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Information Technology and Firm Profitability: Mechanisms and Empirical Evidence[1]

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Do information technology investments improve firm profitability? If so, is this effect because such investments help improve sales, or is it because they help reduce overall operating expenses? How does the effect of IT on profitability compare with that of advertising and of research and development? These are important questions because investments in IT constitute a large part of firms' discretionary expenditures, and managers need to understand the likely impacts and mechanisms to justify and realize value from their IT and related resource allocation processes. The empirical evidence in this paper, derived using archival data from 1998 to 2003 for more than 400 global firms, suggests that IT has a positive impact on profitability. Importantly, the effect of IT investments on sales and profitability is higher than that of other discretionary investments, such as advertising and R&D. A significant portion of the impact of IT on firm profitability is accounted for by IT-enabled revenue growth, but there is no evidence for the effect of IT on profitability through operating cost reduction. Taken together, these findings suggest that firms have had greater success in achieving higher profitability through IT-enabled revenue growth than through IT-enabled cost reduction. They also provide important implications for managers to make allocations among discretionary expenditures such as IT, advertising, and R&D. With regard to IT expenditures, the results imply that firms should accord higher priority to IT projects that have revenue growth potential over those that focus mainly on cost savings.

Keywords: Information technology, profitability, revenue growth, cost reduction, firm performance, discretionary expenditures, advertising, research and development, resource-based view, profitability paradox

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The appendix for this paper is located in the "Online Supplements" section of the *MIS Quarterly*'s website (http://www.misq.org).

Introduction

Information systems researchers have made significant strides in relating information technology and IT-enabled capabilities to firm performance (for a recent review, see Kohli and Grover 2008), but some critical gaps still remain. Prior empirical studies, mostly based on IT investment data before the onset of the "network" era of computing (Hitt and Brynjolfsson 1996; Rai et al. 1997) but also some using data from 1999 to 2002 (Aral and Weill 2007), show either a negative or a null effect of overall IT investments on profitability. These null findings appear to contradict evidence from other studies that show that firms benefit from investments in IT and IT-enabled capabilities, prompting Dedrick et al. (2003, p. 23) to call it "the profitability paradox" of IT.

Furthermore, while researchers argue that IT investments can allow firms to achieve both revenue growth and cost savings (Kauffman and Walden 2001; Kulatilaka and Venkatraman 2001; Sambamurthy et al. 2003), the extent to which IT enables firms to achieve profitability through its impact on revenue growth and cost savings remains unknown. Besides the theoretical importance of exploring whether the revenue growth pathway is more profitable than the cost reduction pathway, this is also an important issue for executives who need to prioritize among IT projects that have varying levels of revenue generation and cost reduction potential. Executives also need to know how to allocate discretionary dollars among IT, advertising, and R&D to maximize profitability.

This article poses the following questions: Do IT investments affect firm profitability? Specifically, how do IT-enabled revenue growth and IT-enabled cost reduction compare in terms of their relative impact on firm profitability? How does the effect of IT on profitability compare with that of advertising and of research and development?

We propose a theoretical framework that explains why IT favorably affects revenues, operating costs, and firm profitability. Then, we use longitudinal archival data from a large sample of more than 400 global firms to test this theoretical framework. Our results suggest a significant effect of IT investments on firm profitability. Specifically, we find that IT investments have a greater impact on firm profitability through revenue growth than through cost reduction, thus complementing related studies that identify mechanisms for IT-enabled value creation (Aral and Weill 2007; Barua et al. 1995; Bhatt and Grover 2005; Cheng and Nault 2007; DeLone and McLean 1992; El Sawy and Pavlou 2008; Kohli and Melville 2009; Lucas 1993; Mithas et al. 2011; Mitra and Chaya 1996; Pavlou and El Sawy 2006, 2010; Sambamurthy et al. 2003; Tallon et al. 2000). Finally, we find that the effect of IT investments on sales and profitability is higher than that of other discretionary investments such as advertising and R&D expenditures.

Theoretical Framework

Background

Prior research has investigated the direct effect of IT on profitability but rarely how this effect is mediated through revenue or cost (Table 1 describes some of the salient studies in the literature). Researchers have offered at least four arguments to reconcile the null findings with the general notion that IT must have some positive impact on profits: competitive effects, level of analysis, changes in the nature of IT systems, and data or modeling issues.[2] Each of these reasons has merit, but related conceptual and empirical work also suggests the need for continued exploration of the mechanisms that can explain how IT may influence profits.

First, firms may be unable to appropriate the value created by IT because they may have been forced to pass on the benefits of IT-enabled productivity in the form of lower prices and increased convenience to customers (Hitt and Brynjolfsson 1996). Although researchers have documented some evidence for this reasoning (Mithas and Jones 2007; Mithas et al. 2005, 2009), if firms can use IT to create customer switching costs or differentiate themselves through better customer service, then IT systems can enable both customer satisfaction and profitability (for a discussion, see Grover and Ramanlal 1999).

Second, the failure to detect profitability effects of IT investment at the firm level might be because of the aggregation involved; it may be possible to detect IT-related value creation at a disaggregated level, such as at the level of specific IT systems or capabilities (Aral and Weill 2007; Banker et al. 2006b; Mithas et al. 2005). Theoretically, if individual IT applications create value that directly or indirectly leads to profitability, overall IT investments should eventually lead to higher profits.

[2] In addition, an argument that sometimes surfaces is that in a perfect setting of rational managers and correct information, it may be difficult to attain supernormal, sustained "economic profits" by investing in IT. Although this may be a useful assumption in analytical models, in reality economic profits can arise as a result of imperfect knowledge and differential capabilities and resources, as the resource-based view argues. Furthermore, economic profits (revenues minus opportunity costs) should be distinguished from accounting profits (revenues minus all costs, except the opportunity cost of equity capital, calculated using standard accounting principles); prior work has primarily used accounting profits in empirical work. When we consider the important distinctions between economic and accounting profits, it is possible to understand why there should theoretically be an effect of IT on accounting profitability, but data or modeling limitations may have made those effects more difficult to detect, as was the case with the productivity paradox of the 1980s.

Table 1. Selected Studies Linking Aggregate IT Investments with Profitability

Study	Dataset	IT Measure	Profitability Measure	Main Result for IT–Profitability Relationship	Remarks
Hitt and Brynjolfsson (1996): Tables 4a, 4b, and 5	IDG Annual Surveys from 1988 to 1992; unbalanced panel of 370 firms	IT stock per employee per year	Return on assets (ROA), return on equity (ROE), and total return	Negative coefficients (sometimes statistically significant) in majority of models. Positive coefficients are statistically insignificant	Mostly cross-sectional analyses
Rai et al. (1997): Table 2c	InformationWeek 1994 Survey	Annual IT budget	ROA, ROE	Not significant (n.s.)	Mostly cross-sectional analyses
Aral and Weill (2007)	Primary survey of 147 U.S. firms from 1999 to 2002	Annual IT budget as a percentage of sales	ROA, Net Margin	n.s.	OLS models (with controls for firm size, R&D, advertising and industry effects) and fixed effects models (see their Table 5)
This study	*Proprietary data from an internationally recognized research firm, 1998 to 2003; unbalanced panel of more than 300 firms*	*Annual IT budget per employee*	*Net income per employee*	*Positive and statistically significant coefficients in most models*	*Panel regressions and other methods that consider longitudinal nature of data*

Notes: This table lists some representative studies and is not meant to be exhaustive. For a more detailed review of the literature on business value of IT, see Dedrick et al. (2003), Kohli and Devaraj (2003), Kohli and Grover (2008), and Melville et al. (2004).

Third, the failure to detect profitability effects of IT investments might be due to limitations of IT in the pre-Internet era, which did not allow as much connectivity and integration as the open standards-based systems that emerged after 1995 (e.g., Andal-Ancion et al. 2003). For example, firms now make much greater use of package applications (e.g., enterprise resource planning systems, customer relationship management systems, supply chain management systems) and IT outsourcing and offshoring services (Aral et al. 2006; Carmel and Agarwal 2002; Han et al. 2011; Hitt et al. 2002; Mani et al. 2010; Ramasubbu et al. 2008). It is likely that IT investments after 1995 may have allowed firms to create and capture greater value than was possible before 1995.

Fourth, limitations of data sets and modeling techniques may have led to the failure to detect a statistically significant relationship between IT investments and profitability (Dedrick et al. 2003). This explanation has also been suggested by meta-analysis results that document the importance of sample size and modeling techniques (Kohli and Devaraj 2003). Therefore, richer datasets and improved modeling may have a better chance at detecting the effect of IT on profitability.

A Resource-Based View on the Effect of IT on Profitability

Drawing on the resource-based view (RBV) of the firm as an overarching framework and prior research (Grover et al. 2009; Melville et al. 2004; Nevo and Wade 2010; Saraf et al. 2007; Wade and Hulland 2004), we propose three reasons to explain why overall IT investments are likely to have a positive association with accounting profits. First, an explanation based on the virtuous cycle argument (see Aral et al. 2006) suggests that firms that invest in IT in period 1 reap benefits and then invest more in IT in period 2. Over time, these effects become magnified, leading some firms to continue investing more in IT compared with their historical investment and that of their competitors and to maintain a more proactive digital strategic posture. Because of their higher investments in IT and greater opportunities to learn from occasional failures in their overall IT portfolio, the firms undergoing the virtuous cycle are also likely to become better at managing IT.

A second, learning-based explanation suggests that years of continued investments in IT and experience in managing these systems may have improved the capability of firms to leverage information and strengthen other organizational capabilities (Grover and Ramanlal 1999, 2004; Mithas et al. 2011). In support of this explanation, several empirical studies show that firms have learned how to make use of IT to improve customer satisfaction, at the same time boosting profitability through the positive effects of customer loyalty, cross-selling, and reduced marketing and selling costs (Fornell et al. 2009; Fornell et al. 2006; Grover and Ramanlal 1999; Mithas and Jones 2007; Mithas et al. 2005).

A third explanation, based on Kohli's (2007) work, suggests that because of a long history of firms viewing IT mainly as an automation-related investment, with a focus on cost reduction rather than revenue generation, firms may have "just about exhausted efficiency gains from IT" (p. 210). To the extent that RBV's logic focuses on differential firm performance; if revenue growth has become a primary driver for differentiation because of exhaustion of cost-based differentiation, tracing the effect of IT on profitability through revenue growth may be more promising.

The preceding three explanations (virtuous cycle, learning, and strategic posture of differentiating through revenue growth rather than through cost reduction) relate to the key tenets of RBV, which uses the notions of social complexity, erosion barriers, path dependence, and organizational learning to explain why resources create and sustain a competitive advantage (see Piccoli and Ives 2005). Table 2 provides a brief summary of the key dimensions of RBV theory and a justification for the hypotheses.

Linking IT Investments to Revenue Growth

We posit that IT investments facilitate revenue growth through new value propositions, new marketing and sales channels, and improved management of the customer life cycle. First, IT systems allow firms to create new value propositions to better meet needs and develop new offerings for customers. For example, IT systems such as CRM applications facilitate personalization of offerings and services through improved knowledge of customers' needs, leading to better customer response (Ansari and Mela 2003) and improved one-to-one marketing effectiveness (Mithas et al. 2006). This is accomplished by enabling a better understanding of unfulfilled and evolving customer needs and capturing and making use of customer knowledge for better design, demand forecasts, manufacturing, delivery, cross-selling opportunities, and fulfillment (Kohli 2007; Kohli and Melville 2009; Liang and Tanniru 2006-07; Weill and Aral 2006).

Second, IT systems enable firms to develop new marketing and sales channels to promote awareness of their product/service offerings to existing customers and to attract new customers. For example, IT systems allow firms to target customers through a large number of new IT-enabled channels, such as e-mail, short messaging systems, websites, and targeted databases, thereby adding to their revenue stream.

Third, IT improves the management of the customer life cycle, from increasing contact and closing rates to improved customer retention, customer knowledge, and customer satisfaction (Bardhan 2007; Srinivasan and Moorman 2005). In turn, higher customer satisfaction leads to higher loyalty and willingness to pay (Homburg et al. 2002), which ultimately leads to higher revenue growth (Babakus et al. 2004).

IT initiatives for revenue growth often require flexibility in response to a range of possibilities. IT initiatives often require subtle changes in interlinkages among business processes involving multiple stakeholders, which involves high levels of social complexity. Such IT-enabled opportunities are characterized by organizational learning and path dependence, which create significant barriers to the erosion of competitive advantage. For example, Dell makes extensive use of IT (e.g., social media) to help engage its employees and customers (Bennett 2009). Investments into online conversational spaces, such as IdeaStorm and EmployeeStorm, forge interlinkages between customers and business units. In turn, these tools help Dell embed feedback into business processes and improve its customer resource life-cycle management. Similarly, Southwest Airlines created an integrated system to form extensive links among customers, employees, and other airlines (Feld 2009). Both Dell and Southwest show how IT investments contribute to an ambidextrous capability: IT infrastructure facilitates complex operational tasks on the back end while presenting a friendly interface to consumers. Furthermore, the operational and customer-facing facets of IT capability are integrated and interdependent with built-in feedback mechanisms, allowing for continual process improvements and organizational learning. These examples illustrate how IT investments can help firms build IT resources and develop capabilities, thus leading to higher revenues.

H1: IT investments have a positive association with firm revenues.

Linking IT Investments to Cost Reduction

IT systems help firms reduce or avoid operational costs, general and administrative costs, and marketing costs. First,

Table 2. Mapping Hypotheses and RBV Constructs

Key Dimensions of RBV	Why IT Will Influence Revenues?	Why IT Will Influence Costs?	Why Effect of IT on Profitability Will Be Greater Through Revenues Than Through Costs?	Why Effect of IT on Profitability Will Be Greater Than That of Advertising and R&D?
Social complexity (Barney 1991)	IT forms interlinkages between customers and organizational units, and is embedded into business processes and customer resource life cycle management. **Examples:** Dell (Bennett 2009), Southwest (Feld 2009)	IT reduces cost through the integration of different individuals, organizational units, and firms leading to greater social complexity. **Examples:** Wal-Mart (Manyika and Nevens 2002), Procter & Gamble (P&G) (Baker 2005; Bloch and Lempres 2008)	IT projects for revenue generation are focused mainly on reconfiguration and restructuring of business processes. In contrast, IT projects for cost reduction are easier to deploy because cost-saving advantages may be based on automation or information sharing. **Examples:** Marriott (Wilson 2007)	High social complexity of IT because of its role in enhancing the breadth and depth of relationships. For example, one-to-one customer relationships can be developed through CRM instead of through traditional marketing channels. **Examples:** Vanguard (Ackermann 2010; King 2008; Wolfe 2010), Wyeth (Carr 2008)
Barriers to erosion of competitive advantage (Grover et al. 2009; Mata et al. 1995; Piccoli and Ives 2005)	IT resources, such as databases of customer profiles and transactions, are cospecialized and information specific. Different combinations of IT resources can be inimitable. Interactions between IT assets and organizational resources can also create complementary resource barriers. Thus, IT resources create preemption barriers. **Examples:** Harrah's Entertainment (IBM 2009)	Competitive barriers to cost reduction can be achieved by IT resources such as supply-chain systems. **Examples:** Wal-Mart (Manyika and Nevens 2002), P&G (Baker 2005; Bloch and Lempres 2008)	The barrier to erosion is greater in the use of IT for revenue generation than in the use of IT for cost reduction because of the greater presence of complementary resources barriers. **Examples:** Harrah's incentive systems, based on team rewards and customer satisfaction, complement its data warehouse and business intelligence initiatives.	Compared with advertising or R&D, which create barriers to erosion primarily in terms of brand loyalty or product innovation respectively, IT may create barriers to erosion along several dimensions simultaneously because of its cross-functional role. **Examples:** Wyeth (Carr 2008), AstraZeneca (NGP 2009)
Path dependence and/or asset stock accumulation (Eisenhardt and Martin 2000; Teece et al. 1997)	IT-enabled resources, such as historical customer databases, information repositories, and infrastructure, are path dependent. This resource accumulation process creates a barrier of erosion that is hard for competitors to imitate. **Examples:** Harrah's Entertainment (IBM 2009)	Early IT systems (e.g., Wal-Mart's satellite network and P&G's SAP investments) created future opportunities that would not be easy to replicate by competitors. **Examples:** Wal-Mart (Manyika and Nevens 2002), P&G (Baker 2005; Bloch and Lempres 2008)	Early investments in Total Rewards allowed Harrah's to collect information that subsequent investments in data warehousing and business intelligence were able to leverage. **Examples:** Harrah's (IBM 2009)	IT systems have greater path dependence than advertising because IT capabilities evolve gradually through integration with many business processes. IT systems have greater path dependence than R&D because of the limited duration of patent protections afforded by R&D. IT-related path dependence is more tacit and is sustained over longer time. **Examples:** Harrah's (IBM 2009)
Organizational learning (Bharadwaj 2000; Dierickx and Cool 1989)	IT systems enable organizational learning to facilitate higher sales through customer knowledge and cross-selling. **Examples:** Harrah's Entertainment (IBM 2009)	IT-enabled organizational learning is facilitated through the replication of cost reduction routines across the organization. **Examples:** Verizon (King 2008), P&G (Baker 2005; Bloch and Lempres 2008)	Since IT-enabled organizational learning for revenue generation is more tacit, complex and novel than that for cost reduction processes, IT will have a greater effect on profitability through revenues than through costs. **Examples:** Harrah's (IBM 2009)	

deployment of IT systems has improved the efficiency of operational and supply chain processes within and across firms by supporting lean transformational efforts (Ilebrand et al. 2010). IT implementations within firms are associated with higher productivity and a reduction in inventory and cycle times, thus reducing overall operational costs (Banker et al. 2006a; Mukhopadhyay et al. 1995). Among initiatives that span across firms, IT has supported cost reduction through better information sharing and tighter coordination in supply chain relationships, sometimes involving outsourcing of business processes (Banker et al. 2006b; Bardhan, Mithas and Lin 2007; Cotteleer and Bendoly 2006; Kohli 2007; Mukhopadhyay and Kekre 2002; Whitaker et al. 2011).

Second, IT-enabled cost reductions are evident in general and administrative processes. For example, IT-enabled automation lowers employee and customer support costs through the implementation of self-service technologies, which facilitate sales and related transactions, such as ordering, payment, and exchange through which customers can transact and get support without human intervention (Meuter et al. 2000). Beyond self-service technologies, integrated IT systems allow customers to perform certain tasks on their own (e.g., entering data about their orders), thus reducing labor costs at the focal firm and freeing time to plan and optimize other costs (Kohli 2007).

Finally, IT-enabled systems allow firms to reduce the costs of customer acquisition and marketing campaigns. For example, the cost of sending messages through electronic media such as e-mail, short messaging systems, and social media is a fraction of the cost of traditional advertising channels (e.g., television, direct face-to-face marketing). The costs of capturing, maintaining, and integrating different sources of information to target consumers are also comparatively lower because of the availability of Internet-based applications, websites, click-stream data, and user profiling technologies (Ansari and Mela 2003).

These IT-enabled opportunities for cost reduction and cost avoidance can be socially complex (because of the inherent complexity involved in integrating multiple systems) and may require significant organizational learning to replicate cost-saving routines across the organization. For example, Wal-Mart uses IT to forge links with vendors and employees in a socially complex way. Investing in the RetailLink system enables Wal-Mart to be tightly linked with its vendors, providing them with frequent, timely, and store-specific sales information. This information system has led to quick turnaround times for Wal-Mart and has driven labor and inventory costs down (Manyika and Nevens 2002). Wal-Mart's earlier investments in a satellite network created a foundation for its later investments. The company heavily invested in RFID, building on top of its existing satellite network to increase efficiency and reduce costs. This case example illustrates how IT investment can enable the reduction of operating costs through greater social complexity, path dependence, and organizational learning.

H2: IT investments have a negative association with firm operating costs (i.e., IT investments decrease overall operating expenses).

Differential Impact of IT-Enabled Revenue Growth Versus Cost Saving on Profitability

While both revenue growth and cost savings are likely to mediate the impact of IT investments on firm profitability, we argue that IT-enabled revenue growth is a stronger driver of profitability than IT-enabled cost savings because revenue-enhancing IT projects are likely to have greater social complexity, path dependence, and organizational learning, as well as higher barriers to erosion than cost-saving IT projects. The social complexity of revenue-enhancing IT projects stems from interlinkages of such IT projects with customer-facing business processes and customer life-cycle management, making successful implementation of these projects more sustainable and making it difficult for competitors to replicate successes (Im and Rai 2008). In contrast, IT projects focused mainly on cost savings may be easier to deploy because they may be based on transaction automation or information sharing rather than on reconfiguration of business processes that are more often associated with revenue-enhancing IT projects.

In addition, because it is difficult to attribute the advantages of revenue-enhancing IT projects to publicly available information, competitors are unlikely to grasp the real sources of competitive advantage and revenue creation potential of these projects. Furthermore, because revenue-enhancing projects are often enmeshed in existing business processes, they have inherent path dependence, involve significant organizational learning, and may require substantial complementary resources for successful implementation. Therefore, we argue that revenue-enhancing IT projects are more difficult for competitors to replicate than IT projects that involve cost reduction.

Note also that many cost reduction innovations in IT are not firm specific, particularly considering that they often involve automation tools that are purchased from vendors. Although there are exceptions, many cost-reducing IT tools can be purchased or developed through contracts with specialized IT vendors or consulting firms. Because there is greater industry concentration (fewer firms) upstream in a supply chain, we argue that the cost side of firm operations is likely to be less differentiated than the customer-facing revenue side of firm operations. Revenue-generating projects are more firm specific because they align with the downstream or customer-facing side of the business, which thrives on unique customer profiles, niche markets, and heterogeneity in products and services. For this reason, revenue-generating projects are less likely to be replicable, and firms are more likely to differentiate themselves and find a niche based on revenue-generating capabilities than on cost reduction capabilities.

Together, greater social complexity, path dependence, and organizational learning and higher barriers to erosion of revenue-enhancing IT projects can provide effective *ex post* limits to competition and can protect a firm against resource imitation, transfer, and substitution, thereby improving the profit-generating potential of revenue-enhancing IT projects more than that of cost-saving IT projects (Piccoli and Ives 2005). Wade and Hulland (2004) provide indirect support for these arguments by suggesting that outside-in and spanning information systems resources (IT systems typically associated with revenue-enhancing initiatives) are likely to have stronger and more enduring effects on competitive position than inside-out IT resources (IT systems typically associated with cost-saving initiatives).

H3: IT investments have a stronger effect on profitability through revenue growth than through operating cost reduction.

Relative Effect of IT, Advertising, and R&D on Profitability

An important question from a managerial perspective is the magnitude of the IT–profitability relationship, relative to the effect of other discretionary expenditures, such as advertising and R&D on profitability. Managers must often make resource allocation decisions that involve trade-offs among IT, advertising, and R&D expenditures. These allocations require significant care because IT is intertwined with many business processes in marketing and new product development that involve advertising and R&D expenditures. For example, many marketing and sales processes are now IT driven, and firms are increasingly using IT-enabled channels to reach and transact with customers (Bradley and Bartlett 2007). Therefore, it is natural to expect that firms will shift their advertising dollars to IT if such shifts in expenditures help firms reach customers more effectively and at less cost. Indeed, with the emergence of online search intermediaries such as Google, the advertising industry is undergoing a transformation, and online advertising is growing faster than offline advertising. Likewise, because IT systems reduce coordination costs and may allow firms to conduct their R&D activities more effectively (see Brynjolfsson and Schrage 2009; Gordon and Tarafdar 2010; Hopkins 2010), it is possible for firms to reallocate a greater share of their discretionary expenditures to IT if they facilitate R&D activities.

While acknowledging that the question regarding which of these discretionary investments is most profitable is ultimately an empirical one, we argue that IT investments are likely to be more profit enhancing than advertising or R&D investments. Drawing on the RBV, we posit that IT resources have greater social complexity than advertising or R&D investments. IT investments can influence business processes that encompass both digital and nondigital channels of communication and can allow a firm to engage a wider range of stakeholders in its innovation ecosystem (Han and Mithas 2011; Linder et al. 2003). For example, Vanguard has been focusing on the Internet and related technologies to forge ties with clients (King 2008). Vanguard has grown its assets from $580 billion to $1.4 trillion, much of which has been driven by IT investments. Over the years, Vanguard's IT investments portfolio has expanded to include live webcasts, chats, blogs, and iPhone applications. This case illustrates the role of IT in coordinating and integrating multiple strategic initiatives. While individual actions may be imitable in isolation, not only does the social complexity-enhancing role of IT strengthen the firm's competitive advantage through the integration of these initiatives, it is also difficult for competitors to imitate.

Even in the most R&D- and advertising-intensive industries, such as the pharmaceutical and biotechnology industries, IT investments play a critical role in revenue generation. Wyeth, a biotechnology and pharmaceutical company that was recently acquired by Pfizer, invested significantly in IT to support its R&D. These investments enabled virtual teams from different business units around the world to collaborate in research and to develop new drugs (Carr 2008). These examples show how capabilities for IT-enabled collaboration have become inseparable from corporate culture and are not easily replicable by competitors investing in isolated technology components.

In light of the foregoing arguments and prior research that suggests significantly higher returns to IT compared with other types of investments (Aral and Weill 2007; Brynjolfsson and Hitt 1996; Dewan and Min 1997; Dewan et al. 2007; Lichtenberg 1995), we posit that IT expenditures have greater effect on profitability than advertising or R&D expenditures.[3]

[3]Among prior studies, Aral and Weill's (2007) includes advertising and R&D expenditures in some of its models when examining the effect of IT on profitability.

H4: IT investments have greater total effect on firm profitability than advertising and R&D expenditures.

We follow prior work (e.g., Bharadwaj et al. 1999; Dewan et al. 2007) in choosing relevant firm- and industry-level variables that are likely to be correlated with our focal independent variables and dependent variables, subject to data availability. If unobserved variables are uncorrelated with our focal variables (e.g., IT, advertising, and R&D investments) or profitability, then our estimation remains unbiased and consistent.[4] Overall, given that we use panel data and methods to investigate the effects of potential endogeneity, we believe that we have accounted for key controls and unobservables.

Method

We conduct an empirical investigation using archival data collected by one of the largest international research firms well known for its IT data and research services. The research firm collected firm-level IT investment data, along with other IT investment-related information, as part of its annual worldwide IT benchmarking survey. The surveys targeted chief information officers and other senior IT executives of large, global firms to collect objective metrics related to IT investments.

IT investments include all hardware, software, personnel, training, disaster recovery, facilities, and other costs associated with supporting the IT environment, including the data center, desktop/WAN/LAN server, voice and data network, help desk, application development and maintenance, finance, and administration. The research firm collected firm-level financial measures, such as profitability and operating expenses, independently from secondary data sources for publicly available measures and from its proprietary survey for measures that were not publicly available.

Table 3 provides the definition, variable construction, and sources for all of the variables used in this research. We assisted the research firm's data collection effort using the Standard & Poor's COMPUSTAT database in such a way that the firm identities in the final sample remained unknown to us. The specific variables from COMPUSTAT include net sales, advertising expenditure, R&D expenditure, cost of goods sold, operating income, and number of employees. We classified firms into industry sectors such as manufacturing, trade, finance, professional services, and a category that includes agriculture, mining, utilities, construction, transportation, and warehousing. Consistent with prior work (Chung and Pruitt 1994; Hou and Robinson 2006; Waring 1996), we constructed variables such as industry average Tobin's q, industry average capital intensity, and Herfindahl index, based on the population of publicly listed U.S. firms in COMPUSTAT.

Our final data set for this study consists of 452 firms for which complete data on key variables of interest were available from 1998 to 2003 (for descriptive statistics and correlations, see Table 4). The total number of firm-year observations was 1,532 because we do not have data on all firms for each of the six years in our study. Of the 452 firms in our panel, 181 appear only once, 28 appear twice, 19 appear three times, 25 appear four times, 56 appear five times, and the remaining 143 appear six times. Approximately 8 percent of the respondent companies have gross revenues greater than \$25 billion, 15 percent have gross revenues between \$10 billion and \$25 billion, 11 percent have gross revenues between \$5 billion and \$10 billion, and 49 percent have gross revenues between \$1 billion and \$5 billion. The rest have gross revenues less than \$1 billion.

Table 4 shows that the average IT spending was \$15,000 (\$0.015 million) per employee during the 1998–2003 period, higher than the average R&D spending of \$13,000 (\$0.013 million) per employee and the average advertising spending of \$10,000 (\$0.010 million) per employee. The average net income (profitability) during this period was \$22,000 per employee, the average sales were \$386,000 per employee, and the average operating expenses were \$44,000 per employee.

In terms of variability of IT, advertising, and R&D expenditures, we find that IT expenditures have the highest standard deviation, followed by R&D and then by advertising. These patterns are broadly consistent with the virtuous cycle argument we describe in the "Theoretical Framework" section, suggesting that firms that have greater initial success with IT tend to invest more and others that have less initial success with IT subsequently tend to invest less, thereby causing larger variability in IT expenditures. We also find that IT investments have a positive and statistically significant correlation with sales and profitability, and a negative and statistically significant correlation with operating expenses. These correlations provide preliminary support for some of our conjectures in the theory section.

[4]Typically, cross-sectional models require a more extensive set of controls for firm heterogeneity than the longitudinal models used in this study, as we discuss subsequently. Bharadwaj et al. (1999) control for weighted average market share at the firm level; we do not have access to this variable, because we do not know the firms' identities. However, this variable in Bharadwaj et al.'s study is statistically insignificant at a conventional level of $p < .05$ or below (using two-tailed tests) in two of the five years of data in their study. Likewise, Bharadwaj et al. use firm diversification in their study, but this variable is statistically insignificant in four of the five years in their models (statistical significance in the remaining year is at $p > .05$ using two-tailed tests).

Table 3. Variable Definitions and Data Sources

Variable Name	Variable Construction/ Definition	Source
PROFITABILITY	Net Income (in millions of dollars) per employee. This variable was computed from publicly available data sources wherever possible and through the use of the research firm's survey when it was not publicly available.	COMPUSTAT and proprietary survey[a]
IT	IT investments (in millions of dollars) per employee. This variable represents the total dollar value of capital and operational expenses to support the IT environment.	Proprietary survey
OPEX	Operating expenses before depreciation (in millions of dollars) per employee, where Operating Expenses = Sales – Cost of Goods Sold – Operating Income	COMPUSTAT
SALES	Revenue (in millions of dollars) per employee	COMPUSTAT
R&D	Research & development (in millions of dollars) expenditure per employee	COMPUSTAT
ADV	Advertising expenditure (in millions of dollars) per employee	COMPUSTAT
INDUSTRY	Firms are classified into trade, manufacturing, financial services and professional services and other industries based on the primary NAICS code of a firm.	Bureau of Labor Statistics
SIZE1-SIZE6	Firm size dummy variables (based on annual firm revenue) Size1 = $ 101–$500 million, Size2 = $500 million–$1 billion, Size3 = $1 billion–$5 billion, Size4 = $5 billion–$10 billion, Size5 = $10 billion–$25 billion, Size6 = >$25 billion	Proprietary survey[a]
Industry Capital Intensity	Physical Capital/Value Added as defined by Waring (1996). Physical Capital is gross property, Plant and Equipment (COMPUSTAT #7). Value Added is the Sales (COMPUSTAT #12) minus Materials. Materials is the difference between Total Expense and Labor Expense. Total Expense is equivalent to Sales minus Operating Income before Depreciation (COMPUSTAT #12–COMPUSTAT #13). Labor Expense is COMPUSTAT #42.	COMPUSTAT, Bureau of Labor Statistics
Herfindahl	Measure of industry concentration, following the procedure described in Hou and Robinson (2006). The Herfindahl index for industry j is measured as follows: $Herfindahl_j = \sum_i s_{ij}^2$ where s_{ij} is the market share of firm i in industry j.	COMPUSTAT
Industry Tobin's q	Industry (three-digit NAICS) average Tobin's q, ratio of market value to book value, as in Chung and Pruitt (1994).	COMPUSTAT

Notes: All monetary figures are deflated to 2000 dollars using the implicit GDP fixed investment deflator (http://www.econstats.com/ gdp/gdp_q4.htm).
[a]Profitability measure is provided by the research firm, and for the most part, these data are likely to have been derived from COMPUSTAT except for the private firms for which COMPUSTAT data are not available.

Table 4. Summary Statistics and Pairwise Correlation Matrix

		1	2	3	4	5	6	7	8	9
1	PROFITABILITY	1.00								
2	SALES	0.85*	1.00							
3	OPEX	–0.05*	0.00	1.00						
4	IT	0.88*	0.92*	–0.07*	1.00					
5	Advertising	0.21*	0.23*	0.62*	0.24*	1.00				
6	R&D	0.33*	0.16*	0.68*	0.22*	0.17*	1.00			
7	Capital Intensity	0.01	0.00	–0.02	0.01	–0.01	0.00	1.00		
8	Herfindahl	–0.04	0.00	0.01	0.00	–0.13*	–0.23*	0.04	1.00	
9	Ind. Tobin's Q	0.06*	0.04	0.07*	0.06*	0.10*	0.02	-0.04	0.01	1.00
	Mean	0.022	0.386	0.044	0.015	0.010	0.013	0.641	0.074	11.673
	Standard Deviation	0.080	0.768	0.059	0.055	0.019	0.025	45.812	0.097	39.521
	Observations	1658	1658	1658	1658	493	865	1563	1658	1629

*Significant at 5% level.

Figure 1 shows the trends of key variables from 1998 to 2003. We observe that average IT expenditures gained a higher share of discretionary expenditures over average R&D and average advertising expenditures, while the relative share of average advertising expenditures declined after 2000. Notably, we observe average net income and average operating expenses both rising until their peak in the 2001, after which average net income fell, while average operating costs show a seesaw pattern (they decline in 2002 and rise again in 2003).

Because of the panel nature of our data set, we specify the following equation for the panel models:

$$Y_{it} = X_{it}\,\beta + u_i + \varepsilon_{it} \tag{1}$$

where Y represents endogenous variables such as profitability, sales, and operating expenses; X represents a vector of firm characteristics, such as IT investment data and other control variables; βs are the parameters to be estimated; subscript i indicates firms and subscript t indicates time; u_i represents unobserved time invariant fixed factors associated with a firm i; and ε is the error term associated with each observation.

Panel models (e.g., random and fixed effects models) assume exogeneity of Xs (i.e., $E\,[\varepsilon_{it}|X_i,\, u_i] = 0$). We conducted a Hausman (1978) test to assess potential endogeneity of the IT investments variable following Wooldridge's (2003) recommended procedure.[5] Our test failed to reject the null hypothesis for exogeneity of IT investments in our models.[6] Due to the efficiency and generalizability advantages of random effects models, we report and interpret random effects models whenever Hausman tests show no significant differences between random and fixed effects estimates. Otherwise, we present and interpret fixed effects estimates. Subsequently, we discuss alternative estimation strategies, specifications, and adjustments as robustness checks.[7]

Table 5 presents the random effects panel estimates with robust standard errors. We performed several diagnostic checks to ascertain the stability of our results and did not detect any significant problems (Belsley et al. 1980). We accounted for heteroskedastic error distribution and calculated heteroskedasticity-consistent standard errors for all of our models (Greene 2000).[8] The highest variance inflation factor in our models was 6.03, indicating that multicollinearity is not a serious concern.

Results

We find support for Hypothesis 1 but not for Hypothesis 2. We find that IT investments per employee have a positive and statistically significant association with revenue. Specifically, an increase in IT expenditure per employee by $1 is associated with $12.22 increase in sales per employee (see Column 1 of Table 5).[9] We do not find support for Hypothesis 2, because IT investments per employee have a positive but statistically insignificant relationship with operating expenses (see Column 2 of Table 5).

Hypothesis 3 tries to resolve whether IT-enabled revenue growth is a stronger causal pathway toward profitability than IT-enabled cost savings. Column 4 of Table 5 shows that the coefficient of SALES is positive and statistically significant,

[5]One way to conceptualize exogeneity of IT investments is that because of significant uncertainties in value realization, managers do not always know whether IT investments will yield the desired outcomes in the context of their firm, and they also do not know what the right level of IT investment is. These factors can theoretically create exogenous variation in IT investments across firms that is unrelated to revenues or profitability of that year (particularly because IT investment decisions are likely to precede the realization of revenues or profits of a given year). Nonetheless, our robustness checks using lagged values of investments also yielded broadly similar results.

[6]In this procedure, we regressed the value of the IT spending variable on lagged values of IT spending and other Xs in our model. We used the predicted value of IT spending from this model to compute predicted residuals for IT spending. We then used this predicted residual in the sales growth, operating expenses, and profitability models along with the contemporaneous IT spending variable. Because this predicted residual was not statistically significant in these models, this test alleviates concerns about the endogeneity of IT spending variable. As an additional way to alleviate concerns due to endogeneity, we estimated the instrumental variable panel regression models and then employed a Hausman specification test to compare instrumental variables models (both fixed and random effects) with noninstrumental variables models. These Hausman tests fail to reject the null hypothesis of equivalence between instrumental and noninstrumental variables models. Because the results of Hausman tests depend on the choice of instruments, we used the Sargan's overidentification test to assess the validity of the chosen instruments. The Sargan statistic was insignificant, providing confidence in the validity of the Hausman test.

[7]All models were estimated using Stata 9.

[8]We investigated the nonlinear effect of IT investments on sales, costs, and profitability. These models, which use an additional quadratic IT investments term, provide broadly similar results. Thus, we continue with linear models for easier interpretation.

[9]Note that our empirical models do not include complementary investments in business processes and human capital that are likely to be related to IT investments; thus, they may assign more credit to IT than to the actual marginal impact of IT in revenue growth models. However, this limitation is well known and is shared by other similar empirical studies on the business value of IT research.

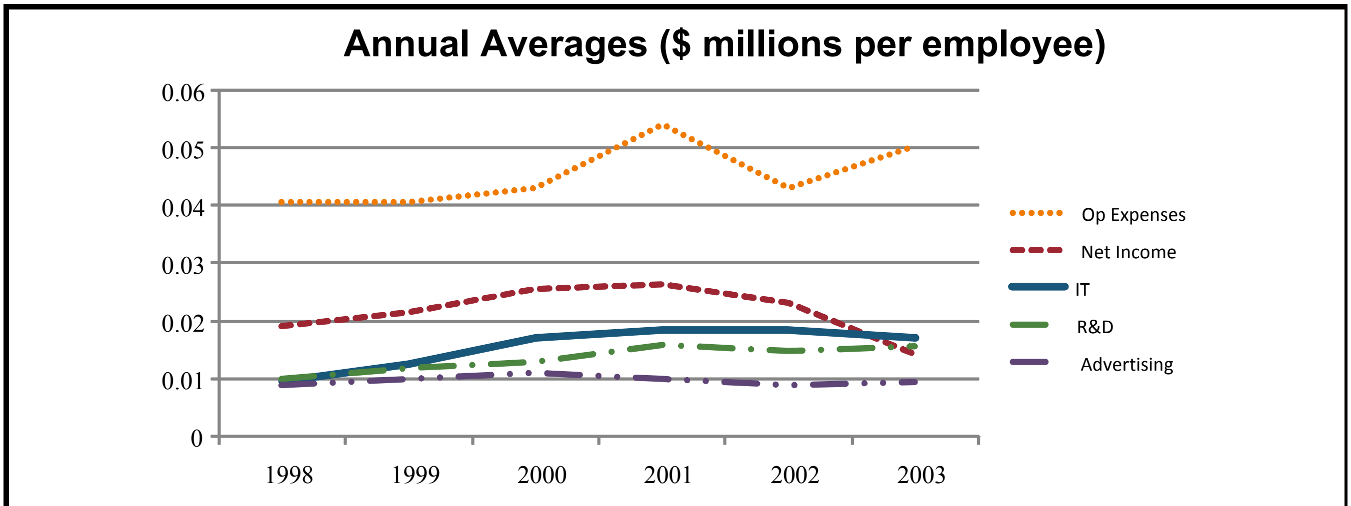

Figure 1. Annual Averages in Expenses and Profitability, 1998–2003

Table 5. Random Effects Panel Regressions[a]

	(1)	(2)	(3)	(4)
	SALES	OPEX	PROFITABILITY	PROFITABILITY
IT	12.215*** (1.047)	0.094 (0.067)	1.228*** (0.130)	0.740*** (0.247)
SALES				0.038** (0.019)
OPEX				0.039 (0.063)
R^2 (overall)	0.835	0.172	0.748	0.770
Chi-squared	314.04***	160.15***	271.49***	365.59***
Observations	1532	1532	1532	1532
Number of firms	452	452	452	452

Robust standard errors in parentheses. * significant at 10%, ** significant at 5%, *** significant at 1%.

[a]Random effects models include an intercept, Herfindahl Index, industry capital intensity, industry Tobin's q, broad industry classifications based on the primary NAICS code, and dummy variables for firm size and year. Hausman test statistic shows that parameter estimates of fixed effect and random effect models are similar for the results reported in columns (1), (3), and (4). Even though the Hausman test statistic is statistically significant for the OPEX model in column (2), the magnitude and significance of the coefficient for the IT variable in fixed effects model is similar to the one reported here (coefficient = 0.122, standard error = 0.100).

while that of OPEX is positive but statistically insignificant. Together with the observation that the impact of IT on revenue is much larger than the impact of IT on operating expenses (see the results for Hypotheses 1 and 2), these results suggest that revenue growth is a stronger causal pathway to profitability than cost reduction, thus providing support for Hypothesis 3. The mediation results indicate that SALES, but not OPEX, has a statistically significant association with profitability in the expected direction (Sobel test, $p < .01$).

To test Hypothesis 4, we conducted our analyses using firm-level R&D and advertising expenditure for the subset of firms that reported these data. Table 6 presents these results and reports fixed effects models because the Hausman test statistic comparing fixed and random effects is statistically significant. The results in Column 1 indicate that the total effect of IT investments on profitability is greater than that of advertising and R&D. Even when we add OPEX and SALES to the model (Column 2), the effect of IT expenditure on profitability is greater than that of advertising and R&D. Panel B

Table 6. Relative Effect of IT, Advertising, and R&D on Profitability (Fixed Effect Models[a])

	(1)	(2)
Panel A	**PROFITABILITY**	**PROFITABILITY**
IT	1.912*** (0.603)	1.837*** (0.497)
SALES		0.054*** (0.017)
OPEX		–0.137 (0.134)
Advertising	0.155 (0.287)	0.142 (0.317)
R&D	1.001*** (0.083)	0.993*** (0.065)
R^2 (overall)	0.49	0.51
Observations	276	276
Number of Firms	86	86
Panel B		
F statistic (IT vs. R&D)	2.46 (0.119)	3.00* (0.085)
F statistic (IT vs. Advertising)	9.79*** (0.002)	9.28*** (0.003)

For Panel A, robust standard errors in parentheses. In all models, the overall F-statistic is statistically significant at p =0.0001. For Wald tests in Panel B, *p*-values are in parentheses.
*Significant at 10%, **Significant at 5%, ***Significant at 1%.
[a]Fixed effect models include an intercept, year, industry average Tobin's q, Herfindahl index, and industry capital intensity.

provides Wald tests that compare the coefficients of IT with that of advertising and R&D expenditures.[10] On the whole, after we allow for the loss of statistical power due to sample size, the results in Panels A and B provide support for Hypothesis 4, suggesting that IT has a greater effect on profitability than advertising and R&D.

Table 7 shows exploratory analyses for how the effect of IT on profitability is moderated by capital intensity, industry sector, competition, and industry growth options. Capital intensity does not have a significant moderating influence on the effect of IT on profitability (Column 1). As industries become more competitive (or less concentrated), the effect of IT on profitability increases (Column 2). This may be because IT enables firms not only to satisfy customers but also to appropriate some of the consumer surplus in the form of higher profits through better targeting, segmentation, and pricing power in hypercompetitive environments (Grover and Ramanlal 1999). As industry growth options increase, the effect of IT on profitability increases (Column 3). This may be because firms are able to leverage IT to create a platform for future growth through new revenue and profit streams.

Finally, to distinguish the effect of IT in industries that rely primarily on physical capital versus those that rely primarily on knowledge capital, we identified firms with two-digit North American Industry Classification System (NAICS) codes of 31, 32, or 33 as belonging to the manufacturing sector, and we classified all others as belonging to the services sector, in line with prior work (Dewan and Ren 2011). The results show that IT has a greater effect on firm profitability in service industries than in manufacturing industries (Column 4). An explanation for this finding may be that services, being more IT intensive, allow greater IT-enabled customization and personalization, thus enabling firms to retain their profitability advantage to a greater extent than in manufacturing industries.

[10] Note that because of missing data on advertising and R&D investments for many firms in the COMPUSTAT database, the sample size in Table 6 is less than one-fifth of that in Table 5. Although the difference between IT and R&D coefficients is not statistically significant in Column 1, it is statistically significant in a more complete model in Column 2 (despite the lower sample size in Table 6, the *p*-value for the Wald test is close to achieving moderate statistical significance at .119).

Table 7. Random Effects Panel Regressions for Profitability Showing Interactions of IT with Industry Variables[a]

	(1)	(2)	(3)	(4)
	PROFITABILITY	PROFITABILITY	PROFITABILITY	PROFITABILITY
IT	0.775*** (0.243)	0.361 (0.258)	0.743*** (0.230)	0.573*** (0.202)
SALES	0.036* (0.019)	0.042** (0.018)	0.035* (0.019)	0.033* (0.019)
OPEX	0.022 (0.063)	0.024 (0.059)	0.023 (0.064)	0.043 (0.064)
IT × Ind. capital intensity	0.001 (0.001)			
IT × HI		–8.627*** (2.491)		
IT × Ind. Tobin's q			0.002*** (0.001)	
IT × Services				0.598*** (0.196)
Observations	1532	1532	1532	1532
Number of firms	452	452	452	452

Robust standard errors in parentheses. In all models, the overall Wald chi-squared statistics is statistically significant at p = 0.0001.
*Significant at 10%, **Significant at 5%, ***Significant at 1%.
[a]Random effect models include an intercept, industry capital intensity, Herfindahl index, industry Tobin's q, and dummy variables for firm size, services sector based on the primary NAICS code, and year. All the variables involved in the interaction terms are mean-centered for easier interpretation of results.

We conducted further robustness checks. First, Table 8 shows Prais-Winsten and Cochrane Orcutt estimates, which account for the first-order serial correlations explicitly using feasible generalized least squares, yielding qualitatively similar results to those in Table 5. Second, in addition to autocorrelation of residuals within a firm, the variances of error terms may also vary (i.e., heteroskedasticity). We used the Breusch-Pagan test, White's test, and a likelihood ratio test comparing estimates from two variations of the generalized least squares estimates— one assuming homoskedasticity and the other assuming heteroskedasticity. These tests indicate the presence of heteroskedasticity. Therefore, we also obtained generalized least squares estimates, adjusting for panel-specific autocorrelation and heteroskedasticity (Table 9). We obtained these estimates using only a subset of data to form a balanced panel; the estimates show similar direction and significance to our main random effects panel regression models. Third, to further alleviate concerns due to reverse causality, we assessed the stability of results by using lagged values of investments. These analyses suggest that the results are broadly similar and robust. Finally, we obtained our parameter estimates using a three-stage least squares estimator that allows errors across revenue, cost, and profitability equations to be correlated. This yielded qualitatively similar results (Table 10).

On the whole, these additional analyses provide results that are qualitatively similar to the main results in Tables 5 and 6. We report the results of our additional analyses and robustness checks in the Appendix. These results provide additional support for our main findings with respect to the significant impact of IT on firm profitability through the revenue growth pathway.

Discussion

Main Findings

Our goal in this study was to examine the effect of IT investments on profitability and the extent to which the effect of IT on profitability is mediated through revenue growth and cost reduction. We used a large sample of more than 400 global firms over a period of six years (1998–2003) to test our conceptual model. We find that IT investments have a positive impact on revenue growth and profitability. In addition, IT-enabled revenue growth has a greater impact on profitability than IT-enabled reduction in operating expenses. We also find that IT expenditures have a greater effect on firm profitability than advertising and R&D expenditures.

Table 8. Cochrane-Orcutt and Prais-Winsten Estimates for Effect of IT on Profitability[a]

	(1)	(2)	(3)	(4)
	PROFITABILITY	PROFITABILITY	PROFITABILITY	PROFITABILITY
	Cochrane-Orcutt	Prais-Winsten	Cochrane-Orcutt	Prais-Winsten
IT	1.155*** (0.078)	1.257*** (0.075)	0.946*** (0.195)	0.768*** (0.251)
SALES			0.017 (0.012)	0.037* (0.019)
OPEX			0.114 (0.095)	0.050 (0.065)
R^2	0.424	0.495	0.434	0.516
F-statistic	36.73***	44.43***	31.32***	40.30***
Observations	1075	1532	1075	1532

The Cochrane-Orcutt estimator omits the first observation for each firm, for computational ease (Greene 2000).
Robust clustered standard errors in parentheses. *Significant at 10%, **Significant at 5%, ***Significant at 1%.
[a]These models include an intercept, dummy variables for firm size, year, industry capital intensity, Herfindahl index, industry average Tobin's q, and broad industry classifications based on the primary NAICS code of a firm.

Table 9. Generalized Least Squares Results Accounting for Panel Specific AR1 Error Structure and Heteroskedasticity[a]

	(1)	(2)	(3)	(4)
	SALES	OPEX	PROFITABILITY	PROFITABILITY
IT	12.420*** (0.239)	0.049* (0.029)	1.275*** (0.038)	0.855*** (0.061)
SALES				0.034*** (0.004)
OPEX				0.090*** (0.016)
Chi-squared	3743.62***	740.68***	1776.85***	2063.77***
Observations	858	858	858	858
Number of firms	143	143	143	143

*Significant at 10%, **Significant at 5%, ***Significant at 1%.
[a]These models include an intercept, dummy variables for firm size, year, industry capital intensity, Herfindahl index, industry Tobin's q, and broad industry classifications based on the primary NAICS code of a firm. The sample has been truncated to include only firms with data points from 1998 to 2003 in order to create a balanced panel structure enabling the use of generalized least squares adjusted for panel specific AR1 and heteroskedasticity.

Table 10. Three Stage Least Squares Regression Results[a]

	(1)	(2)	(3)
	SALES	OPEX	PROFITABILITY
IT	1.666*** (0.173)	0.002 (0.01)	0.921*** (0.05)
SALES			0.026*** (0.004)
OPEX			0.039** (0.019)
Chi-squared	36447.55***	12020.08***	5306.41***
Observations	1517	1517	1517

*Significant at 10%, **Significant at 5%, ***Significant at 1%.
[a]These models include an intercept, industry capital intensity, Herfindahl index, industry Tobin's q, broad industry classifications based on the primary NAICS code of a firm, and dummy variables for firm size and year. SALES and OPEX models also include lagged values of sales and OPEX, respectively, for identification.

Research Implications

This study has several research implications. First, from a theoretical perspective, the findings provide implications for how the RBV tenets work when it comes to IT investments. To the extent that RBV logic focuses on the role of resources in terms of their impact on differential firm performance, our results suggest that IT-enabled revenue growth opportunities may be more promising than IT-enabled cost reduction opportunities to create sustainable competitive advantage. This may be because (1) there is not enough variation across firms in using IT for cost reduction (if Firm A can use an enterprise resource planning or supply chain management solution to reduce its costs, nothing prevents the vendor from selling the same solution to other firms and thereby eroding that cost-based competitive advantage of Firm A) or (2) IT-enabled revenue growth may have stronger virtuous cycles and learning-based advantages, leading to stronger path dependence and relatively less replicability of such advantages, thus causing a more sustainable differential advantage in profitability.

Our research suggests that IT investments are positively associated with profitability, thus underscoring the strategic importance of managing overall levels of IT investments as a critical intangible firm resource. Although prior work has argued for the superiority of proprietary in-house built systems of the 1970s and 1980s that fostered switching costs and price premiums, these features of old IT systems were expected to be difficult to sustain in an environment of open architectures, reverse engineering, and hypercompetition. While such open networks are wringing cost efficiencies out of supply chains through higher process visibility, this does not mean that IT is totally commoditized as some have argued (for further discussion, see Mithas 2012).

Our results suggest that newer technologies may have created further opportunities for value creation and value capture, consistent with the arguments of Porter (2001) and Grover and Ramanlal (1999), who note that Internet-enabled IT systems provide better opportunities to establish distinctive strategic positioning and that firms may have learned to make better use of IT to their advantage, in general, over time. Although our study provides an indirect test of the "learning-based" explanation, to the extent that firms that invest more in IT have greater learning cumulatively than those that invest less, a more direct test of this explanation requires longitudinal data spanning many more years and, perhaps, primary, field-based data to gauge organizational learning and maturity.

Second, although we find that sales growth accounts for a substantial portion of the total effect of IT on profitability, there is a need to identify and validate other mechanisms to further explain the effect of IT on profitability that is currently captured in the direct effect of IT in our models. The other causal pathways may be enhanced globalization capabilities, innovation capabilities (Ravichandran et al. 2011; Kleis et al. 2011; Kohli and Melville 2009) or other organizational capabilities that IT systems enable through improved information flows and information management capabilities (El Sawy and Pavlou 2008; Mithas et al. 2011; Tafti et al. 2012). Although we failed to find a favorable effect of IT investments on overall operating costs, IT investments or its subcategories (e.g., allocations to outsourcing) may influence some categories of costs that we could not study here. There could also be other mediating or moderating influences on the relationship between IT and profitability such as the digital strategic posture, digital business strategy, or governance processes that need further investigation (see Lazic et al. 2011).

Third, we find substantial returns to IT investment in terms of both revenue growth and profitability compared with other discretionary expenditures, such as advertising and R&D. The high returns on IT (compared with advertising and R&D) in terms of sales and profitability in our study provide validation for findings of other studies that show high shareholder valuations of IT investments (Anderson et al. 2003; Brynjolfsson et al. 2002). The results comparing relative returns to IT, advertising, and R&D also provide an explanation for observed patterns in relative allocations among discretionary expenditures over the 1998–2003 period in Figure 1. Even after we allow for the difficulty in accounting for all of the other complementary investments or the higher risk or uncertainty associated with IT investments (Courtney et al. 1997; Dewan et al. 2007), substantial returns on IT compared with returns on similarly risky expenditures, such as advertising (see Rust and Oliver 1994) and R&D (see Raelin and Balachandra 1985), make IT investments attractive from a profitability perspective.[11]

Implications for Practice

Our findings have important managerial implications. First, substantial returns on IT investments from a profitability perspective should dispel any lingering doubts about the strategic value of investing in IT (Mithas 2012). Second, an

[11]The trade press reports several stories of failure of marketing campaigns and R&D projects, suggesting that spending on advertising and R&D is as risky in terms of implementation failures as the spending on IT projects. According to an estimate, only one in ten new product development ideas becomes a commercial success, and some suggest that only approximately 50 percent of advertising budgets are effective, and it is not possible to know which 50 percent.

indirect implication of our results is that IT-enabled revenue growth projects are more rewarding from a profitability perspective than IT-enabled cost reduction projects. Although these may not be the only pathways linking IT investments to firm profitability, understanding the differential effect of these two factors on profitability should help managers allocate resources among IT projects that differ with respect to these two objectives. Our findings provide validation to Kulatilaka and Venkatraman's (2001, p. 15) arguments when they note that "cost center projects may be easy to justify and implement but can also be imitated easily by competitors."

Finally, insofar as IT investments may be more profitable than R&D and advertising investments, investors should consider this when determining the market valuations of firms based on their relative allocations to such discretionary investments. Financial analysts should pay attention to the shifts in relative allocations among IT, advertising, and R&D dollars because these shifts can provide early signals about subsequent sales growth or firm profitability.

From a top management or board perspective, IT investments should receive significant attention in governance and resource allocation processes because they appear to be more important than R&D and advertising in terms of profitability. Chief information officers can use the findings to develop a business case and justification for continued investments in IT.

From a policy perspective, given that prior work has shown the value relevance of IT in financial markets and given that this study provides an explanation for this finding, it is time for U.S. firms listed on public stock exchanges to be required to disclose their IT investments and risks associated with them (as is already done in Australia), just as they are required to do with R&D. Doing so can lead to further transparency with respect to managerial actions and generate useful research and signals for more efficient financial markets (Mithas et al. 2011).

Limitations and Further Research

Although our study provides useful insights, it has some limitations that are inherent in our research design and data availability. First, our study uses data on large global firms, which limits the generalizability of our findings. In addition, although we use longitudinal data and panel models and several steps were taken to address the endogeneity of IT investments, our findings should be treated as associational because there may still be some reverse causality and feedback loops. Future research should explore use of a potential outcomes or counterfactual approach to assess causality (Mithas and Krishnan 2009). Second, while our study focuses on the effect of IT investment on firm profitability through revenue expansion and cost reduction pathways at the firm level, there is a need to conduct such an analysis at the business unit level and project level (e.g., Bardhan, Krishnan and Lin 2007).

Third, our study period encompassed both the stock market boom (e.g., the 1999–2000 period which lies in the middle of the dataset was particularly turbulent) and the bust, so the findings are not driven by either.[12] Nevertheless, we acknowledge that there remains a need for further studies to continually verify the generalizability of the findings in other contexts (e.g., Morgeson et al. 2011) and time periods. Finally, while our study suggests that the effect of IT on profitability is mediated through sales growth, we cannot pinpoint whether the sales growth is because of higher volumes or higher margins, because doing so would require data on the quantities of stockkeeping units and their margins.

To conclude, this study documents the strategic importance of investing in IT by showing that IT contributes significantly to firm profitability. The effect of IT on profitability is more pronounced than that of other discretionary expenditures, such as advertising and R&D. Notably, firms reap greater profitability gains through IT-enabled revenue growth than through IT-enabled operating cost reduction. Together, these findings suggest that senior managers should pay attention to the allocation of resources in favor of IT in their governance processes and accord higher priority to revenue-enhancing IT projects for superior firm performance.

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[12]If some general factor affected all firms uniformly, this factor would not bias our results because by definition such a general factor will be uncorrelated with variation in IT expenditures, and we already control for year dummy variables in our empirical models. Although in 1999–2000 some Dotcoms justified their valuations based on Internet traffic (not revenues or profits), our study involves more established and larger firms, and we use economically substantive measures of firm performance such as revenues or profits. In fact, the irrational exuberance of the 1999-2001 period may make our results even more conservative because it would have driven up IT investments but not revenues or profits.

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