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Information Technology Usage and Project Performance: The Mediating Role of Process Capabilities

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INFORMATION TECHNOLOGY USAGE AND PROJECT PERFORMANCE: THE MEDIATING ROLE OF PROCESS CAPABILITIES

Social, Behavioral and Organizational Aspects of Information Systems

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Abstract

The impact of information technology on improving the productivity of knowledge and information-intensive work has been mixed. Prior research has primarily focused on the impact of IT spending on firm-level performance. To further this line of research, it is necessary to understand the operational and process-level changes, and isolate the impact of IT application usage on process-level capabilities associated with information work. We focus at the level of business process in information work contexts and measure the impact of IT usage on organizational performance based on business process-level measures such as project cycle time, cost, and completion rates. The central research contribution is the development of an empirically validated research framework to improve our understanding of the operational impact of technology on the effectiveness of information work. Our results indicate that the impact of IT on project performance is mediated through its enablement of process capabilities which explains differences in process-level performance across a cross-section of companies.

Keywords: Information work productivity, process capabilities, project performance.

Introduction

Information technology (IT) has delivered significant productivity improvements in the manufacturing sector of the economy (Weill, 1992; Barua et al., 1995). Improving information work productivity is the next frontier for IT applications. Information work – defined as the "creation, coordination, integration and management of information within a firm and its value network" (Conner and Prahalad, 1996) – is however in the early stages of being mapped, measured, and managed. Consider some examples of information work: spotting and serving a market need with an innovative, compelling new software or hardware product or identifying and cross-selling new offerings in a services setting. In the new economy, such value-added information work constitutes a greater share of firm investments.

Despite the increasing role and importance of information work, our understanding of why, how, and when technology enables information work productivity improvement is in its rudimentary stages resulting in a lag in productivity growth (Jorgenson and Stiroh, 2000). The intangibility and diversity of information work and its outputs presents unique challenges in its description, measurement, and improvement. Also, prior research on the business value of information technology has focused primarily on the aggregate impact of IT spending on firm performance (Barua et al., 1995; Brynjolfsson and Hitt, 1996; 1998; Kohli and Devaraj, 2003). To develop a finer and a more nuanced understanding of the business value of IT, we focus on the business processes constituting information work. We draw on two streams of research, the resource-based view (RBV) of the firm and the process-oriented model of IT productivity measurement, to explain how firms create business value by developing relevant business process capabilities to leverage their IT assets (Barua and Mukhopadhyay, 2000). Our research questions can be summarized as follows: (a) how do we measure the value of information work in terms of process capabilities enabled by IT?, and (b) what is the impact of IT resource usage on process-level outcome?

We validate our research using survey data from business managers and executives (information technology users in the context of information work) drawn from a large cross-section of North American firms. Our results suggest that IT-enabled process capabilities have a significant impact on improvement in three process-level outcomes (cost, quality, and cycle time). While breaking new ground on the hitherto under-researched domain of information work, we build on the business value of IT framework offered by Melville et al. (2004, Fig. 1, pp. 293), and develop an integrated model focusing on a process-level of analysis consistent with the work of Barua and Mukhopadhyay (2000).

Background

One of the difficulties in managing information work productivity is the challenge involved in measuring the effects of IT. In industrial work, the productivity effect of technology was to simply increase the output and/or decrease the inputs needed for processing. In an information work context, quality of the work and the outcome may be as important, if not more salient, than the quantity of output produced. The application of IT in information-intensive work settings, such as R&D, requires adaptation and additional sensitivity to the unique characteristics of these settings. Unlike manufacturing where the benefits of technology are seen in terms of greater output or lower input, the impact of IT on information work is less direct and more complex. IT's primary benefits in the area of information work seems to be to (a) help achieve consistent results and help the organization create better quality output through improved market intelligence and customer insight (Balasubramaniam et al. 2000), and (b) enable a firm to keep the customer engaged throughout the project, learn third-party customer information from online media, leverage the work of global suppliers, and reuse knowledge assets from other organizational entities (Bryan and Zanini, 2005).

Our approach is to study the impact of IT resource usage on business process-level capabilities, and examine the impact of such capabilities on improvement in project-level performance.[1] Business processes are defined as a specific ordering of work activities that a firm develops to transform a set of inputs into outputs (Davenport, 1993). Melville et al. (2004) argue that business processes provide an appropriate context to examine the "locus of direct resource exploitation of IT". Furthermore, process-level studies analyze the impact of IT and organizational factors through a chain of relationships to performance measures at various levels of aggregation (Barua and Mukhopadhyay, 2000; Mukhopadhyay et al., 1997a; Barua et al., 1995). For instance, Davamaniranjan et al. (2000) show that higher levels of EDI integration with customers in financial services leads to greater improvements in process performance, which in turn is associated with improvements in firm profit margins. Isolating the impact of IT at the process-level allows us to trace IT's impact on specific measures, and overcomes the potential for confounding when multiple business processes are studied at an aggregate level. Production economics-based approaches do not have the explanatory power to identify where and how IT's impact occurs and when management action is needed to increase payoff from IT investments (Barua and Mukhopadhyay, 2000). In addition, such approaches are unable to handle key intangibles such as the quality and speed of outputs (Brynjolffson, 1993; Hitt and Brynjolffson, 1998).

We propose that proper usage of IT leads to an enhancement of process capabilities that represent sets of identifiable routines in various functional areas (Eisenhardt and Martin, 2000). For example, effective product development projects are characterized by the use of cross-functional teams that leverage different sources of expertise which

[1] Note that the "business process" represents our level of analysis, while business projects are used for measuring process-level outcomes since projects are characterized by distinct start and completion times.

enables coordination and concurrency of manufacturing, marketing, and design activities. Similarly, combinative capabilities that support reducing process variance and improving consistency of output, represent knowledge-based capabilities that impact business profitability (Rosenzweig and Roth, 2005; Roth, 1996). Other project capabilities associated with information work include effective external communication capabilities (Clark and Fujimoto, 1991), resource reconfigurability capabilities for new product development (Pavlou and El Sawy, 2004), and knowledge transfer and reuse capabilities which include routines for replication and brokering (Hansen, 1999, Hargadon and Sutton, 1997).

Thus, our approach is in line with the business value of IT literature which suggest that IT investments should be first related to intermediate performance measures, such as time to market and customer response time, rather than high-level firm profitability measures (Barua and Whinston, 1998; Grenci et al., 1999; Melville et al. 2004). The impact of these intermediate measures on firm-level performance is likely to be positive, but contingent on external factors such as industry characteristics and the complementarities between IT investments and organizational strategies, processes, and incentives (Barua and Mukhopadhyay, 2000).

Research Framework

A broad variety of information technologies are, in fact, used in practice. To be able to measure information work productivity, we must first develop a better understanding of different types of information technologies used in information work settings.

Information Technology Resource Usage

The complexities inherent in information work involve significant differences in information processing requirements which, in turn, entail deployment of different types of information technologies (Forster et al., 2002). Building upon prior research on task interdependencies (Thompson, 1967), we argue that information work entails usage of different types of IT based on three types of task interdependencies: pooled, sequential and reciprocal. Information technologies that are typically used for information work fall into three categories: core communication technologies, enterprise software, and group collaboration technologies. Our definition of "IT resource usage" encompasses the usage of software applications that belong to these three broad categories. For instance, it includes basic technologies, such as e-mail and Web portals, which support tasks where the IT resource is shared by all entities. IT resources also encompass technologies, such as enterprise resource planning (ERP) and document management systems, which facilitates information exchange across cross-functional processes, and team collaboration technologies such as groupware, team discussion databases, instant messaging and video-conferencing, which enable teams to communicate in real time (Carte and Chidambaram, 2004).

We measure the level of usage of these three types of IT for information work. Our intent is to develop an overall measure that captures the variance in IT usage, across different types of business processes, in order to develop a better understanding of the impact of IT resources on process capabilities (Burton-Jones and Straub, 2005). Hence, we conceptualize "IT resource usage" as a meta-construct that consists of the degree of usage of different types of IT applications across diverse business processes such as R&D, sales, marketing, customer service, and finance. We now discuss these process capabilities in greater detail.

Process Capabilities

Process capabilities, as discussed earlier, support the attainment of better customer-perceived outcomes with fewer and lower-cost resources (Ray et al., 2004; Tatikonda and Montoya-Weiss, 2001). Specifically, the capabilities of a business process can be measured along the following dimensions: (a) quality-*consistency* of the business process/project, (b) customer and market *relevance* of the outcome (Zeithaml and Bitner, 1996), and (c) degree to which the project effort is structured to *leverage* the efforts of suppliers and other value chain partners (Yu et al., 2003).

Quality, a key component of the effectiveness of a process capability, is particularly difficult to measure for information work, in contrast to manufacturing where it is measured as conformance to specifications. One measure of quality we use is *consistency*, which refers to the extent to which IT users are able to achieve targeted business results in a predictable manner and achieve their stated goals. By helping to aggregate business information across the enterprise, IT should improve a firm's ability to track progress, spot and correct deviations, and consistently execute on business plans. We cite the example of ExxonMobil, whose ability to execute core processes, such as R&D and capital allocation, consistently across the firm is among the key factors behind its success (Bryan and Zanini, 2005)

A second dimension of process capability is *relevance*, which measures the degree to which processes are customer-centric in terms of their ability to meet current and future customer needs (Barua et al., 2004; Ray et al., 2005). Used appropriately, IT should help the firm build "high bandwidth" channels with its lead users and mainstream customers to capture tacit and emerging customer information (Zeithaml and Bitner, 1996).[2]

Leverage measures the degree to which a firm is able to utilize its prior investments and that of its supply chain partners. IT helps a firm improve leverage in a number of ways including spotting low cost and high quality global partners, and integration of existing assets from other parts of the organization.[3] Marshalling its key suppliers' capabilities to meet emerging customer needs becomes essential to achieve superior performance.

Process and Firm Performance

In their research on customer service in the US insurance industry, Ray et al. (2004, 2005) observe that the choice of the dependent variable is critical in empirically validating the role of IT and business process capabilities in sustaining competitive advantage. They argue that examining the impact of IT at the process-level rather than the firm-level has several advantages: (1) aggregating the outcomes of multiple business processes at the firm-level results in confounding effects and makes it difficult to observe whether process-specific resources create measurable improvements in firm performance, (2) it is possible that economic profits that are generated by specific business processes may be appropriated elsewhere before they are reflected in a firm's profitability, and (3) business processes represent the pathways through which IT and organizational resources are bundled together to enable execution of project tasks and exploit the potential of process-specific capabilities (Tatikonda and Montoya-Weiss, 2001).

We draw on prior work in the process-oriented stream of "IT business value" research, where the impact of IT on organizational performance is typically measured using intermediate process-level measures in the first stage, and firm-level measures in the second stage (Devaraj and Kohli, 2003). We posit that, deployment of IT and organizational resources for managing information work will result in tangible improvements to process capabilities, which in turn, will drive improvements in business process/project performance, as well as financial performance. In our research context, the impact of IT-enabled process capabilities on business processes is measured by studying their impact on project outcomes, such as reduction in project cost and cycle time, and improvements in project quality. Such performance project-level measures have been widely used to evaluate project success (Nelson, 2005). Since projects represent important vehicles for firms to realize business value, we also examined the impact of process capabilities on firm financial measures, such as gross margins and return on assets (Bharadwaj, 2000).[4]

Our research model, conceptually shown in Figure 1, examines the role of *process capabilities* in mediating the impact of IT and organizational resources on business project- and firm-level measures of performance. We integrate the information processing view of IT with the process-oriented resource based view to provide a sharper understanding of (a) the impact of IT resource usage, and (b) the role of process capabilities in mediating the impact of IT on business process outcomes and firm performance. We contribute to extant research by developing an integrated model of the business value of information work wherein the role of IT resource (applications) usage is

[2] IBM's emerging business opportunity process stimulates and provides staged investments for ideas from customers, venture capitalists, and employees across organizational silos (Bryan and Zanini, 2005)
[3] Dell relies on the rigorous standardization of its new product development processes to offer tailored products and services, by leveraging its supplier network, while keeping complexity to a minimum (Bryan and Zanini, 2005).
[4] We obtain empirical evidence supporting the argument that IT-enabled process capabilities have a positive impact on firm financial performance. However, we do not present these new Results due to space constraints.

explicitly examined, unlike prior studies which study the aggregate impact of IT capital which includes other forms of IT spending (such as hardware, personnel, networks, and peripherals).

Research Hypotheses

Impact of IT Usage on Process Capabilities

While the impact of aggregate IT capital on firm productivity, measured as profitability, market share, and shareholder value, has been extensively studied in prior research, less attention has been given to studying the impact of specific types of IT resources (Barua et al., 1995; Brynjolffson and Hitt, 1998; Barua and Mukhopadhyay, 2000).

Enterprise software, such as project management software and business intelligence systems, enable firms to improve the *consistency* of project execution by facilitating greater visibility to project data and allowing managers to track progress more easily. Similarly, customer relationship management software enables managers to identify and disseminate customer requirements in a timely manner and allow greater customer involvement in project decisions. Knowledge management systems enable project managers to identify emerging market trends and develop relevant product enhancements and new market opportunities.

Core communication technologies enable project teams to solicit customer and supplier involvement in key project decisions which can lead to improvements in the quality of project decisions. They facilitate re-use of knowledge assets within and across project teams. Similarly, group collaboration technologies, such as groupware and online teamspaces, facilitate quicker exchange of mission-critical data, and thereby enable more effective alignment of distributed project teams. Hence, we hypothesize that greater usage of IT resources is associated with an improvement in process capabilities.

H1: *Greater usage of IT is associated with higher levels of process capabilities.*

We control for a project team's *propensity to use IT*, as measured by its adoption of emerging technologies, which may reflect the characteristics of project teams and the types of projects that are undertaken and has the potential to impact the development of process-specific capabilities. We also control for project *autonomy* which reflects the degree to which the goals and objectives of projects are set by the project team or manager instead of being dictated by a higher authority such as the business unit head (Banker, Field and Sinha, 1999). We also control for project-specific characteristics, such as *team size,* extent of *co-location* of project teams, and *project duration*, which may have an impact on the development of process capabilities. Team size dictates the extent of information processing that is required to disseminate information across project teams. The increasing use of virtual project teams, where team members may be distributed across different offices in different countries, also has an impact on process capabilities.

Impact of Process Capabilities on Project Performance

Since a limitation of the resource-based view is that it assumes that resources are applied in their best uses, saying little about how this is done, we expand our research framework to better understand how IT is applied to improve process performance. Although the impact of IT on operational efficiency and competitive advantage has been supported in the IT business value literature (Melville et al., 2004; Barua et al., 1995; Soh and Markus, 1995), the research question that is not well-understood is "what are the *mechanisms* or pathways by which IT enables firms to achieve efficiency and competitive advantage?" Recent work by Ray et al. (2004) suggests that it is important to develop a better understanding of the relationship between a firm's resources and the effectiveness of its organizational routines. We propose that IT resources enable improvements in process capabilities which, in turn, lead to improvements in process-level outcomes.

Improvements in process capabilities have an impact on business operating outcomes. For measuring operating outcomes, we use business projects as the unit of analysis. By enabling greater access to enterprise data and facilitating greater re-use of corporate knowledge assets, IT should lead to reduction in project rework and a reduction in non-value added tasks. These improvements in process capabilities are, in turn, associated with greater quality and cost improvements, since defects/errors that are identified and corrected in later stages of the project life-cycle are costlier to fix. Improved quality-consistency of project execution, can also improve project completion rates. Improvements in a firm's ability to leverage its existing network of partners to manage its sourcing/procurement processes is associated with reduction in project cycle times and costs. Similarly, achieving better alignment through closure of functional gaps and distributed project teams, can lead to greater project quality and cycle times. Hence,

H2: *Improvements in process capabilities are associated with improvements in business project outcomes.*

H2a: *Improvements in process capabilities are associated with a reduction in project cycle time.*

H2b: *Improvements in process capabilities are associated with a reduction in project costs.*

H2c: *Improvements in process capabilities are associated with greater project quality.*

We draw on resource-based theory to explain how firms create value by creating relevant organizational processes to leverage their IT assets. Although IT assets may be viewed as mobile and imitable resources, they enable unique organizational routines and are often bundled with an organization's commitment to specific business processes (Banker et al., 2006). Customization of IT application infrastructure to project-specific processes is complex and often inimitable. Hence, we posit that IT assets provide the building blocks for business processes to form capabilities, and a project's ability to enhance these process capabilities can be a source of competitive advantage. In information-intensive work settings, usage of IT resources may add value through two pathways: (a) improvements in the *efficiency* of project work, such as reduction in latency, and elimination of some types of transaction processing activities, and (b) improvements in the *effectiveness* of project work associated with greater consistency, better leverage of partner assets, and relevance to customer needs. In other words, we argue that while IT assets may have a positive impact on project performance by supporting improvements in the efficiency of information work, its impact on project effectiveness will be mediated through its enabling impact on the development of process-specific capabilities. Hence, we posit that process capabilities link the impact of IT and organizational resources to improvements in project performance. Accordingly, we frame our hypothesis as:

H3: Process *capabilities mediate the impact of IT resources on improvements in business project outcomes.*

We control for the impact of firm and project characteristics on project- and firm-level performance, specifically for firm size and the number of concurrent projects managed, since these variables are indicators of a firm's scale and project management capabilities. Firm size may have an impact on the ability of firms to realize improvements in project outcomes, since smaller firms may be more agile in responding to shifting market trends. At the same time, larger firms can leverage greater scale economics and access to a broader range of resources to improve performance. We also control for the number of projects concurrently managed by a respondent, since this reflects the degree to which a manager can focus on a project.

Research Data Collection and Construct Validation

We now discuss construct measurement based on data from business project managers.

Data Collection

We designed a research survey to capture the organizational work characteristics, IT usage, and project performance data, associated with the use of IT for managing business projects, as shown in the questionnaire provided in the Appendix. A cross-sectional survey was employed for data collection, administered online through an independent, professional survey firm, to a random sample of project and product managers, drawn from their business-to-business (B2B) panel of North American private- and public-sector organizations. A first phase of pilot data collection in May 2004 was followed by a final data collection effort in June 2004 which yielded 780 responses. The final dataset of 529 respondents represents completed surveys where the respondents met key survey screening criteria.[5] The overall response rate to our Web-based survey was 21.15%. Table 1 shows the profiles of respondents based on their firm characteristics. The Web-based survey allowed us to observe the firm characteristics of respondents who abandoned or terminated the survey prior to completion. Respondents provided demographic information about areas of responsibility, job title, company type, company annual revenue, location/market, and devices/technologies used for business purposes. Non-response bias was assessed by comparing the percentage of complete responses for each of the six "firm revenue" categories in our survey. A chi-square test indicates that there does not exist a statistically significant difference between the response rates of respondents in firms of different sizes ($\chi^2 = 6.85$; p-value = 0.23; Mantel-Haenszel $\chi^2 = 0.61$; p-value =0.43). Hence, our data did not indicate a non-response bias.

We note that our sample consists of 56 firms for which we recorded two responses from business project managers within the same division of the firm. Inter-rater correlations for the model variables were statistically significant at $p < 0.01$. For these observations, the scores on each variable were averaged over the two responses for subsequent analyses, which allowed us to address concerns associated with single-rater bias (Boyer and Verma, 2000).

Construct Measurement

We now discuss the operationalization of the constructs that represent usage of different types of IT resources and process capabilities. The IT Resource Usage (ITR) construct encompasses the three classes of information technologies described in section 3. The twelve types of technologies, that comprise this construct, represent a broad range of information processing requirements associated with information work in typical project environments (Devaraj and Kohli, 2003). The process capabilities (PRCAP) construct consists of four dimensions (consistency, leverage, alignment and relevance) and is measured using twelve indicators, where each dimension is represented by three indicators (section 3).

Project duration is measured as the average length of a typical project (measured in years), while *Team size* represents the size of the project team measured as the number of full-time equivalent (FTE) of project staff. *Co-location* measures the extent of dispersion among team members. Higher values represented dispersed project teams while lower values represent teams that are located in one location.

Autonomy is measured as the extent to which project teams have autonomy from management in making project decisions, in line with the definition proposed by Mendelson (2000). The *propensity to use IT* is an indicator of a project team's willingness to deploy emerging information technologies, and measures whether project teams are early adopters, mainstream users or late adopters of IT. We also collected data on the *number of concurrent projects* managed since this is an important indicator of managers' roles and their dedication to current projects. *Firm size* is used as a control variable to study the impact of IT on firm-level performance. We measured firm size as the number of firm employees.

We measured the change in performance of a recent project in comparison to a similar project that was completed three years ago. We defined three project outcomes which represent changes in project cost, quality, and on-time completion rate. *Δ(Cost)* represents the change in project costs, defined as the total program/project lifecycle cost incurred from project initiation to completion. *Δ(Quality)* represents the change in project quality, measured as the total number of errors and rework associated with the project.

[5] The survey firm is one of the largest, international online panel survey firms involved in a variety of market research and online panel data collection. They drew the panel based on double opt-in enrollment in order to ensure that respondents are engaged and to safeguard against spam. Respondent validation was required through address verification, and the sampling population was defined as decision makers who manage or lead business projects/programs in US and Canadian organizations. The B2B panel, which was drawn from the survey firm's database, consists of business decision makers drawn from a broad range of business areas, including administration, customer service, sales and client development operations, finance, engineering, account management, production, and R&D. Job titles of respondents were also collected in our survey.

Table 2 provides descriptive statistics on our model variables and constructs, including the pairwise inter-correlation coefficients between these variables.

Construct Validity and Reliability

Exploratory factor analyses (EFA) was first conducted to check if the proposed factors are consistent with our survey data. The factor structures suggested by EFA are consistent with the factors identified in our research model and account for 62% of the variance in the data. Cronbach alpha values for these factors range from 0.72 to 0.94 which indicate good internal consistency.

Since our survey data are self-reported, we performed a Harmon's one-factor test to check for common methods bias (Podsakoff and Organ, 1986). The items measuring the independent variables and those measuring project outcomes loaded on different factors, which do not indicate common methods bias. We also applied the method factors test which suggests that common methods bias is not an issue (Williams et al., 1989; Podsakoff to al., 2003).

We also performed confirmatory factor analysis (CFA) to establish the reliability of our constructs. Composite reliability reflects the internal consistency of the indicators and it exceeded the recommended threshold of 0.7 for all constructs, as shown in Table 3 (Werts et al., 1974; Nunnally, 1978). The t-statistics for all factor loadings were significant and suggest that our indicator measures satisfy convergent validity (Phillips and Bagozzi, 1986). We calculated the average variance extracted (AVE), a ratio of the construct variance to the total variance among indicators, which exceeds the threshold value of 0.5 for all constructs (Fornell and Larcker, 1981). We observe that the AVE estimates for constructs (on the diagonal of Table 3) are greater than the values of the squared correlations (on the off-diagonal). This confirms discriminant validity among our model constructs.

Analyses and Results

Since IT resource usage and process capabilities are measured as latent variables, we estimated the model shown in Figure 1 using structural equation model (SEM) procedures implemented in the SAS statistical software. We estimated the path coefficients of the structural model using maximum likelihood estimation (ML) estimation.[6] We used a covariance matrix for estimation which required 11 iterations for convergence.

Impact of IT and Organizational Resources on Process Capabilities

The impact of IT resource usage (ITR) on the extent of process capabilities is shown in column (1) of Table 4. Our results indicate the level/intensity of usage of IT resources has a positive impact (coeff. = 0.465, $p < 0.01$) on the effectiveness of process capabilities. Hence, our results support hypothesis H1, and suggest that IT usage is associated with improvements in the consistency, relevance, leverage and alignment of project work. Our analysis also indicates that a project team's "propensity to use IT" has a significant association in terms of its process capabilities. Specifically, late adopters of IT are likely to be associated with deterioration in process capabilities, as evidenced by the negative and significant regression coefficient.

Impact of IT and Process Capabilities on Project Performance

Table 4 also shows the impact of IT and process capabilities on three types of project outcomes: *change* in cycle time, cost, and quality. For each project performance variable, we first regress the dependent variable on IT

[6] We also estimated the model using a second-generation estimation technique, partial least squares (PLS), which allows us to handle formative constructs as well. The PLS results are consistent with the SEM results. We do not report these results in order to conserve space.

resource usage (ITR) to understand whether information technologies have any direct impact on project performance. The regression equation is specified as:

Project performance = f (ITR, Firm-level controls) (1)

Our estimation results for equation (1) indicate that IT resource usage (ITR) has a positive, *direct* impact on all three project outcomes. Greater levels of ITR are associated with significant reductions in project cycle time and cost, and an improvement in project quality, as evidenced by the positive regression coefficients of ITR in columns (2), (5), and (8), respectively.

Next, we regress the dependent variable on the mediator variable (i.e., PRCAP), along with other firm-level control variables, as specified in equation (2).

Project performance = f (PRCAP, Firm-level controls) (2)

Equation (2) is consistent with our research hypotheses which suggest that the impact of IT on project performance will be completely *mediated* through process capabilities. The estimation results for equation (2) suggest that process capabilities (PRCAP) have a significant impact on all three project performance measures, and this model explains a higher percentage of the variance (R^2) in project performance compared to the model shown in equation (1). Hence, our results support hypotheses H2a, H2b, and H2c.

In order to understand to what extent PRCAP mediates the impact of ITR on project performance, we test the *complete* mediation model (i.e., equation 2) against a competing "*partial mediation*" model which also includes direct paths from ITR to project performance. This partial mediation model is specified, in equation (3), as

Project performance = f (ITR, PRCAP, Firm controls) (3)

The regression estimates are provided in the last column for each project performance outcome in Table 4. We note that ITR has a positive impact on each project performance variable, although the magnitude of the ITR coefficient is smaller than its corresponding coefficient in equation (1). In other words, the magnitude of ITR's impact compared to its coefficient in the direct impact mediation model is reduced, after the introduction of PRCAP in the partial mediation model. PRCAP continues to have a significant, positive impact on all three project outcomes. This result suggests that the impact of ITR on project performance is partially mediated though PRCAP (Barron and Kenny, 1986).

To compare the complete and partial mediation models specified in equation (2) and (3), respectively, we compared their R^2 values which represent the percentage of variance in project performance explained by the predictors. Since these models are nested, we can examine whether the complete mediation model provides an adequate explanation of the variance in project outcomes, through a chi-square test (Venkatraman, 1988). We performed a chi-square test on the difference in R^2 between equations (2) and (3), and report these χ^2 statistics in the last row of Table 4. We note that the χ^2 test statistic is statistically significant at $p < 0.05$, for the Δ(cycle time) and Δ(cost) performance models.[7] Hence, our results suggest that PRCAP *completely mediates* the impact of ITR on project performance. Hence, our findings indicate partial support for hypothesis H3, to the extent that the impact of IT resource usage on project cost and cycle time is *partially* mediated through their enabling effect on process capabilities. We note that we find weak support for the partial mediation model in the case of Δ(quality).

Next, we estimated the path coefficients of the mediated paths as shown in Table 5. The indirect effect of IT on project performance was estimated as a*b, where a and b represent the magnitudes of the paths between ITR and PRCAP, and PRCAP and project performance, respectively (Sobel, 1982). The magnitudes of the mediated paths are statistically significant for all three project performance outcomes, and provide further support of the mediation model described in Table 4.

[7] We note, however, that the differences in R^2 values are very small for each of the three pairs (complete and mediation) of regression models.

We conclude that our empirical results provide partial support for hypothesis H3, since we show that process capabilities partially mediate the impact of IT resource usage on project cycle time and cost, while they do not mediate the impact of IT on project quality. Our results are consistent with the findings reported by Rosenzweig and Roth (2004) who conclude that combinative process capabilities, such as conformance quality, delivery reliability and low cost, have a tangible impact on profitability, based on their study of high-tech manufacturers.

We observe that we tested an alternate model specification, using a moderation framework, where we studied whether IT usage (ITR) moderates the impact of process capabilities on project performance. The moderation tests, as shown in Table 6, suggest that the interaction paths are not statistically significant in the hypothesized direction. These results suggest that, although the moderation model may have intuitive appeal, it is not supported by empirical evidence. On the other hand, the mediation model provides a better explanation of the key phenomena in our paper.

Discussion and Conclusions

Improving information work (IW) productivity has been a major challenge due to the intangibility of organizational outcomes. As a first step toward gaining a more nuanced understanding of the role and business value of IT, we focused on the role of information work in a project context. Our research objectives were to (a) understand how IT and complementary organizational resources impact process-level capabilities within organizations, and (b) develop and validate an integrated model to measure the business value of IT in an information work setting. Our contributions can be summarizes as follows: (a) this paper improves our understanding of IT resource usage on the effectiveness of process capabilities, while incorporating the role of software when conceptualizing IT resources, (b) we operationalize a salient dimension of business process performance, as represented by process capabilities, which provides a critical pathway that explains a significant portion of the relationship between IT usage and project-level performance, and (c) we have provided empirical support to test our framework with data collected in an information work setting, where information technologies are used to manage business projects, programs, and people.

We build on prior research on the use of resource-based theory to explain the role of IT application infrastructure in terms of its impact on project performance. Specifically, we propose that "process-specific capabilities" play an important role in mediating the impact of IT on project performance. While researchers have proposed theoretical frameworks that describe the role of such organizational capabilities, our research represents one of the first studies to conceptualize and empirically validate this theory using project-level data collected from a large cross-section of firms. Furthermore, our exploration of two different types of model specifications indicates that the "moderation" framework to study the role of IT and organizational capabilities on project performance is not supported by our data. Rather, we find greater support for the partial mediation model as a means to explain variations in project performance outcomes through the development of IT-enabled process capabilities.

Our results suggest that prior studies that have attempted to measure the productivity of information work may be inadequate since they primarily capture the efficiency dimension of information work. Our results indicate that quality of firm outputs (effectiveness) may be even more important in terms of its impact compared to the quantity of outputs (efficiency). We contribute to the emerging IS literature on organizational capabilities which examines the impact of IT infrastructure capabilities on firm performance (Xia and King, 2004; Sambamurthy, 2000). Unlike prior work which focus on the firm or business unit (Mithas et al., 2004), we study these phenomena at the process level of analyses and focus on the usage of specific IT resources and their impact on process outcomes.

Our study has several limitations. First, we do not account for the use of information technologies by individual contributors or non-managerial personnel who may have different IT usage patterns from project/program managers. Second, while our study contains a large number of data points, it can be enhanced further by including respondents in non-North American organizations to account for country- or culture-specific differences in their IT usage. Third, our survey findings must be validated with more field studies and additional data collected in industry-specific settings which will allow us to examine the impact of industry characteristics and IT usage on the development of dynamic capabilities in different environments. Future research should also include data on project complexity, team diversity and task uncertainty which are important project management variables.

The overall results suggest that IT needs to be implemented with the intent of maximizing project and financial outcomes, in a manner that fundamentally improves business process capabilities, which, in turn, will improve project and firm performance. Effectiveness should be as much of a focus as efficiency, which has hitherto driven IT investment decisions. Our findings amplify the need for firms to strengthen their process capabilities after making investments in IT (Dorgan and Dowdy, 2004). While we have experienced many anecdotally-driven discussions regarding whether IT matters or not (Carr, 2003), our data shows that IT matters to the extent that it can improve business capabilities.

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Figure 1. Conceptual Research Model

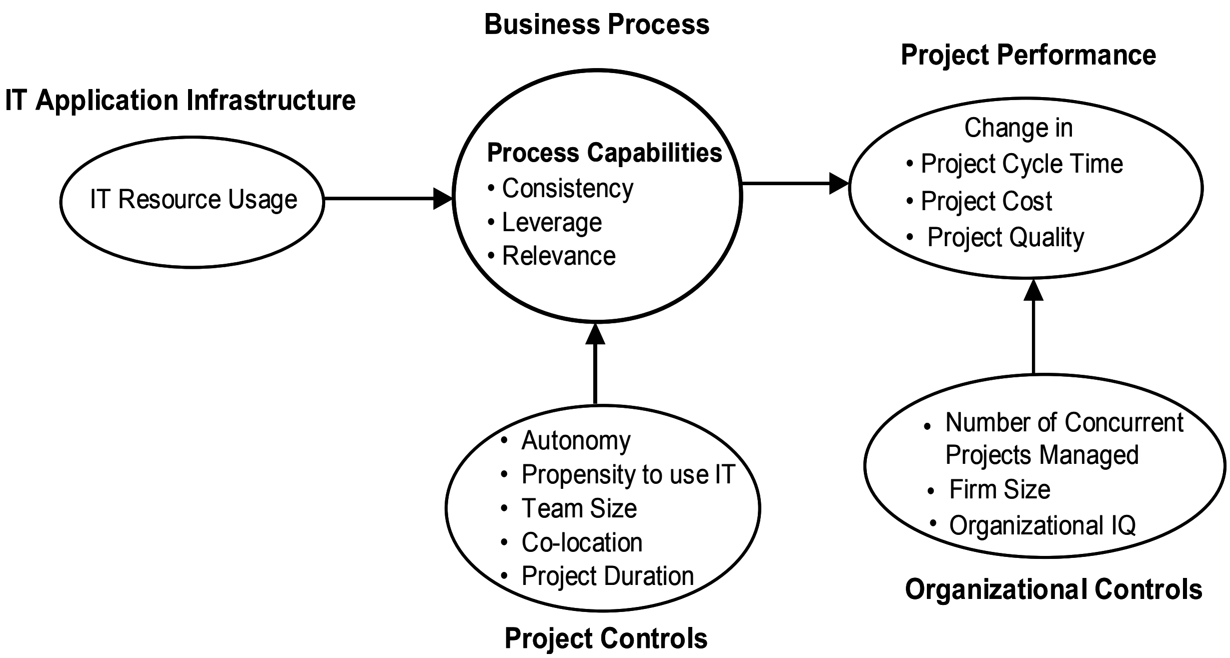

Table 1. Profiles of Survey Respondents

Firm Revenue	**Number of Respondents**	**Percent (%)**
$10 million to $49.9 million	75	14.18%
$50 million to $99.9 million	45	8.51
$100 million to $499.9 million	62	11.72
$500 million to $999.9 million	41	7.75
$1 billion to $9.9 billion	84	15.88
$10 billion or more	91	17.20
Not for profit	58	10.96
Don't Know or not at liberty to disclose	73	13.80
Industry		
Communication	53	10.02%
Energy	19	3.59
Financial Services	78	14.74
Healthcare	68	12.85
Public Sector	109	20.60
Manufacturing	122	23.06
Retail/Wholesale	55	10.40
Travel and Transportation	25	4.73
TOTAL	**529**	

Table 2. Descriptive Statistics of Model Variables and Constructs

	Mean (SD)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
IT Resource Usage (1)	2.72 (0.88)	0.670											
Team Size (2)	1.81 (1.15)	0.307 (0.000)	1.000										
Co-location (3)	2.08 (1.31)	0.145 (0.001)	0.186 (0.000)	1.000									
Propensity to use IT (4)	2.71 (1.15)	-0.379 (0.000)	-0.146 (0.001)	-0.119 (0.006)	1.000								
Project Duration (5)	1.75 (1.12)	0.142 (0.001)	0.388 (0.000)	0.046 (0.295)	-0.135 (0.002)	1.000							
Autonomy (6)	2.23 (1.12)	0.103 (0.018)	-0.019 (0.665)	-0.051 (0.243)	-0.141 (0.001)	-0.003 (0.949)	1.000						
Process Capability (7)	5.28 (0.89)	0.427 (0.000)	0.121 (0.005)	0.075 (0.085)	-0.255 (0.000)	0.086 (0.048)	0.082 (0.059)	0.740					
No. of Concurrent Projects (8)	3.16 (1.31)	0.030 (0.494)	0.074 (0.091)	0.002 (0.961)	0.008 (0.854)	-0.018 (0.682)	-0.044 (0.317)	0.026 (0.558)	1.000				
Firm Size (9)	5.22 (2.01)	0.125 (0.004)	0.174 (0.000)	0.173 (0.000)	-0.159 (0.000)	0.090 (0.039)	0.050 (0.249)	0.087 (0.046)	0.028 (0.524)	1.000			
Δ (Cycle Time) (10)	1.56 (1.15)	0.252 (0.000)	0.087 (0.046)	0.002 (0.959)	-0.204 (0.000)	0.094 (0.030)	0.082 (0.059)	0.307 (0.000)	0.050 (0.250)	0.056 (0.198)	1.000		
Δ (Cost) (11)	1.57 (1.22)	0.239 (0.000)	0.050 (0.248)	-0.026 (0.547)	-0.198 (0.000)	0.068 (0.116)	0.094 (0.031)	0.317 (0.000)	0.051 (0.245)	0.047 (0.279)	0.636 (0.000)	1.000	
Δ (Quality) (12)	1.98 (1.33)	0.218 (0.000)	0.024 (0.588)	-0.054 (0.219)	-0.207 (0.000)	0.030 (0.493)	0.054 (0.218)	0.356 (0.000)	0.070 (0.110)	0.033 (0.451)	0.544 (0.000)	0.503 (0.000)	1.000

p-values are shown in parentheses. AVE estimates for model constructs are shown on the diagonal while squared correlations are off-diagonal.

Table 3. Confirmatory Factor Analyses Results

Construct	Indicator	Standardized Loading	*t*-statistic	Composite Reliability	Average Variance Extracted (AVE)
IT RESOURCE USAGE (ITR)	ITR1	0.594	14.50	0.91	0.67
	ITR2	0.665	16.73		
	ITR3	0.414	9.55		
	ITR4	0.664	16.70		
	ITR5	0.777	20.71		
	ITR6	0.658	16.50		
	ITR7	0.760	20.06		
	ITR8	0.716	18.46		
	ITR9	0.771	20.49		
	ITR10	0.649	16.19		
	ITR11	0.652	16.30		
	ITR12	0.694	17.70		
PROCESS CAPABILITIES (PRCAP)	PRCAP1	0.772	20.54	0.92	0.74
	PRCAP2	0.765	20.28		
	PRCAP3	0.736	19.21		
	PRCAP4	0.750	19.72		
	PRCAP5	0.716	18.47		
	PRCAP6	0.788	21.17		
	PRCAP7	0.755	19.89		
	PRCAP8	0.673	17.01		
	PRCAP9	0.698	17.84		

Table 4. Impact of IT on Process Capabilities and Project Performance

	Process Capability	Δ (Cycle Time)			Δ (Cost)			Δ (Quality)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
IT Resource Usage (ITR)	0.465*** (6.37)	0.432*** (5.47)	—	0.255*** (3.12)	0.411*** (5.22)	—	0.219*** (2.70)	0.374*** (4.78)	—	0.139* (1.74)
Team Size	-0.020 (-0.53)									
Co-location	0.009 (0.28)									
Propensity to use IT	-0.080* (-2.22)									
Project Duration	0.022 (0.63)									
Autonomy	0.021 (0.65)									
Process Capability (PRCAP)	—	—	0.404*** (6.98)	0.322*** (5.17)	—	0.422*** (7.27)	0.351*** (5.60)	—	0.473*** (8.24)	0.428*** (6.88)
Concurrent Projects	—	0.041 (0.98)	0.041 (1.00)	0.039 (0.94)	0.042 (1.00)	0.042 (1.01)	0.039 (0.96)	0.062 (1.47)	0.060 (1.48)	0.059 (1.45)
Firm Size	—	0.022 (0.51)	0.029 (0.69)	0.014 (0.35)	0.014 (0.34)	0.018 (0.45)	0.006 (0.15)	0.002 (0.05)	0.000 (0.01)	-0.007 (-0.18)
Model Fit Statistics										
R^2	*0.171*	*0.070*	*0.101*	*0.12*	*0.063*	*0.11*	*0.12*	*0.055*	*0.138*	*0.142*
AGFI		0.850	0.852	0.853	0.849	0.851	0.851	0.846	0.852	0.852
CFI		0.896	0.899	0.900	0.894	0.897	0.899	0.892	0.899	0.899
IFI		0.897	0.900	0.901	0.895	0.898	0.899	0.893	0.900	0.900
RMSEA		0.059	0.058	0.058	0.060	0.059	0.058	0.060	0.058	0.054
χ^2 / df		2.834	2.786	2.765	2.884	2.814	2.801	2.919	2.790	2.790
χ^2 test statistic			*p*-value = 0.002			*p*-value = 0.006			*p*-value = 0.080	

*** indicates $p < 0.01$, ** indicates $p < 0.05$ and * indicates $p < 0.10$. Two-tailed t-statistics are shown in parentheses.

Table 5. Impact of Mediated Paths from IT Resources to Project Performance Outcomes

Overall Effect	Mediated Paths	Path	Z stat
ITR → Δ(Cycle Time)	ITR → PRCAP → Δ(Cycle Time)	0.403	4.49***
ITR → Δ(Cost)	ITR → PRCAP → Δ(Cost)	0.380	4.23***
ITR → Δ(Quality)	ITR → PRCAP → Δ(Quality)	0.336	3.72***

** $p < 0.05$ and *** $p < 0.01$ in two-tailed tests.

Table 6. Test for Moderation Effects of IT

	Δ (Cycle Time)	**Δ (Cost)**	**Δ (Quality)**
Process Capability (PRCAP)	0.344*** (5.36)	0.373*** (5.79)	0.457*** (7.14)
IT Resource Usage (ITR)	0.267*** (3.24)	0.234*** (2.85)	0.160** (1.99)
ITR * PRCAP	-0.121 (-1.63)	-0.125 (-1.68)	-0.163** (-2.22)
Concurrent Projects	0.043 (1.05)	0.044 (1.07)	0.065 (1.60)
Firm Size	0.014 (0.33)	0.006 (0.14)	-0.009 (-0.21)
R^2	12.15%	12.47%	15.00%

*** indicates $p < 0.01$, ** indicates $p < 0.05$ and * indicates $p < 0.10$. Two-tailed t-statistics are shown in parentheses.

APPENDIX: SURVEY QUESTIONNAIRE

The objective of this research survey is to develop an understanding of the business processes, management practices and information technologies (IT) in use in your firm. Please provide your responses to the following survey questions based on a typical project that you have managed recently. A project is defined as a collection of activities that has been established to complete a specific goal. (The question headings in bold were not shown on the questionnaire and questions were arranged in random order).

1. Select the generic role below that best describes your role within your current company:
   1=Individual Contributor, 2=Business Project Manager, 3=Business Program Manger, 4=Product Manager, 5=Line of Business Manager

2. Is your company…? (Please select only one response.)
   0=Publicly traded, 1=Privately held. Provide your company name.

3. **FIRM SIZE**: How many regular full-time employees are in your company? (Please select only one)
   1 = < 100 employees (TERMINATE); 2 = 100 to 249; 3 = 250 to 499; 4 = 500 to 999; 5 = 1,000 to 4,999; 6 = 5,000 to 9,999; 7 = 10,000 to 24,999; 8 = 25,000 or more; 9 = Not Sure

4. **NUMBER OF CONCURRENT PROJECTS MANAGED:** What is the typical number of projects you manage concurrently (at any one time)?
   1 = 1 Program/project; 2 = 2 - 3 Programs/projects; 3 = 4 - 5 Programs/projects
   4 = 6 - 10 Programs/projects; 5=More than 10 Programs/projects

5. **PROJECT DURATION**: How long does your typical program or project last?
   1 = Less than 1 Year; 2 = 1 - 2 Years; 3 = 3-5 Years; 4 = 6 - 10 Years; 5 = > 10 Years

6. **TEAM SIZE:** How many people are typically involved in your projects?
   1 = 1 - 10 People; 2 = 11 - 20 People; 3 = 21 - 50 People; 4 = 51 - 100; 5 = > 100 People

7. **CO-LOCATION:** Describe the extent of co-location of your team. Most of the project team is in the:
   1 = Same Building; 2 = Same City; 3 = Same Time Zone; 4 = Different Time Zones;
   5 = Different Country and Time Zone

8. **PROPENSITY TO USE IT:** How would you describe your project team's use of IT?
   1 = Leading Edge User; 2 = Early User; 3 = Mainstream User; 4 = Conservative Adopter; 5 = Late Adopter

9. **AUTONOMY:** Project/program targets/goals are primarily set by (choose one):
   1= Business Unit Head; 2 = Program Sponsor; 3 = Project Manager; 4 = Project Team

10. **INFORMATION TECHNOLOGY RESOURCE USAGE (ITR)**
    Please rate the following IT applications on their degree of usage in your recent project:
    1 = No Use; 2 = Limited Use; 3 = Medium Use; 4 = High Use; 5 = Heavy Use

    i. Mobile Communication (WLAN, Voice, Cell phones, Wireless laptops)
    ii. Instant Messaging Software
    iii. Mobile Computing (e.g. Tablets, PDA, Blackberry hand-helds)
    iv. Video-Conferencing Technologies (e.g. Webex)
    v. Groupware and Online Teamspaces (e.g. Sharepoint, LiveLink, eRoom)
    vi. Enterprise Application Software (ERP, Supply chain management software, Financials)
    vii. Knowledge Management Software
    viii. Customer Relationship Management Software (CRM, Collaboration Tools)
    ix. Project Management Software

x. Business Intelligence (e.g. SAS, Hyperion, Cognos)
xi. Content Management Systems/Project Portals
xii. Document Management Solutions/Systems

11. **PROCESS CAPABILITIES (PRCAP)**
Please evaluate the following statements based on what you would consider a typical project that you have managed recently.
1 = Significant Negative Effect; 2 = Moderate Negative Effect; 3 = Mild Negative Effect; 4 = No Effect; 5 = Mild Positive Effect; 6 = Moderate Positive Effect; 7 = Significant Positive Effect

i. Current program/project information (schedule, goals) is visible throughout the team
ii. Ease of tracking and monitoring programs/projects throughout the company
iii. Identifying and mitigating program/project and business risks
iv. Identification and facilitation (management) of qualified suppliers and partners
v. Ability to lower procurement cost of goods
vi. Re-use of information and corporate knowledge assets across the enterprise
vii. Identifying and disseminating customer needs and requirements to the program/project teams
viii. Continual involvement of customers in programs/projects
ix. Creating new markets, product enhancements, and business opportunities

12. **PROJECT PERFORMANCE**
In comparison to a similar project that you managed about three years ago, please evaluate the change in outcomes of the recent project:

1 = Increased more than 80%; 2 = Increased 61-80%; 3 = Increased 41-60%; 4 = Increased 21-40%; 5 = Increased 1-20%; 6 = No change; 7 = Decreased 1-20%; 8 = Decreased 21-40%; 9 = Decreased 41-60%; 10 = Decreased 61-80%; 11 = Decreased more than 80%

i. **COST**: Project costs, defined as the total program/project cost incurred from initiation to completion (including labor, equipment, services) for the recent project
ii. **QUALITY**: Project quality, measured as the total number of errors, defects, and rework associated with the recent project *
iii. **CYCLE TIME**: Project completion time, defined as the time elapsed from project initiation to completion, for the recent project.

* These measures was re-ordered so that higher values represent performance improvements.