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A process-oriented perspective on differential business value creation by information technology: An empirical investigation☆

Abirami Radhakrishnan[a], Xingxing Zu[b], Varun Grover[c,*]

[a]*Morgan State University, 507 MM Hall, Maryland, MD 21251, USA*
[b]*Morgan State University, Maryland, MD 21251, USA*
[c]*William S. Lee Distinguished Professor of Information Systems, Department of Management, Clemson University, 101 Sirrine Hall, Clemson, SC 29634 1305, USA*

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Abstract

The relationship between information technology investments and firm value as an area of inquiry has sustained interest among IS researchers over the past decade. More recently, some have challenged the notion differential value among firms through Information Technology (IT) as it evolves into a ubiquitous utility-like set of technologies. This study examines the relationship between IT and business value from a process-oriented perspective, and also helps to identify the underlying links between IT and its differential business value to firms. By drawing upon economic and organizational theories, this paper develops a process framework to assess the intermediate organizational process capabilities and overall performance of firms that effectively deploy and use IT. Using data from over 80 firms, the study finds empirical support for the differential business value created by IT along a number of process oriented dimensions. These findings are discussed as these results set an optimistic tone for IT as a major causal driver of differentiation.

Keywords: Information technology; Differentiation; Process framework; Capability building; Business value

1. Introduction

Despite the widely held belief that Information Technology (IT) is fundamental to a firm's survival and growth, scholars are still struggling to answer the important question: can IT bring about differential business value to an organization over its competitors? While there is some evidence that the "strategic systems" of yester-years created competitive advantage [1], Carr [2], in his article "IT does not matter", concludes that IT does not provide differential performance (value) over competitors. He argues that with its increasing ubiquity, IT becomes a highly replicable, standardized commodity available to all the entrants in industry. He opines that even the way information technology is used becomes standardized as best practices become widely understood and emulated, resulting in commoditization of information technology [2]. Carr [3], in his follow-up article, emphasizes that IT at best can be a source of competitive necessity but not a provider of differential performance over competitors. Therefore increased IT spending cannot bring about differential business value to one organization over its competitors.

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* Corresponding author. Tel.: +1 864 656 3773; fax: +1 864 656 6768.
E-mail addresses: aradhak@gmail.com (A. Radhakrishnan), zuxingx@yahoo.com (X. Zu), vgrover@clemson.edu (V. Grover).

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We agree that IT investments per se do not provide any sustained advantages to organizations. However, prior research suggests that organizations can leverage their IT investments by effectively deploying, absorbing, and using IT into the organizations to create unique, hard to copy, non-substitutable and immobile organizational capabilities so as to provide organizations a differential value over their competitors in the market place [4–6]. Thus, despite uniformly high investments in technology, these organizational capabilities tend to be heterogeneously distributed across firms leading to superior differential business value [7].

This study thus, challenges Carr's assertions and suggests that effective deployment and use of IT in organizations can bring about differential value to organizations by creation of organizational capabilities. We argue that firms that focus on IT and effectively deploy, diffuse, absorb, and use IT (in this study we call such firms as IT focal firms) enjoy improved organizational capabilities when compared to their counterparts in the industry. In order to assess these capabilities, we argue that unlike much of the previous research on IT impacts, we should evaluate IT at the level it has the major impact: the process level. Such process level assessment can offer considerable insight on how and in what manner IT interacts with organizational processes to create process capabilities, which in turn can help firms in deriving differential business value from IT investments.

Based on theoretical foundations of economic and organizational theories, we introduce a process framework that refines the existing process oriented view of Mooney et al. [8]. Using our process oriented framework, we investigate two key research questions:

- Do IT focal firms have better process capabilities than other firms in the same industry?
- Do IT focal firms enjoy better firm performance than other firms in the same industry?

The remainder of this paper is organized as follows. In the next section, we review the background literature on business value and productivity. This is followed by theoretical foundations behind IT's impact on process level, hypotheses and a description of data collection methods. The final sections discuss the results, implications, and conclusion of the study.

2. Impact of IT on the firm at economy, industry and firm levels

As Melville et al. [7] suggested, we categorize these studies based on the level at which the analysis was done: at the Economy level, at the Industry level, and at the Firm level. Studies at the economy level investigated macroeconomic indicators (Table 1) and their results described as the "IT Productivity Paradox" [18]. Economist Robert Solow epitomized this paradox in the statement: "You can see computers everywhere but in the productivity statistics" [19]. In other words, business organizations demonstrated higher levels of investments in IT even in the absence of measured productivity gains [9,11–14]. However, studies did not report productivity paradox universally. Two other economy level studies found that IT investment in the context of Asian countries produced positive productivity returns [15,17]. At the industry level, research studies investigated the impact of IT on the changes in industrial productivity [20–24] (Table 2). Similar to the mixed results at the economic level studies, there was no agreement on the relationship between IT investment and industrial productivity. While some studies found that IT investment and productivity growth are positively correlated [20,21,23], others found no relationship between IT investment and productivity [22,24]. The Economy and Industry level studies provided mixed results on the prevailing macro trend and provided little managerial guidance. A number of firm level studies examined the relationship between the firm's IT investment and organizational performance variables including profitability and productivity (Table 3). While some found no evidence of IT payoff [25,26,34,40], a few others found negative IT effect on profitability [29], administrative productivity [33] and cost ratios [5,38], and some found positive IT effect on labor productivity [29,33], productivity growth [37], lower inventory levels [28], higher profitability ratios [5,38], lower cost ratios [30], greater market share and consumer surplus [29,35], substitutability of non-IT capital and labor by IT capital [31], and better hospital performance [36,39].

All aforementioned studies on the aggregate impact of IT at the economy/industry/firm level measured the relationship between IT spending and firm performance *directly without examining possible underlying mechanisms to link IT to financial firm performance*. As Barua et al. [41] point out, by attempting to relate IT spending directly to output variables at the firm level, the intermediate processes through which IT impacts are felt are totally ignored. When IT is deployed effectively it can interact with intermediate organizational processes, and deliver differential value by building unique, hard to copy organizational capabilities [4]. Very recently, a few studies have started to explore the impact of IT on organizational process-level outputs, such as inventory levels, quality, and capacity utilization (Table 4). They

Table 1
Economy level studies

Study	Focus of the study	Relationship between IT and output
Baily [9]	Productivity growth during the 1970s	Negative
Bresnahan [10]	Estimated the welfare gains (consumer surplus) from use of main frame computers in financial services sector during period 1958–1972	Positive
Roach [11]	Compared the productivity of information workers with that of the production workers during the period 1970s through mid 1980s	Mixed
Baily and Chakrabarti [12]	Computed the productivity gain from IT during the 1980s	None
Morrison and Berndt [13]	Profitability of IT investments viz. a viz. other capital investments	None
Loveman [14]	Examined the productivity impact of IT in the manufacturing industry for period 1978–1984	None
Kraemer and Dedrick [15]	Productivity and GDP growth in 12 Asia Pacific countries during the period 1984–1990	Positive
Jorgenson and Stirch [16]	Comparison of productivity growth in the pre and post 1972 periods	Negative
Tam [17]	Comparison of the return on investment on computer capital stock in three Asian economies (Hong Kong, Singapore, and Malaysia)	Positive

Table 2
Industry level studies

Study	Focus of the study	Relationship between IT and output
Siegel and Grillches [20]	Examination of productivity growth	Positive
Kelley [21]	IT's impact on efficiency	Positive
Brendt and Morrison [22]	Examination of productivity contribution from IT viz. a viz. other investments	None
Lehr and Lictenberg [23]	Examination of productivity growth during the period 1987–1992	Positive
Koski [24]	Examination of productivity growth	None

examine the relationship between IT utilization, intermediate process variables and firm level performance. But the major limitation of these studies is that these studies ignore the 'latency effects' that reflect the time lag between deployment of IT and their impact on intermediate processes and final outcome [36]. Therefore, there is a need for more granular studies that incorporate appropriate latency effects and controls, and explicate the underlying linking mechanism (process) between IT investments and differential firm level performance effects. This study intends to assess the organizational capabilities at intermediate process level where IT might have differential impact with a latency effect. Through such an examination we can get a better understanding of how IT investments get transformed into business value.

3. Impact of IT at the process level

This study focuses on how IT can impact intermediate *organizational processes* and create differential business value to organizations. We adopt Davenport's [44] definition of organizational process and its two subcategories. *Process* refers to a specific ordering of work

Table 3
Firm level studies to assess the relationship between the IT spending and firm's performance

Study	Independent variables	Performance measures	Relationship between IT and output	Process-oriented approach	Latency effect considered
Strassman [25]	IT investment	Return on investment	None	No	No
Strassman [26]	IT spending	Net income to sales, value added per employee	None	No	No
Mahmood and Mann [27]	IT investment	Sales/employee, return on sales, sales/total assets, return on investment and market to book value of shares	Mixed	No	No
Diewart and Smith [28]	IT spending	Inventory levels, inventory holding cost, sales growth rate	Positive	No	Yes
Hitt and Brynjolfsson [29]	IT stock, IT stock per employee	ROA, ROE	Mixed	No	Yes
Mitra and Chaya [30]	IT spending	Operating expenses/sales, gross margin percentage, selling goods and administration expenses/sales, labor expenses/sales	Positive	No	No
Dewan and Min [31]	nonIT capital and labor by IT capital	NonIT capital, labor expense, value added to sales, value added to employees	Positive	No	Yes
Shin [32]	IT spending	Intermediate variable: coordination costs; final variable: output (total sales)	Positive	No	No
Rai et al. [33]	Various measures of IT spending	Labor productivity (value added per employee), ROA, ROS, total sales, admin productivity (value added per SG&A expenses)	Mixed	No	No
Strassmann [34]	IT spending per employee (IT intensity)	ROE, sales growth, market share gain, effectiveness, quality, productivity	None	No	No
Tam [17]	IT stock in four Asian countries	ROA, ROE, ROS	Mixed	No	No
Sircar et al. [35]	IT spending	Sales, total assets, market share, shareholder's equity, shares outstanding, stock price, net income before taxes	Positive	No	No
Bharadwaj [5]	IT capability (those that feature in 2 out of the 4 years in Information Week)	Profit ratios: ROA, ROS, operating income/assets, operating income/sales, operating income per employee; cost ratios: cost of goods sold/sales, selling goods and administration expenses/sales, operating expenses to sales	Positive	No	No

Devaraj and Kohli [36]	IT investments in the healthcare industry	Net patient revenue per day, mortality rates, customer satisfaction index. Being moderated by organizational variables such as degree of BPR implementation	Positive	No	Yes
Brynjolfsson and Hitt [37]	IT stock	Productivity growth based on data from over 600 firms during the period 1987–1994	Mixed	No	Yes
Santhanam and Hartono [38]	IT capability (those that feature in 2 out of the 4 years in Information Week)	Profit ratios: ROA, ROS, operating income/assets, operating income/sales, operating income per employee; cost ratios: cost of goods sold/sales, selling goods and administration expenses/sales, operating expenses to sales	Positive	No	No
Devaraj and Kohli [39]	IT usage (CPU time, number of records accessed, and reports generated)	Hospital performance: mortality, revenue/admission, revenue/day	Positive	No	Yes

activities across time and place, with a beginning, an end, and clearly identified inputs, and outputs: a structure of action [44]. Organizational processes include both the operational processes and management processes. *Operational process* refers to execution of tasks relating to primary activities of an organization's value chain. Operational processes include inbound logistics process (supplier relations), production and operation process, product and service development process, sales and marketing process, customer relationship process (outbound logistics) [45,46]. *Management process* refers to processes carried out at different management levels of an organization associated with administration, allocation of resources, resources utilization, communication, coordination and control. Management processes can help improve decision making related to resources allocation, resources utilization, strategic planning on mergers and acquisitions, new product planning, new market entry planning, R&D planning, budgetary control, etc. [8,47]. They are *not directly related* to the primary (core) activities of the value chain and they help in carrying out the support functions of an organization. Process capabilities refer to the firm's capacity to apply IT to operational and management processes, to affect desired firm's performance [48]. Below, we describe how IT can create differential value from both a theoretical and pragmatic perspective.

4. Theoretical view

Economic theories such as Transaction Cost Economics (TCE) [49] and Theory of Production [13] offer guidance on how information technology can interact with organizational processes to add value. TCE posits that organizations will adopt one of the two governance structures (i.e. either hierarchies or markets) so as to minimize the total cost (sum of production cost and transaction cost) [50–52]. Production costs are costs associated with primary processes (i.e. operational processes) necessary to create and distribute the goods and services. Transaction costs include the costs of information processing to support the primary processes [53] (i.e. management processes). IT supports both operational and management processes and help in reducing the total costs. IT can be effectively used to automate, informate, and transform these two types of processes [8,54] and add value by minimizing total cost. Similarly, Theory of Production posits that firms employ a method for transforming various inputs into outputs, which is generally represented by a production function. Organizational inputs include labor, materials, and capital. Organizational outputs include the products and

Table 4
Studies to assess the relationship between the IT spending and process level outcomes

Study	Process variables	Firm-level variables	Results
Mukhopadhyay et al. [42]	Inventory levels; quality	ROA; ROS	IT (use of EDI) has positive impact on intermediate variables; mixed results on final performance measures
Barua et al. [41]	Capacity utilization; inventory turnover; relative price; quality of product	Market share; ROA	IT has a positive impact on some intermediate variables (such as capacity utilization, inventory turnover) but that the effect was too small to measurably make positive impact on all the final SBU level variables
Shin [32]	Coordination cost	Firm's output level	Higher IT spending is related to lower coordination costs and at the firm level, higher IT spending led to higher output level
Mukhopadhyay et al. [43]	Process quality; output of facility	Nil	Investments in sorting application system led to higher output of mail sorting facilities and better process quality

services delivered by the organization. IT, which captures, transmits, stores, disseminates information, can support work systems by influencing the combination of inputs that can be used to generate a certain level of output [29,55].

While the economic theories such as TCE offer us guidance that *IT can add value* by its interaction with organizational processes, an organizational theory such as resource based view (RBV) [4,6,7,56] offers us guidance on *how IT can bring about differential value to firms when compared to their counterparts in the industry*. RBV posits that firms compete on the basis of "unique" resources that are valuable, rare, appropriable, inimitable, non-substitutable, and immobile [6,48,56–58]. It assumes that the resources needed to conceive, choose, and implement strategies are heterogeneously distributed across firms and that these differences remain stable over time [56]. Resources tend to survive competitive imitation when protected by mechanisms such as time compression diseconomies, historical uniqueness, embeddedness and causal ambiguity [56,58,59]. Although proponents of the resource-based view generally tend to define resources broadly, to include assets, capabilities, etc., Grant [60] distinguishes between *resources* and *capabilities*. Resources include tangibles and intangibles used by organizations. Our variable of interest, IT, is a standard undifferentiated resource that can be purchased and deployed by all firms [3,31,61]. Firms achieve competitive advantage by using such standard resources to create organizational capabilities. Capabilities, thus, refer to an organization's ability to effectively deploy valued resources, usually in combination or copresence [48]. Capabilities subsume the notion of organizational competencies and are rooted in organizational processes—operational and management processes [62]. When the firms absorb and effectively deploy standard IT into their operational and management processes (i.e. in IT focal firms), they create *differentiated operational and management process capabilities*. Since these capabilities are valuable, rare, appropriable, inimitable, immobile and non-substitutable, IT focal firms enjoy better performance than their counterparts. Therefore, contrary to what Carr [3] opined, it is our view that IT can be rendered a *differentiating* resource capable of creating valuable, heterogeneous, immobile, non-substitutable and hard to copy operational and management process capabilities.

The extent of operational and management process capability development depends upon the extent to which IT effectively interacts with operational and management processes within firms. For instance, the degree of sharing of the IT related knowledge and business related knowledge among IT managers and functional managers, IT—business process alignment skills, IT change management practices, business systems thinking govern the organization's capacity to absorb and effectively use IT [6].

In sum, the theoretical lenses of Economic theories such as TCE and Theory of Production offer guidance on how IT can add value to organization by interacting with operational and management processes while

the organizational theory of RBV offers guidance on how firms can derive differential business value from IT. When IT is effectively absorbed, assimilated, and managed by firms (i.e. in IT focal firms), it creates valuable, heterogeneous, immobile operational and management process capabilities. These capabilities enable IT focal firms to have superior performance by creating differential business value when compared to the rest in the industry [61]. Based on these theoretical perspectives, the next section presents a pragmatic (illustrative) view on how IT interacts with processes within firms and creates operational and management process capabilities.

5. Pragmatic view

5.1. IT and operational process capabilities

IT can have three types of impacts on operational processes—to automate, to informate, and to transform operational processes to create operational process capabilities [8,54].

Automation enhances the ability to produce more or better quality output from inputs. Use of robots, computer aided manufacturing (CAM), computer integrated manufacturing (CIM), automated JIT systems and flexible manufacturing systems (FMS) to improve manufacturing processes is common. These automated techniques result in enhanced processing capacity, higher labor efficiency, economies of scale resulting in lower production costs, smaller production runs, better product/service quality and lesser defectives, scrap etc. all resulting in decreasing overall operating costs and lowering buffer inventory levels [29,33,41,42].

> Allen-Bradley uses a fully automated "factory within a factory" concept to assemble contactors and relays for its electrical motors. The machines do virtually all the work, including the materials requirement planning, parts ordering, scheduling, packaging, shipping, and quality control. Operators just monitor the working. The company has enjoyed substantial labor efficiency over its rivals.

Automation can aid in the product development process through computer-aided design (CAD), and computer numerically controlled machines (CNC).

> Texas Instruments uses CAD for new product design and development, involving personnel in different countries such as Japan, India, Malaysia, and the US, diminishing the development time by 39%. Reduced product development time increases the operating income by 30%.

IT can informate by storing, retrieving, manipulating and disseminating information. Firms commonly use the planning systems such as MRP, MRPII and ERP in material requirement planning, scheduling, quality control reporting, capacity planning, and work load planning. The use of these systems has reduced the overall operations cost and improved the inventory turns and operational efficiency [63].

> Singapore based Flextronics International rolled out MRP 2 in its 26 locations around the globe. One improvement that came out very quickly was lowering of production costs.

IT is used to informate product development process to create better economies of scope.

> Benetton, S.P.A, "mass customizes" products through the "Benetton information system." This system tracks the orders, manages the capacity information, and coordinates with its retail outlets. The visibility of order and capacity information has helped Benetton improve its operational efficiency as well as economies of scope through its wider product range.

IT is also used in informating sales and marketing process in coming up with better ways to forecast and manage demand, and to identify potential markets.

> Fashion Apparel Merchants use demand forecasting information systems to predict demand so that they avoid higher product stockouts. They are able to effectively cope up with the unpredictability of fashion trends and seasonally changing assortment of goods. The bottom line impact is felt as increased sales and higher inventory turns [64].

IT helps in informating customer relationship process, which helps in sustaining customer relationships [65].

> At National Semiconductor, a web based broadcasting system to capture customer information online is used. This has resulted in more accurate forecasts of demand, and in boosting sales of key components.

IT transforms operational processes by changing the pattern of how firm interact within a value chain. IT helps to integrate the firm with its suppliers through EDI, supply chain management systems, e-procurement systems, enterprise application system, etc. [66]. These systems strengthen the firm's relationships with the suppliers [62]. Sharing of information related to production schedules, demand and forecasting reduces information

asymmetry, operating costs, and inventory levels in the supply chain network [42,67].

A web based transportation information system has facilitated successful supply chain integration efforts by Ahold Inc—Sealed Air Inc—Mitsubishi in US. It has resulted in improvement in operating efficiency, by decreasing the accounts receivables and payables for all the three firms.

5.2. IT and managerial process capabilities

Management processes are associated with administration, allocation and utilization of resources, communication, coordination and control that are carried out at different levels of an organization. IT can automate, informate and transform management processes [8,54].

IT plays a central role in office automation. The use of personal computers their productivity tools (word processors, spreadsheets) purportedly have a direct effect on office productivity and administration efficiency. According to Gartner Dataquest the world population of PCs passed the one billion mark and is expected to reach two billion by 2008.

IT informates management process through the use of executive information systems (EIS), decision support systems (DSS), electronic document management, electronic meeting systems. These systems help personnel to take better decisions related to allocation/utilization of resources, and other strategic issues, which leads to improvement in decision quality, employee empowerment, better utilization of resources (assets) and administrative efficiency [8].

Conoco's EIS led to improved administrative efficiency. Employees at Conoco felt so empowered that they were allowed to take decisions and this enhanced the organizational effectiveness and decision quality.

Merril Lynch uses financial CMA to make investment portfolio decisions in a very timely manner and this has improved its ability to allocate financial resources. This has improved its financial resources utilization.

IBM uses electronic meetings systems for group meetings across all levels of management in 33 sites of IBM. This has reduced the administrative costs by more than 30%.

IT transforms some organizations through its role in information and knowledge dissemination. IT is critical to knowledge management as technologies such as groupware, multimedia systems assist in eliciting tacit knowledge, constructing histories of insights and cataloging them [68–70].

Hughes Space and Communications has built a "lessons learned" database that captures the unstructured knowledge of its design team in the form of wisdom, experience.

IT transforms organization structure. Networked infrastructure and communication facilities enable new organizational structures such as team based work units, virtual offices and virtual organizations. The Internet and other satellite systems create better global communication in order to facilitate firms to disperse their operations to the optimal locations.

In Verizon Inc., employees work from the virtual offices. Cisco Inc. has a digital organization that fosters open information access, and communicates the goals, performance expectations.

In sum, both the theoretical and pragmatic perspectives lead to the following conceptual model, refined from Mooney et al. [8] that guides our study (see Fig. 1). We adopt a two-step approach. First, we examine the impact of IT on the organizational processes to create process capabilities. Theoretical underpinnings of TCE, Theory of production and Organizational theory of RBV strongly suggest that when firms effectively absorb, deploy and manage IT resource (i.e. IT focal firms) into their organizational processes (*operational and management processes*), they can enjoy better process capabilities when compared to other firms in the same industry. This directly leads us to the first two hypotheses:

H1a: IT focal firms will have significantly higher operational process capabilities than other firms in the industry.

H1b: IT focal firms will have significantly higher management process capabilities than other firms in the industry.

The second step is to examine the impact of process capabilities on firm performance. We predict that firms that possess better process capabilities enjoy higher firm performance when compared to others in the same industry. This leads us to our second hypothesis.

H2: IT focal firms will have significantly higher firm performance than other firms in the industry.

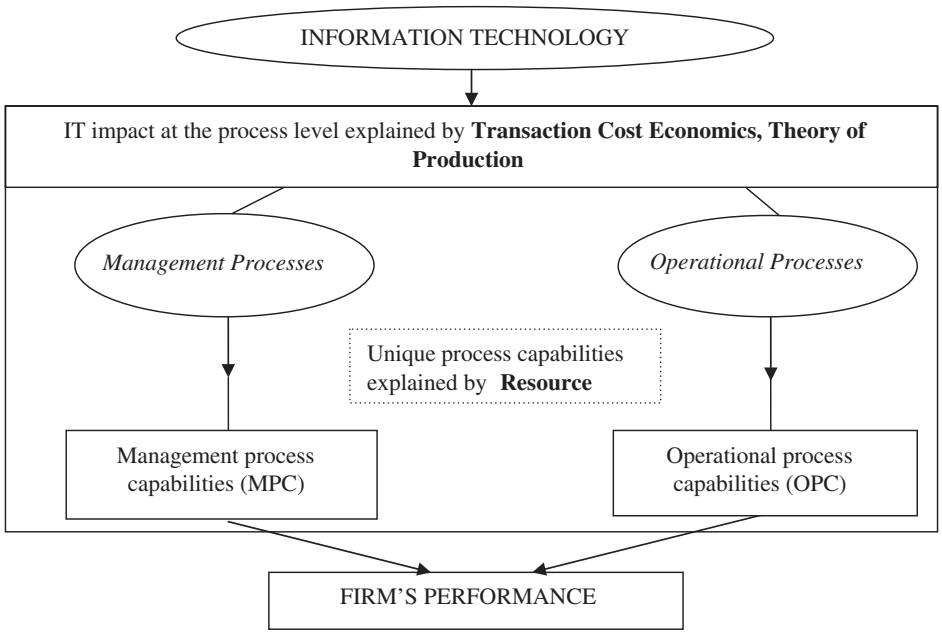

Fig. 1. Conceptual process model to explain the impact of IT on management and operational processes to create final firm performance.

6. Research methodology

To test the proposed hypotheses, we employed the matched-sample-comparison group method which has been used in several studies on IT and firm performance (e.g. in [5,38,71,72]). We did two set of comparisons. First, we compared variables between a treatment group consisting of a sample of IT focal firms that are widely recognized as effective IT users and a control group of industry average of the IT focal firms. Second, we compared the IT focal firms with their counterpart firms in the same industry.

Fig. 2 represents the mechanism of comparing IT focal firms with the industry average (average of all other firms in the same industry). OP*i* denotes the operational processes of IT focal firm *i* and OP*i*a denotes the operational processes of all other firms in the same industry as IT focal firm *i*. MP*i* denotes the management processes of IT focal firm *i* and MP*i*a denotes the management processes of all other firms in the same industry. OPC*i* denotes the operational process capability of the IT focal firm *i* and OPC*i*a denotes the industry average of operational process capability. MPC*i* denotes the management process capability of IT focal firm *i* and MPC*i*a denotes the industry average of management process capability. FP*i* is the firm performance of the IT focal firm *i* and FP*i*a is the industry average of firm performance.

Fig. 3 shows the mechanism of comparing the IT focal firms with their counterpart firms. Both the IT focal firm and its counterpart belong to the same industry (i.e. have the same SIC code) and have similar firm sizes. Firm size is measured by the number of employees. Following Barber and Lyon's specification [73] for defining counterpart, we consider a counterpart firm that has firm size that lie within the range of 70–130% of the IT focal firm.

6.1. Sample selection

We selected the treatment sample of IT focal firms from the Annual InformationWeek 500 (IW500) list. IW conducts yearly surveys to collect objective measures related to IT, such as the amount of money spent on IT (includes high performance PCs, LANs, distributed processors, communication equipment, main frames, client server technologies, etc.) and type of hardware and software used, and extent of usage of IT. Objective measures are likely to be relatively unbiased in contrast to perceptual measures [74]. IW500 list covers the five hundred effective users of information technology. IW500 list is widely accepted in industry and academic research, because its longitudinal large-scale database is compiled by experts who are largely familiar with industry practices [5]. Our study is based on 1995–1999 IW500 data. Prior research [5,38] studied the impact of IT capability on firm performance based 1991–1994 IW500 data. However, in the post-1994 era, there is rapid diffusion and use of computing and communication technologies, distributed and open computer architecture platforms, networking and Internet facilities [75]. Thus, this period is particularly important to study as firms

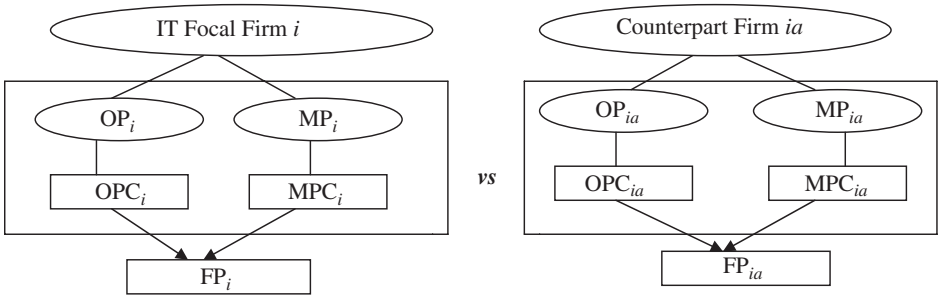

Fig. 2. Comparison of the process capabilities and firm performance of IT focal firms with their respective industry average.

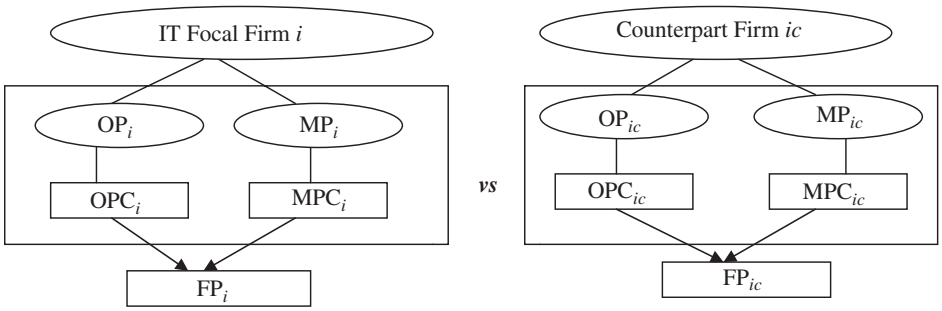

Fig. 3. Comparison of the process capabilities and firm performance of IT focal firms with their counterpart firms.

positioned themselves for competing within a new paradigm of IT.

Using the IW500 list, we first considered *all firms that made the list in all the five years* from 1995 to 1999. This stringent criterion of considering effective users of IT over a sustained period resulted in 163 IT focal firms. Prior studies using IW data only focused on the top 50 firms in the list.[1] After excluding firms that did not provide publicly accessible accounting data and outliers, a sample of 88 firms remained.

Next, corresponding to each IT focal firm in the treatment sample (based on SIC code), we computed the industry average from the Compustat database to create the control sample. These industry average figures were then cross-verified with the industry average figures reported in Annual Statement Studies, which is published annually by RMA Inc.[2] If multiple IT focal firms came from the same industry, then the same control data was used for matching. However, if there was a missing observation in the treatment group or in the control group, list-wise deletion was adopted. Average industry performance is appropriate choice to generate a control sample because it: (1) exactly represents all the firms in the industry other than IT-focal firm; (2) reduces the possible inconsistency in selecting one company as a benchmark for comparison; (3) is equivalent to incorporating industry level control; (4) increases the efficacy and external validity of the study [38]. After comparing the IT focal firms with the industry average, we performed a second comparison by considering the control group of a counterpart firm from the same industry as the IT focal firms.

6.2. Operationalization of the constructs

There is a hierarchy of capability metrics—firm level metrics that reflect aggregated process outcomes within the firm and non-aggregate metrics at the process level. The best process capability measures are reflected by non-aggregate metrics at the process level. Such outcomes are unique to each process. For instance, outbound logistics can be assessed through delivery time, decision making processes by decision quality, customer service processes by customer satisfaction, etc.

[1] We would argue that these firms had the enormous financial and human resources that other firms in the industry could not compete, and it is not surprising that they enjoyed higher firm performance than others. In the present study, we consider the IT focal firms from the entire IW500 list.

[2] It may appear that firms reported in Compustat are smaller in size when compared to firms reported in IW500. To avoid any possible errors, we cross-verified the industry averages computed from the Compustat database with that reported in Annual Statement Studies. This lends more credibility to our industry average data considered in this study.

However, such data is often proprietary and difficult to benchmark. Furthermore, our unit of analysis is the firm. Therefore, we consider the next best alternative capability metrics. We operationalize process capabilities through firm level metrics that reflect aggregated process outcomes within the firm. Selection of these measures (variables) is based upon extant literature on IT business value and strategic management [76–78].

We conceptualize operational process capability along five dimensions reflecting the five critical primary activities of a value chain i.e. production and operations, sales and marketing, product/service enhancements, supplier relations and customer relations processes.

- *Production and operations process capability* reflects the capacity to use IT to automate and informate the production process in order to increase processing capacity, reduce use of labor in operations, achieve economies of scale, and shorten production runs that results in lower production costs. We measure this capability by labor efficiency (ratio of sales to employees) and production cost efficiency (cost of goods sold to sales) [33,76].
- *Product and service enhancement process capability* reflects the capacity to use IT in automating, and informating the product and service enhancement process. This process basically involves engineering design and development of product variations, quality assurance and inspection, service enhancements etc. The improvement in this capability will result in economies of scope and decrease in operating costs due to better quality control. We measure this capability by operating efficiency (ratio of operating income to sales) and allocative efficiency (ratio of operating income to assets).
- *Sales and marketing process capability* reflects the capacity to use IT in informating sales and marketing process. This process involves stewardship of product/service after it has been produced [76]. The improvement in this capability will result in fulfilling existing demand through sale of product and services. We measure this capability by inventory turns (ratio of cost of goods sold to inventory) [41,42].
- *Supplier relations process capability* reflects the capacity to use IT in transforming the supplier relations process. This process lays emphasis on timely procurement from suppliers by maintaining proper supplier relations. Reliable supplier relations result in procurement of raw materials and components needed for manufacture/assembly operations just at the right time that will result in maintaining lower levels of inventory of raw materials [79]. We can foster reliable procurement process only by maintaining higher payables efficiency (sales to payables) [77]. We measure this capability by levels of inventory (of raw materials) and higher payables efficiency (sales to payables ratio).
- *Customer relationship process capability* reflects the capacity to use IT in informating the customer relationship process. This process lays emphasis on establishing, sustaining and retaining customer relationships that enable firms to establish a market presence and also widen market share. A large part of this relationship is reflected in the ability to manage financial transactions that bring revenue to the firm. We measure this capability by receivables efficiency (sales to receivables ratio) [76,77].

We measure management process capability by various proxy measures associated with various management processes of administration, coordination, communication, better decision making (related to resources allocation and utilization, strategic planning), and innovativeness of managerial personnel.

- *Administration, coordination, and communication process capability* reflects the capacity to use IT in automating, informating, and transforming administration process to enhance organizational effectiveness. Therefore, we measure this capability by a proxy variable administration and coordination efficiency (general and administration to sales ratio) [30].
- *Decision making related to resources allocation and utilization* is another major management process. The process capability, here, refers to capacity to use IT in informating and transforming organizations. This process involves prudent and timely decision making related to allocation and utilization of overall resources (both physical and human resources). We measure quality of decision-making by a proxy variable of resources utilization (sales to assets ratio) [77].
- *Innovativeness* arises from empowerment and encouragement to think laterally and apply to problem situations that result in higher levels of product and process innovations. IT plays a central role in informating and transforming organizations where innovative thinking is fostered. Therefore, we measure this capability by a proxy measure of R&D expenses to sales [80].

For firm performance we use multiple ratio measures such as return on assets (ROA) which is a ratio of net

Table 5
(a) Operational process capability measures

Operational process capability dimension	Variable	Definition of the measure	Meaning of the variable	Refs.
Production and operations process	Labor efficiency	Sales/number of employees	Higher the ratio, higher employee efficiency. Higher ratio desirable	Dess et al. [80] Cool and Schendel [84] Segars and Grover [76] Rai et al. [33]
Production and operations process	Production cost efficiency	Cost of goods sold/sales	Lower the ratio, higher production cost efficiency. Lower ratio desirable	Cool and Schendel [84] Segars and Grover [76] Bharadwaj [5] Santhanam and Hartono [38]
Product and service enhancement process	Operating efficiency	Operating income/sales	Higher this ratio, higher operating efficiency. Higher ratio desirable	Bharadwaj [5] Santhanam and Hartono [38]
Product and service enhancement process	Allocative efficiency	Operating income/asset	Higher this ratio, higher allocative efficiency. Higher ratio desirable	Porter [45] Bharadwaj [5] Santhanam and Hartono [38]
Sales and marketing process	Inventory turns	Cost of goods sold/inventory	Higher this ratio, higher inventory turns is. Higher ratio desirable	Mukhopadhyay et al. [42] Barua et al. [41]
Supplier relations process	Inventory levels (raw material inventory in days of inventory held)	365 * RM Inventory in dollars/sales in dollars	Lower this ratio, lower inventory levels. Lower ratio desirable	Diewart and Smith [28] Mukhopadyay and Cooper [79]
Supplier relations process	Payables efficiency	Sales/payables	Higher this ratio, higher payables efficiency. Higher ratio desirable	Hatten et al. [77] Dess et al. [80] Cool and Schendel [84]
Customer relations process	Receivables efficiency	Sales/receivables	Higher this ratio, higher receivables efficiency. Higher ratio desirable	Hatten et al. [77]Dess et al. [80] Cool and Schendel [84] Segars and Grover [76]
Management process capability dimension	Variable	Definition of the measure	Meaning of the variable	Refs.
(b) Management process capability measures				
Administration and coordination	Administration and coordination efficiency	General and administration expenses/sales	Lower this ratio, higher the efficiency. Lower ratio desirable	Mitra and Chaya [30] Shin [32] Bharadwaj [5] Santhanam and Hartono [38] Grover and Saeed [85]
Decision making for better resources utilization	Resources utilization	Sales/assets	Higher this ratio, higher resources turnover. Higher ratio desirable	Hatten et al. [77] Dess et al. [80] Cool and Schendel [84]
Creativity and innovativeness	Innovativeness	R&D investment/sales	Higher this ratio, higher innovativeness. Higher ratio desirable	Hatten et al. [77] Dess et al. [80] Hambrick [86] Snow and Hrebiniak [87] Cool and Schendel [84] Segars and Grover [76] Grover and Saeed [85]

Firm performance measures	Definition of the measure	Meaning of the variable	Refs.
(c) Firm performance measures			
Return on assets	Net income/average assets	Effectiveness of the firm in utilizing both the fixed and current assets to generate net income	Barua et al. [41] Hitt and Brynjolfsson [29] Rai et al. [33] Tam [17] Bharadwaj [5] Santhanam and Hartono [38]
Return on sales	Net income/sales	Effectiveness of the firm in generating net income from sales	Rai et al. [33] Tam [17] Bharadwaj [5] Santhanam and Hartono [38]
Return on equity	Net income/average shareholder equity	Effectiveness of the firm to enhance the shareholder's value	Hitt and Brynjolfsson [29] Strassman [34] Tam [17]
Altzman Z score	Altman Z-score = (return on total assets ×3.3) + (sales to total assets ×0.999) + (equity to Debt ×0.6) + (working capital to total assets ×1.2) + (retained earnings to total assets ×1.4)	Indicator of the overall long term financial health of the firm	Horngren et al. [81]
Relative market share	Percentage of market share held by the firm in its industry	Indicator of the market power of the firm	Barua et al. [41] Strassman [34] Sircar et al. [35]

income to average assets, indicates how much profit a firm gets by employing its assets, return on sales (ROS) which is another indicator of a firm's net profit margin [5], and return on equity (ROE) which is a ratio of net income to average shareholder equity and measures the net profitability enjoyed by shareholders [34]. In addition, we assess relative market share which is the percentage of market share held by the firm in the industry and indicates the extent of market presence in a competitive environment [35]. Finally, we use the Altzman Z score measures the overall financial health. This is a very comprehensive measure that captures various measures such as the firm's financial leverage, level of retained earnings for future growth, assets turnover, etc. [81]. These ratios have been widely used in IT payoff literature [5,25,29,38,40,82,83]. The various measures corresponding to the process capabilities and firm performance are defined and presented in Table 5.

6.3. Statistical tests

We use paired two sample t-tests to compare the mean levels of all the process capability measures and final firm performance between the IT focal firms and the control group.

6.3.1. Lag effect

Deployment of IT does not make immediate impacts on the firm performance [36]. There is usually a time lag between the time of IT deployment and the time when IT impacts are felt at the firm level [88,89]. Lag effect arises in organizations because of "technology assimilation and interaction" between the IT and organizational processes which takes time to affect financial indicators [90,91]. Mahmood et al. [92] pointed out that a two-year lag exists between the time of IT investments and final firm performance. Thus, consistent with this line of thought, in this study, we use a two-year lag in data analysis.[3]

6.3.2. Adjustment for halo effect

Another concern of using IW500 list is that of possible influence of firms' previous year performance, i.e. a "halo effect" on current year firm performance [93]. Therefore before conducting the t-test for matched group comparison, we adjust for the "halo effect" of prior firm performance. We use two regression models (models 1 and 2) consistent with prior research by

[3] We assume that the lag occurs from the time the focal firms are deemed effective (i.e. have major money spent on IT assets). An overestimation of this lag will only understate our results.

Table 6
Results for the regression models for the impact of prior period performance

	Model	N	R^2 change	Prior year firm performance	Dummy for IT focal firms
2001					
ROS	1	176	0.2811	0.691[a]	
	2	176	0.0531	0.683[a]	0.0413[a]
ROA	1	176	0.4011	1.350[a]	
	2	176	0.0357	1.352[a]	0.037[a]
ROE	1	156	0.3278	0.582[a]	
	2	156	0.0270	0.580[a]	0.0002
Altzman Z score	1	166	0.3970	0.737[a]	
	2	166	0.0021	0.735[a]	0.0003
2000					
ROS	1	176	0.2611	0.671[a]	
	2	176	0.0412	0.670[a]	0.0479[a]
ROA	1	176	0.4097	1.379[a]	
	2	176	0.0410	1.371[a]	0.041[a]
ROE	1	156	0.3391	0.597[a]	
	2	156	0.0160	0.595[a]	0.0002
Altzman$Z$ score	1	166	0.3853	0.772[a]	
	2	166	0.0011	0.772[a]	0.0003
1999					
ROS	1	176	0.2264	0.798[a]	
	2	176	0.0476	0.706[a]	0.0318[a]
ROA	1	176	0.3517	1.250[a]	
	2	176	0.0235	1.178[a]	0.0261[a]
ROE	1	156	0.3178	0.682[a]	
	2	156	0.0170	0.680[a]	0.00027
Altzman Z score	1	166	0.3890	0.734[a]	
	2	166	0.0016	0.732[a]	0.00035
1998					
ROS	1	176	0.3472	0.572[a]	
	2	176	0.0019	0.557[a]	0.0039
ROA	1	176	0.5861	0.709[a]	
	2	176	0.0069	0.695[a]	0.0066[b,c]
ROE	1	156	0.3246	0.713[a]	
	2	156	0.0091	0.711[a]	0.0006
Altzman Z score	1	166	0.3762	0.742[a]	
	2	166	0.0012	0.741[a]	0.0003

[a]Indicates that p value is significant at $\alpha = 0.01$.
[b]Indicates that p value is significant at $\alpha = 0.05$.

Santhanam and Hartono [38] and we compare the statistical significance of D in model 2.

$$\mathrm{FP}_t = \beta_0 + \beta_1 \mathrm{FP}_{(t-1)} \rightarrow \text{ Model 1,}$$
$$\mathrm{FP}_t = \alpha_0 + \alpha_1 \mathrm{FP}_{(t-1)} + \alpha_2 D \rightarrow \text{ Model 2,}$$

where FP is firm performance, t denotes the time period (i.e. year), β_0 and α_0 represent the intercepts, β_1, α_1, and α_2 are the regression coefficients, and D denotes the dichotomous variable: 1 for the IT focal firms, and 0 for the control group. The significance of the coefficient for D will suggest whether IT has a statistically significant impact on firm performance after adjusting the effect of prior period firm performance. Table 6 present results for the direct impact of IT on overall firm performance after adjustment for the halo effect (prior firm level performance). We find that for years 2001, 2000, 1999 IT has a significant impact on ROS and ROA at the level of $\alpha = 0.01$, and for year 1998, IT has a significant effect on ROA at the lower significance level of $\alpha = 0.10$. These results suggest that IT has a significant impact on firm performance after adjusting for the halo effect.

7. Empirical results

7.1. Hypothesis 1a—IT and operational process capabilities

Table 7 presents the results of the paired t tests for the operational process capabilities. For all the 5 years

Table 7
Results of the paired two sample t-tests for the operational process capabilities

	N	2001	2000	1999	1998	1997
IT focal firm vs. industry average						
Labor efficiency	88	$t = 2.67^{a}$	$t = 2.65^{a}$	$t = 2.56^{a}$	$t = 2.25^{b}$	$t = 1.82^{b}$
Operating efficiency	88	$t = 3.75^{a}$	$t = 3.73^{a}$	$t = 3.66^{a}$	$t = 2.73^{a}$	$t = 3.87^{a}$
Allocative efficiency	88	$t = 2.83^{a}$	$t = 2.78^{a}$	$t = 3.33^{a}$	$t = 1.67^{b}$	$t = 2.62^{a}$
Production cost efficiency	67	$t = -2.47^{a}$	$t = -2.47^{a}$	$t = -2.45^{a}$	$t = -2.31^{b}$	$t = -2.39^{a}$
Inventory turns ratio	66	$t = 4.59^{a}$	$t = 4.57^{a}$	$t = 4.26^{a}$	$t = 4.70^{a}$	$t = 4.60^{a}$
Inventory levels	66	$t = -6.05^{a}$	$t = -6.02^{a}$	$t = -5.90^{a}$	$t = -6.34^{a}$	$t = -6.47^{a}$
Receivables efficiency	76	$t = 1.22$	$t = 1.19$	$t = 1.22$	$t = 1.35^{c}$	$t = 1.28^{c}$
Payables efficiency	74	$t = 3.47^{a}$	$t = 3.43^{a}$	$t = 3.17^{a}$	$t = 3.70^{a}$	$t = 3.58^{a}$
IT focal firm vs. counterpart firm						
Labor efficiency	88	$t = 2.39^{a}$	$t = 2.32^{a}$	$t = 2.02^{b}$	$t = 1.95^{b}$	$t = 1.41^{c}$
Operating efficiency	88	$t = 2.82^{a}$	$t = 2.79^{a}$	$t = 2.76^{a}$	$t = 1.91^{b}$	$t = 2.91^{a}$
Allocative efficiency	88	$t = 2.36^{a}$	$t = 2.29^{b}$	$t = 2.96^{a}$	$t = 1.21$	$t = 2.19^{b}$
Production cost efficiency	69	$t = -2.02^{b}$	$t = -2.01^{b}$	$t = -1.89^{b}$	$t = -1.86^{b}$	$t = -1.78^{b}$
Inventory turns ratio	71	$t = 3.96^{a}$	$t = 3.91^{a}$	$t = 3.61^{a}$	$t = 4.11^{a}$	$t = 4.07^{a}$
Inventorylevels	71	$t = -4.31^{a}$	$t = -4.21^{a}$	$t = -3.91^{a}$	$t = -4.61^{a}$	$t = -4.67^{a}$
Receivables efficiency	82	$t = 0.92$	$t = 0.81$	$t = 0.91$	$t = 1.05$	$t = 0.97$
Payables efficiency	78	$t = 3.01^{a}$	$t = 2.89^{a}$	$t = 2.67^{a}$	$t = 3.21^{a}$	$t = 3.17^{a}$

[a]Indicates that p value is significant at $\alpha = 0.01$ (one tailed test).
[b]Indicates that p value is significant at $\alpha = 0.05$ (one tailed test).
[c]Indicates that p value is significant at $\alpha = 0.1$ (one tailed test).

Table 8
Results of the paired t-tests for the management process capabilities

	N	2001	2000	1999	1998	1997
IT focal firm vs. industry average						
Administration and coordination efficiency	84	$t = -2.47^{a}$	$t = -2.43^{a}$	$t = -2.36^{a}$	$t = -2.50^{a}$	$t = -2.64^{a}$
Resources utilization ratio	88	$t = 2.11^{b}$	$t = 1.95^{b}$	$t = 1.83^{b}$	$t = 1.89^{b}$	$t = 2.52^{a}$
Innovativeness	32	$t = 0.82$	$t = 0.79$	$t = 0.80$	$t = 0.78$	$t = 0.74$
IT focal firm vs. counterpart firm						
Administration and coordination efficiency	85	$t = -1.94^{b}$	$t = -1.81^{b}$	$t = -1.88^{b}$	$t = -2.01^{b}$	$t = -2.16^{b}$
Resources utilization ratio	87	$t = 1.67^{b}$	$t = 1.58^{c}$	$t = 1.61^{c}$	$t = 1.53^{c}$	$t = 2.03^{b}$
Innovativeness	31	$t = 0.57$	$t = 0.51$	$t = 0.61$	$t = 0.49$	$t = 0.51$

[a]Indicates that p value is significant at $\alpha = 0.01$ (one tailed test).
[b]Indicates that p value is significant at $\alpha = 0.05$ (one tailed test).
[c]Indicates that p value is significant at $\alpha = 0.1$ (one tailed test).

1997–2001, the operational process capabilities of the IT focal firms are generally significantly higher than the industry average at $\alpha = 0.01$ level of significance. First, the production and operations process capability of the IT focal firms, measured by labor efficiency and production cost efficiency, is significantly higher than their corresponding industry average. Second, the IT focal firms have higher production and service enhancement process capability, represented by operating efficiency and allocative efficiency, than the industry average in all the 5 years. Third, as regards sales and marketing process capability denoted by inventory turns, the IT focal firms is significantly better than industry average. Next, the IT focal firms have obtained significantly higher supplier relations processes capability measured by inventory levels and payables efficiency, when compared to the industry average. Finally, as regards customer relations process capability—receivables efficiency for IT focal firms is only marginally better than the industry average.[4]

[4] Receivables reflect only one aspect of customer relations and could be influenced by non IT factors. For instance, IT focal firms could have tried to widen their market reach and broaden their customer base by enhancing credit limits, thereby decreasing their receivables efficiency.

Next, we find that for all the 5 years 1997–2001, the operational process capabilities of the IT focal firms are generally significantly higher than their counterparts. Among the five dimensions of operational process capabilities, first production and operations process capability of the IT focal firms, is significantly higher than their counterparts at $\alpha = 0.05$ level of significance for all years other than 1997. In 1997, this capability measure is significant at $\alpha = 0.10$ level. Second, the IT focal firms have significantly higher production and service enhancement process capability, than their counterparts. The operating efficiency capability measure of IT focal firms is significantly higher than their counterparts at $\alpha = 0.01$ level of significance for all years other than 1998. In 1998, this capability measure is significant at $\alpha = 0.05$ level. The allocative efficiency capability measure of IT focal firms is significantly higher than their counterparts for all years other than 1998. For years, 2001 and 1999, this capability measure is significant at $\alpha = 0.01$ level. For years, 1997 and 2000, this capability measure is significant at $\alpha = 0.05$ level. Third, as regards sales and marketing process capability, the IT focal firms is significantly better than counterparts at $\alpha = 0.01$ level. Next, the IT focal firms have obtained significantly higher supplier relations processes capability when compared to their counterparts at $\alpha = 0.01$ level. Finally, as regards customer relations process capability—receivables efficiency for IT focal firms is marginally better than their counterparts. In sum, the IT focal firms have significantly higher operational process capabilities when compared to other firms in the same industry, which supports H1a.

7.2. Hypothesis 1b—IT and managerial process capabilities

Table 8 exhibits the results of the paired two-sample *t* tests for the management process capabilities. The administration and coordination capability as measured by selling goods and administration expenses to sales is significantly lower for the IT focal firms when compared to their industry average at $\alpha = 0.05$ level. Also, the resource utilization ratio is significantly higher for the IT focal firms when compared to their counterparts at $\alpha = 0.05$ level suggesting better capability in quality of decision making for better resources utilization. Likewise, the administration capability and the resource utilization capability of the IT focal firms are significantly better than their counterpart firms. However, from our sample data, we cannot determine differences in innovativeness based on R&D investments to sales ratio. One of the main reasons for this lower ratio could be

Table 9
Results of the paired *t*-tests for the firm performance

	N	2001	2000	1999	1998	1997
IT focal firm vs. industry average						
Return on assets	88	$t = 3.57^{a}$	$t = 3.39^{a}$	$t = 3.42^{a}$	$t = 3.01^{a}$	$t = 2.31^{b}$
Return on sales	88	$t = 4.37^{a}$	$t = 4.41^{a}$	$t = 4.23^{a}$	$t = 3.20^{a}$	$t = 4.90^{a}$
Return on equity	78	$t = 1.35^{c}$	$t = 1.35^{c}$	$t = 1.36^{c}$	$t = 1.33^{c}$	$t = 1.32^{c}$
Altzman *Z* score	83	$t = 2.10^{b}$	$t = 2.26^{b}$	$t = 2.06^{b}$	$t = 2.27^{b}$	$t = 2.51^{a}$
Relative market share		60% of the IT focal firms are the market leader or the market challenger	61% of the IT focal firms are the market leader or the market challenger	63% of the IT focal firms are the market leader or the market challenger	63% of the IT focal firms are the market leader or the market challenger	64% of the IT focal firms are the market leader or the market challenger
IT focal firm vs. counterpart firm						
Return on assets	87	$t = 3.01^{a}$	$t = 2.81^{a}$	$t = 2.75^{a}$	$t = 2.45^{a}$	$t = 1.74^{b}$
Return on sales	88	$t = 3.64^{a}$	$t = 3.59^{a}$	$t = 3.19^{a}$	$t = 2.45^{a}$	$t = 4.15^{a}$
Return on equity	79	$t = 0.85$	$t = 0.71$	$t = 0.84$	$t = 0.82$	$t = 0.81$
Altzman *Z* score	82	$t = 1.62^{c}$	$t = 1.77^{b}$	$t = 1.58^{c}$	$t = 1.79^{b}$	$t = 2.02^{b}$

[a]Indicates that *p* value is significant at $\alpha = 0.01$ (one tailed test).
[b]Indicates that *p* value is significant at $\alpha = 0.05$ (one tailed test).
[c]Indicates that *p* value is significant at $\alpha = 0.1$ (one tailed test).

due to very low sample size[5] for this specific measure. This results in lowering of the statistical power to detect significant results [94–96]. In general however, the IT focal firms are shown to enjoy the significantly better management process capabilities, providing partial support for H1b.

7.3. Hypothesis 2—IT and firm performance

The paired two-sample t tests for the final firm level performance in Table 9 show that during 1997–2001, the IT focal firms generally have significantly higher overall firm performance than the industrial average. Both ROA and ROS measures are all significantly higher for IT focal firms than their counterparts as well as their respective industry average at the significance level of 0.01–0.02. For return on equity, p values are marginally significant at $\alpha = 0.1$. The bottom-line profitability impact on ROA, ROS, and ROE indicate that by focusing on effectively deploying, assimilating, and using IT in organizational processes, the IT focal firms can obtain higher returns. Then, Altzman Z score, an indicator of the firm's overall financial health, and the relative market share are significantly higher for the IT focal firms than the industry average as well as the counterparts. Also, nearly 60% of the IT focal firms occupy prominent positions (market leader or challenger) in their respective markets. Thus, the IT focal firms have the significantly better overall firm performance, which supports H2.

8. Implications for practice

With increased capital spending on IT in recent years by US firms [97], this study is relevant to managers who are constantly seeking to leverage their IT investments. We can draw several normative implications for IS managers. First, the study provides a perspective for understanding how IT can create superior process capabilities, which in turn can result in differential value creation to firms. This study provides strong evidence that firms that focus on IT and take measures to effectively diffuse, absorb, manage and use IT at the process level enjoy a differential business value. Thus, this study counters Carr's argument [2,3] that ubiquity and standardization of IT can never bring about differential advantage to firms. In short, IT can bring out organizational effectiveness by being a differentiating resource [7].

Second, this study provides added justification for investments in IT technologies that can leverage on the critical business processes. Carr [3] has cautioned the managers to take a defensive stand when they think of capital investments in IT. This study demonstrates that firms *differ in the way IT is effectively used*. In short, we can say it is effectiveness in IT usage [36,98], which is a determining factor for superior performance, rather than a defensive posture.

Third, this study shows the importance of developing process capabilities. Managers need to be sensitive to the development of differentiated, hard-to-copy, non-substitutable, immobile capabilities [6]. To do so, they should identify critical organizational processes before deploying IT. It is important to recognize information technologies that interact with key organizational processes [99–102]. Swanson [103] calls such technologies as Type III innovation. In other words, IT can be used to harness value only if it is deployed in the core organizational processes. For example, in consumer retailing industry, the key organizational processes are distribution and logistics, merchandise planning and management, and store operations. In the semiconductor industry, the key levers are electronic design automation, process control, and yield optimization [104].

On a broader note, both the IT managers and business managers should stop viewing IT as a "mere technology". To derive value out of IT, it has to be viewed as "Joint IT- organization" endeavor [100–102]. As Wade and Hulland [6] pointed out, managers should effectively use outside-in and spanning resources such as IT management practices, IT change management, business systems thinking together with inside-out IT resources such as basic IT infrastructure and IT technical manpower. This means that IT innovations and organizational process changes should be in tandem. For example, Wal-Mart would have gained little from its investments in innovative IT systems if it had not redefined its relationships with suppliers and simplified the logistics practices at its distribution centers [104]. Timing and sequencing of IT investments are important. Firms that install sophisticated newer applications before they have done the necessary organizational process changes are not going to reap benefits from IT investments.

Finally, the results of this study suggest a temporal aspect of technology payoff; i.e., payoffs may not be realized instantaneously, but only after certain periods of time. Hence it becomes important for IT managers to consider the lag effect when they evaluate impacts

[5] Not all firms report R&D expenditures in their annual reports. Moreover, we have twenty service companies in our sample and generally service companies do not incur R&D expenditures. So we need to exercise caution while interpreting this result.

of IT [36,37]. This ties into recent thinking of IT as an options generator [105] where IT investments do not lead to immediate impacts, but open up possibilities (options) for innovation (e.g., process capabilities) under the right conditions. Progressive thinking firms can evaluate these options when considering IT investments.

9. Implications for research

The study and the process framework presented here add granularity to our understanding of the critical linkages between IT investments and firm performance. Unlike the much-touted strategic systems of the 1980s, where unique information technologies were used to manipulate competitive forces, today's IT is more open, accessible, and undifferentiated. Our results, consistent with the theoretical framing of the problem, suggest that competitive advantage stems from creating unique process capabilities through proper interaction between IT and organizational processes. What is striking about this study is that unlike prior research, there is consistency across the results of IT impact after considering process oriented variables, benchmarking with industry norms, and lagged effects. We would suggest that in order to understand IT's impact, it is useful to undertake studies at the process level. In doing so, certain non-accounting measures to assess the organizational processes capabilities such as customer satisfaction, employee empowerment, and organizational competitiveness, etc. provide a more comprehensive view on IT's effect on processes.

While a number of research studies tried to examine if IT brings out business value to firms, not much attention has been paid on examining differential value of IT. We hope that we have set a stage for further research on differential business value of IT. This can be studied from a variety of different theoretical perspectives. For instance, digital options theory could serve as an underlying mechanism for creating differential value to firms. IT could be a digital options generator for firms to increase firms' agility. These capabilities, digital options and agility could be mediating concepts between IT-performance relationships in hyper-competitive environment [105]. Other mediating variables between IT investments and performance that could differentiate firms could include "IT usage" or "system effectiveness" [36].

Since organizations in the present day competitive environment do not compete as stand alone entities but as extended enterprises (called supply chains), we need to test if IT can deliver differential value for such extended enterprises. One way to accomplish this could be to integrate theories of TCE and RBV to test if effective usage of inter-organizational systems such as supply chain systems, extended ERP systems can deliver differential value to extended enterprise (supply chain). For example, based on key concepts of TCE and RBV, we can explore if degree of information integration by use of inter-organizational systems among firms in a supply chain can bring about differential business value to the entire supply chain.

Finally, researchers should further this line of research by exploring other complementary organizational assets (such as organizational culture or intangibles human resource capabilities) that IT capability can leverage on to create business value. It is appropriate to view IT as a catalyst for leveraging the organizational capital to harness business value.

10. Limitations

While we believe that this study contributes to the important stream of studies on IT impact, two limitations are noteworthy. First, the study uses financial ratios and metrics to reflect process outcomes at the organizational level. While these metrics are widely used in strategic group analysis and do reflect important process outcomes, their tie-in with their construct domain may be questioned. For instance, the payables efficiency ratio captures only a limited aspect of supplier relations capability. Similarly, sales per unit asset does reflect an aggregation of resource allocation decisions, but could also reflect organizational orientation towards capital investment. While constrained by data availability, we would argue that despite this limitation, our metrics do reflect core process ideas, and can be effectively benchmarked with industry. However, true process measures should be at the process unit of analysis (e.g., cycle time, number of defects, improved product quality, customer satisfaction). We hope that such studies, despite difficulty in obtaining such data will be forthcoming.

Second, in fairness to Carr, assertions about the ubiquitous nature of IT are based on the current situation and future trends. Our study is based on the data up to 2001. But Carr [2,3] states that IT is losing its power to create competitive advantage because of such reasons as the dropping price of IT technologies, rapid diffusion of the Internet, and the wide replication of the originally unique information systems etc. These happenings were occurring even during the time frame of our study. However, whether there have been changes in more recent periods remains to be seen. We believe however that firms that are focused on integrating IT resources into their processes will continue to enjoy

better chances of successfully competing in their industry. Of course, with open architectures comes open imitation, necessitating the importance of creating unique interaction effects (capabilities) with IT and continuous innovation.

11. Concluding remarks

This study provides evidence that effective deployment of IT can improve firm-level financial metrics reflecting operational and management processes, thereby creating differential advantage when compared to their industry counterparts. Thus, IT can be a differentiating resource to such IT focal firms as compared to the rest in the industry. In conclusion, we can say that what really matters is how to effectively use IT on key organizational processes to create differential business value to firms. In the words of Brown and Hagel [106], and we quote "The lesson to learn from the past several decades is that IT by itself, if rarely, if ever, confers strategic differentiation. Yet IT is inherently strategic because of its indirect effects. It creates possibilities and options that did not exist before. Companies that see and act on these possibilities before others do will continue to differentiate themselves in the marketplace and reap economic rewards [p. 2]". We hope that this study sets an optimistic tone for IT as a major catalyst for business value.

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