2), 1990, pp. 55–69.

[2] P. Attewell, Information Technology and the Productivity Paradox, Version 2.1 mimeograph, Department of Sociology, City University of New York, September 1991.

[3] R.M. Barron, D. Kenny, The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations, Journal of Personality and Social Psychology, 51(6), 1173–1182.

[4] E.R. Berndt, C.J. Morrison, High-tech capital, economic performance and labor composition in U.S. manufacturing industries: An exploratory analysis, National Bureau of Economic Research manuscript, 1991.

[5] E. Brynjolfsson, The productivity paradox of information technology, Communications of the ACM 35(12), 1993, pp. 66–77.

[6] E. Brynjolfsson, L. Hitt, The three faces of IT value: Theory and evidence, Proceedings of the Fifteenth International Conference on Information Systems, Vancouver, Canada, 1994, pp. 263–277.

[7] J.W. Candler, P.C. Palvia, J.D. Thompson, S.M. Zeltmann, The ORION project: Staged business process reengineering at Federal Express, Communications of the ACM 39(2), 1996, pp. 99–107.

[8] J. Cohen, P. Cohen, Applied Multiple Regression and Correlation Analysis for the Behavioral Sciences. Hillsdale, NJ: Lawrence Erlbaum, 1983.

[9] W. Cron, M. Sobol, The relationship between computerization and performance, Information and Management 6, 1983, pp. 171–181.

[10] T.H. Davenport, Process Innovation: Reengineering Work through Information Technology, Harvard Business School Press, 1993.

[11] T.H. Davenport, D.B. Stoddard, Reengineering business change of mythical proportions? MIS Quarterly 18(2), 1994, pp. 121–127.

[12] T.H. Davenport, N. Nohria, Case management and the integration of labor, Sloan Management Review, Winter 1994, pp. 11–23.

[13] G.W. Downs, L.B. Mohr, Toward a theory of innovation, Administration and Society 10(4), 1979, pp. 379–408.

[14] D.A. Garvin, Leveraging processes for strategic advantage, Harvard Business Review, Sept–Oct. 1995, pp. 77–90.

[15] N. Georgantzas, J.H. Shapiro, Viable forms of synchronous production innovation, Journal of Operations Management 11, 1993, pp. 161–183.

[16] V. Grover, S.Y. Jeong, W.J. Kettinger, J.T.C. Teng, The implementation of business process reengineering, Journal of MIS 12(1), 1995, pp. 109–144.

[17] V. Grover, J.T.C. Teng, K.D. Fiedler, Information technology enabled business process redesign: An integrated planning framework, OMEGA 21(4), 1993, pp. 433–447.

[18] G. Hall, J. Rosenthal, J. Wade, How to reengineering really work, Harvard Business Review 71(6), 1993, pp. 119–131.

[19] M. Hammer, J. Champy, Reengineering the Corporation: A Manifesto for Business Revolution, Harper Collins, 1993.

[20] S.E. Harris, J. Katz, Organizational performance and information technology intensity in the insurance industry, Organizational Science 2(3), 1991, pp. 263–295.

[21] L.M. Hitt, E. Brynjolfsson, Productivity, business profitability, and customer surplus: Three different measures of information technology value, MIS Quarterly 20(2), 1996, pp. 121–142.

[22] J.K. Ho, Prosperity in the Information Age, Informatics, Wilmette, IL, 1994.

[23] G.P. Huber, D.J. Power, Retrospective reports of strategic level managers: Guidelines for increasing their accuracy, Strategic Management Journal 5, 1985, pp. 171–180.
[24] G.P. Huber, A theory of the effects of advanced information technologies on organizational design, intelligence, and decision making, Academy of Management Review 15(1), 1990, pp. 47–71.
[25] C.M. Judd, D.A. Kenny, Process analysis: Estimating mediation in evaluation research, Evaluation Research 5, 1981, pp. 602–619.
[26] W.J. Kettinger, V. Grover, S. Guha, A.H. Segars, Strategic information systems revisited: A study in sustainability and performance, MIS Quarterly, 18(1), 31–58.
[27] K.C. Laudon, K. Marr, Productivity and the enactment of a macro culture, Proceedings of the Fifteenth International Conference on Information Systems, Vancouver, Canada, 1994, pp. 243–261.
[28] G. Loveman, An assessment of the productivity impact of information technologies, Working Paper 88-054, MIT Sloan School of Management, 1988.
[29] E. Mumford, New treatment or old remedies: Is BPR really socio-technical design?, Journal of Strategic Information Systems, 3(4), 313–326.
[30] P. Osterman, The impact of computers on the employment of clerks and managers, Industrial and Labor Relations Review 39, 1986, pp. 175–186.
[31] R.R. Panko, Is office productivity stagnant? MIS Quarterly 15(2), 1991, pp. 191–204.
[32] A. Pinsonneault, K.L. Kraemer, Survey research methodology in management information systems: An assessment, Journal of Management Information Systems 10, 1993, pp. 75–105.
[33] S.S. Roach, Services under siege – The restructuring imperative, Harvard Business Review 65(5), 1991, pp. 82–91.
[34] A.H. Segars, V. Grover, The communication architecture: Toward a more robust understanding of information flows and emergent patterns of communication in organizations, European Journal of Information Systems 2, 1993, pp. 1–14.
[35] A.B. Shani, R. Grant, K. Krishnan, E. Thompson, Advanced manufacturing systems and organizational choice: Socio-technical system approach, California Management Review 34(4), 1992, pp. 91–111.
[36] G. Smith, L. Willcocks, Business process reengineering, politics management: From methodologies to processes, in: V. Grover, W.J. Kettinger (Ed.), Business Process Change: Reengineering Concepts. Methods and Technologies. Idea Publishing: Harrisburg, PA, 1995.
[37] D. Stoddard, S. Jarvenpaa, Business process reengineering: Tactics for managing radical change, Journal of Management Information Systems 12(1), 1995, pp. 81–108.
[38] P.A. Strassman, The Squandered Computer: Evaluating the Business Alignment of Information Technologies, The Information Economics Press, 1997.
[39] D.W. Straub, J.C. Wetherbe, Information technologies for the 1990s: An organizational impact perspective, Communications of the ACM 32(11), 1989, pp. 1328–1339.
[40] J.T.C. Teng, V. Grover, K.D. Fiedler, Developing strategic perspectives on business process reengineering: From process reconfiguration to organizational change, OMEGA 24(3), 1996, pp. 271–294.
[41] J.T.C. Teng, V. Grover, K.D. Fiedler, Business process reengineering: Charting a strategic path for the information age, California Management Review 36(3), 1994, pp. 9–31.
[42] M. Tyre, O. Hauptman, Effectiveness of organizational responses to technological change in the production process, Organizational Science 5(3), 1992, pp. 301–320.
[43] P. Weill, The relationship between investment in information technology and firm performance, Information Systems Research 3(4), 1992, pp. 307–333.

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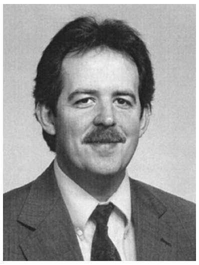

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