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IT Enabled Innovation: A Theoretical and Empirical Investigation of the Role of Information Technology and Outsourcing in Business Innovation

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ABSTRACT

In this paper I present a summary of my dissertation in which I study the relationship between information technology, outsourcing and innovation. I propose to do this in three distinct, but related, papers. The first paper will be a theoretical essay that reviews and synthesizes relevant literature from information systems, economics, public policy and management research. This paper will develop a model of innovation in firms and will propose research questions and hypotheses, grounded in relevant management theories, relating IT and outsourcing to innovation. The second paper will focus on the relationship between IT investments and innovation in firms. The third paper will specifically study the relationship between engaging in outsourcing and innovation in firms Both empirical papers will test their hypotheses on unbalanced panel data sets of large US-based firms using patent counts as the measure of innovative output.

Keywords

Innovation, IT-enabled innovation, business process outsourcing, IT capabilities, firm performance, IT investments, business value of IT

INTRODUCTION

My research interests center around the question of what factors enable certain firms to be more innovative than others. In considering various predictors of innovation, I have been particularly interested in how information technology and globalization affect a firm's ability to innovate. Although the relationship between IT and firm performance has been well studied, there have been relatively few studies of the relationship between IT and business innovation (Han and Ravichandran, 2006; Pavlou and El Sawy, 2006). IT investments confer a number of capabilities upon firms which should reasonably be expected to facilitate innovation processes. My dissertation will help further our understanding of how IT capabilities confer competitive advantage by facilitating the creation of innovative output in firms.

The increasing globalization of business has profoundly affected the way firms think about their operations. In addition to opening up new markets, globalization has opened up a world of resources that firms can use to perform needed business functions. Initially movement towards offshoring (moving business units overseas) and outsourcing (contracting business functions to external entities) were expected to provide firms with cost benefits that would directly impact profits. Subsequently, as firms in developing countries have further developed expertise and service offerings, outsourcing firms have now come to be viewed as sources of competitive advantage beyond mere cost-benefits. For example, the success of 24x7 Customer and Marketics demonstrates the capabilities of these firms to provide world-class customer service and marketing analytics services. As outsourcing firms further develop and refine their capabilities, focal firms that use their services should be able to leverage these resources to confer a number of firm-level benefits. In particular, leading business scholars have recently suggested that successfully leveraging global resources will be a key enabler of innovation and will be a source of strategic differentiation between firms (Prahalad and Krishnan, 2008).

I propose to complete a dissertation that investigates three aspects of how technology enabled globalization is affecting the ability of firms to innovate. The first paper will review the literature on innovation and synthesize it with relevant literature from information systems, economics, public policy and management research. This paper will develop a model of

innovation at the firm-level and will specifically discuss how information technology and outsourcing can enable firms to be more innovative. The second paper will test some of the hypotheses developed in the first paper on an unbalanced panel data set of large US firms for the years 1998 through 2003. This paper will attempt to answer the question of whether IT investments are associated with higher levels of innovative output and what specific IT capabilities confer innovation advantages upon firms. The third paper will examine the innovation implications of an increasingly common firm strategic decision: the decision to outsource internal business processes. As I discuss below, there are compelling reasons to believe that engaging in business process outsourcing should enable firms to be more innovative. I will empirically address this question by analyzing a panel data set of large US firms for the years 2002 through 2006. In the remainder of this paper I present a snapshot of the current status of each of the papers described above.

PAPER 1: IT AS AN ENABLER OF FIRM-LEVEL INNOVATION

For the first paper in my dissertation, I will provide a comprehensive review of the literature on innovation with a view towards identifying a satisfactory model of how innovation occurs in organizations. I then will identify specific IT capabilities that have been studied in the IS literature and will develop specific hypotheses as to how these IT capabilities might affect the innovation process within an organization. The specific model and theoretical propositions will evolve as I continue to analyze the literature and interact with my dissertation committee; however, in the remainder of this paper I present a snapshot of my current thinking on the interrelationships between IT and innovation.

Literature Review

Information Systems Research

A number of studies in the IS literature have sought to characterize the value firms have been able to extract from IT investments. Hitt and Brynjolfsson evaluated three potential measures of IT benefits: (1) productivity, (2) consumer surplus and (3) profitability (Hitt and Brynjolfsson, 1996). They found that IT capital investments are correlated with productivity and consumer surplus, but not with profitability. Their study suggested a strong need to consider measurement issues when assessing IT business value. While they were able to show that benefits from IT investments can be realized in productivity and consumer surplus measures, they suggest that other measures such as profitability may not reflect the true value of IT investments. Bharadwaj addressed this measurement issue specifically by using the forward-looking Tobin's q as a measure of IT benefits and found a significant association between IT expenditure and Tobin's q (Bharadwaj, Bharadwaj and Konsynski, 1999). Dos Santos, Peffers and Mauer investigated various types of IT investments (innovative vs. non-innovative) and the effect of announcements of such investments on firm market value (Dos Santos, Peffers and Mauer, 1993). They found that only announcements of innovative IT investments were positively related to firm market value. Finally, Brynjolfsson and Hitt used a production function approach on firm-level data to demonstrate that the gross marginal product for computer capital investments was quite high (81%) and that the gross marginal product for IS labor was at least as high as that for non-IS labor in their data set (Brynjolfsson and Hitt 1996).

As should be clear from the last paragraph, the business value of IT has been measured in many different ways. Hitt and Brynjolfsson measured IT value with respect to profitability and consumer surplus (Hitt and Brynjolfsson, 1996). Mithas, Krishnan and Fornell examined the impact of IT investments on customer satisfaction (Mithas, Krishnan and Fornell, 2005). Other authors have examined the impact of IT on various financial performance variables (Bharadwaj et al. 1999; Dos Santos et al, 1993). I suggest that a significant contribution to IS scholarship would be a series of studies examining the relationship of IT investments to another proposed measure of IT business value: innovation. The core question of this research stream would be do IT investments make firms more innovative and, if so, to what extent? The second paper of my dissertation would begin to address this question.

Innovation Research

Having reviewed some of the relevant literature from the IS research domain, I now will discuss prior work on modeling innovation and identifying its antecedents. Many studies have demonstrated the value of networks in fostering innovation. Schilling and Phelps demonstrated that membership in alliance networks that were highly clustered and with high reach (short average path lengths to a wide range of firms) was correlated with greater firm innovative output (Schilling and Phelps, 2007). Earlier studies examined the role of direct and indirect ties on firm innovative output and found that both are correlated with innovation (Ahuja, 2000).

A number of articles have also examined the role of collaboration and knowledge spillovers in the innovation process. Singh examined knowledge diffusion patterns in collaborative networks and found that, while intra-regional and intra-firm

knowledge spillovers were common, knowledge diffusion was largely determined by interpersonal networks (Singh, 2005). Owen-Smith and Powell distinguished proprietary channels of information from open conduits of information between firms and examined how knowledge accessibility affected the reach of innovation benefits within collaborative networks (Owen-Smith and Powell, 2004). Some recent publications have investigated the role customers may play in the innovation process, suggesting that firms can reap innovation benefits by co-creating products and services with their customers (Prahalad and Krishnan, 2008; Sawhney, Verona and Prandelli, 2005)

A recently proposed model of innovation describes the typical activities a firm has to perform in order to generate innovations (Roper, Du and Love,. 2008). A schematic of these activities is provided in Figure 1.

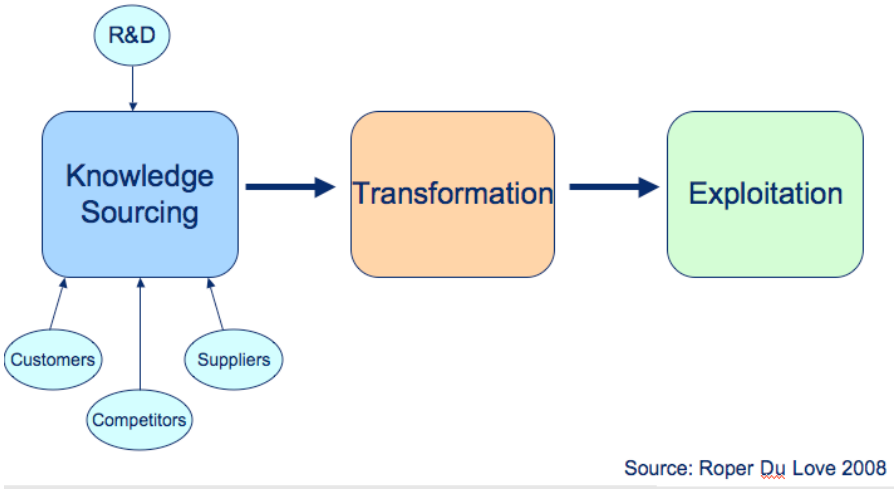

Figure 1. The Innovation Value Chain (adapted from Roper, Du & Love 2008)

Knowledge Sourcing refers to activities the firm engages in to bring various sources of knowledge into the firm. Typically this is comprised of internal R&D, but increasingly firms are gaining knowledge from a number of external sources (e.g. their customers, competitors and suppliers). Once knowledge has been brought into the firm it gets converted into a useful invention during the Transformation phase. Significant value is added during this phase as various knowledge sources are recombined and developed to address strategic objectives. In the Exploitation phase, the best inventions are commercialized and generate profits for the firm.

Increasingly, the activities that occur along the innovation value chain are becoming globally dispersed. First, firms have moved to disaggregate their innovation activities by increasingly outsourcing work across international borders. Similarly, teams within organizations have become increasingly geographically distributed, and understanding how to utilize technology and management practices to maximize the performance of globally distributed teams is vital to researchers and managers alike. I propose to adopt the innovation value chain as a model of firm-level innovation and to develop theoretical propositions as to how information systems can support activities along the innovation value chain. Next steps for this paper include completing the literature review, choosing management theories relevant to innovation processes and proposing a research agenda (including specific research questions and hypotheses) as to how the IT investments and outsourcing affect innovation processes within firms.

PAPER 2: EVALUATING THE EFFECTS OF IT INVESTMENTS AND IT CAPABILITIES ON INNOVATION IN HIGH TECHNOLOGY FIRMS

The core thesis of my dissertation is that firms with advanced information technology capabilities are better able to leverage internal and external resources to enable innovation which leads to superior firm performance. This paper further develops the theoretical framework of the first paper by focusing on the IT resource and its role in firm-level innovation processes. Building on recent efforts (Han and Ravichandran, 2006) to evaluate the impact of IT investment on innovation, I develop hypotheses concerning the relationship between IT investment and firm-level innovation propose to evaluate these hypotheses on an unbalanced panel data set of firms in high-technology management industries. These knowledge-intensive industries include aerospace equipment, chemicals, computer and office equipment, household audiovisual equipment,

medical equipment, petroleum refining and products, pharmaceuticals, semiconductors, telecommunications equipment and measuring and controlling devices and represent industries that tend to patent their innovations (Schilling and Phelps, 2007).

BACKGROUND & HYPOTHESES

My goal in this study is to empirically evaluate the effects of IT investments on innovation in high-technology firms. Firms are increasingly becoming dependent on information technology for all areas of business operations including R&D, logistics, customer service, supply chain management, etc., and business processes are tightly coupled with technology architecture in innovative firms (Prahalad and Krishnan, 2008). The increasing level of digitization in every aspect of a firm's business model suggests that the capacity of a firm to reconfigure resources and leverage R&D investments may depend on the level of its IT investments and the quality of its technology architecture.

As *innovation* is the phenomenon I seek to explain, in the remainder of this section I briefly review relevant prior research on innovation and its antecedents. Due to space constraints I focus only on prior research that is most directly related to the work I propose to do for my dissertation. For a more complete review of prior research on innovation, I refer the reader to two excellent recent literature reviews (Ahuja, 2008; Gilbert, 2006).

Prior Research on Innovation

Schumpeter was one of the first to suggest that *firm size* might be an important predictor of firm innovative output (Schumpeter, 1942). He argued that larger firms, with resource and scale advantages over smaller competitors, are better positioned to pursue R&D intensive industrial strategies that ultimately result in innovative output. A number of scholars have tested this assertion and the empirical evidence for this assertion has, at best, been mixed. Some studies have confirmed his hypothesis, showing that firm size is positively associated with innovative output (Lieberman, 1987; Schwartzman, 1976); others have not (Graves and Langowitz, 1993; Halperin and Chakrabarti, 1987).

A number of studies have examined the relationship between *R&D expenditures* and firm innovative output (Pakes and Griliches, 1980; Hausman, Hall and Griliches, 1984; Hall, Hausman and Griliches, 1984). Innovation is often conceptualized to be the output of R&D processes, and the level of R&D expenditure can therefore be viewed as a measure of the intensity of a firm's innovative effort. Patents, a commonly used measure of innovative output, frequently are filed after intensive periods of research and development. Arguments against the role of R&D expenditures in innovation processes suggest that since patents typically are filed very early in the R&D process, there are in fact an input into (and not an output of) R&D processes. Empirical analyses of large sample panel data has not supported this claim and instead has suggested that the relationship between R&D and patenting is either contemporaneous or at most lagged by one year (i.e. one-year lagged R&D is associated with higher patent counts) (Hall et al, 1984). The evidence suggests that R&D investment is positively associated with firm innovative output, particularly as measured by patenting activity.

IT & Innovation

Having discussed some of the known predictors of firm innovative output, I now turn to a consideration of the IT resource and its hypothesized effects on firm-level innovation that I intend to test in this study.

Paper 1 of this dissertation explores in great detail how the IT resource theoretically can impact innovation processes. Overall these IT capabilities should help firms perform a number of functions that are germane to innovation processes. These include providing firms with flexibility and agility in their business processes, enhanced collaboration and coordination capabilities, robust experimentation capacity and heightened knowledge gathering and management capabilities. The level of IT investment has been used as a measure of overall firm IT capabilities (Hitt and Brynjolfsson, 1996), and it is my expectation that, as such, greater IT capabilities will be associated with greater innovative output leading to the following hypothesis:

H1: Firms with higher levels of information technology investments will have higher levels of innovative output

IT investments provide firms with enhanced *coordination* and *collaboration* capabilities. Innovation processes typically rely on input from many, often distributed, players each performing tasks relevant to the process. Coordinating activities amongst these participants in the innovation process is vital to successful innovation. Ensuring that tasks are properly handed off and resources are well managed should help workers assimilate knowledge into new products and services. Similarly, innovation is very often dependent on interactions between distributed employees and partners. Prior research has shown that such ties

add value to innovation processes even beyond the boundaries of the firm (Ahuja, 2000; Owen-Smith and Powell, 2004). IT investments have been shown to enhance coordination and communication amongst employees and with partners (Hitt, 1999; Malone, Yates and Benjamin, 1987). Furthermore, IT investments have been shown to enable collaboration between distributed workers by facilitating better communication (Finholt and Olson, 1997) and aiding in the development of trust (Bos, Olson, Gergle, Olson and Wright, 2002). Because IT enables the development of robust coordination and collaboration capabilities, and because these capabilities are essential to innovation processes, I hypothesize that:

H2a: Greater usage of IT systems that facilitate coordination of work activities will be associated with higher levels of innovative output.

H2b: Greater usage of IT systems that facilitate collaboration between employees and partners will be associated with higher levels of innovative output.

In addition to direct effects on innovative output, I consider the possibility that IT investments may enhance the efficiency of known predictors of innovation. With respect to R&D, I consider the *knowledge management* capabilities provided by IT investments. Innovation processes are very knowledge intensive. Innovators create and evaluate large bodies of data that provide the building blocks for future commercial products. For example, a key challenge for pharmaceutical companies is to search through the information space of possible drug candidates to identify those that might be most likely to succeed. Managing this data and providing employees with the capabilities to sift through it to extract useful information will be a key determinant of innovative success. Consequently, I hypothesize that:

H3: Greater usage of IT systems that facilitate knowledge management will be associated with higher levels of innovative output.

RESEARCH DESIGN & METHODOLOGY

Data Sources

I test my hypotheses on a data set constructed from multiple sources as described here. I use yearly patent counts from the US Patent & Trademark Office as a proxy for firm-level innovation. I obtained patent data from the US only for two reasons. All of the firms in my sample are large-US based high tech firms and it is likely that a large proportion of their patenting activity occurs within the US. Second, as patenting regimes can vary significantly across nations (including the frequency at which patents are granted and the level of protection provided by patents, I limited my data to US patents only to be able to consistently compare patent counts across firms and years (Ahuja, 2000).

Variables relating to IT expenditures and IT capabilities were constructed from *Informationweek 500* surveys conducted between 1999 and 2006. These surveys are circulated annually to large US-based firms. Data from these surveys has been used in a number of prior IS studies (Bharadwaj et al, 1999; Han and Ravichandran, 2006; Rai, Patnayakuni and Patnayakuni, 1997; Santhanam and Hantoro, 2003). Data for relevant control variables (e.g. firm size, R&D expenditures) was obtained from COMPUSTAT.

Estimation Method

When the dependent variable is a count variable the traditional Ordinary Least Squares (OLS) assumptions of homoskedasticity and normally distributed errors are violated. As a result, the OLS estimator will be biased. When using count data, it is most appropriate to use an estimation method that accounts for the discrete, non-negative nature of count data. While Poisson regression models have been widely used to estimate count data models, most real count data (including patent counts) often exhibits *overdispersion*. The Poisson model assumes equal mean and variance. An estimation method that allows for overdispersion of the count variable and accounts for its discrete nature is the negative binomial regression model (Hausman et al 1984). In negative binomial models, the probability of observing a particular count value (e.g. k) follows a negative binomial distribution:

$$\Pr(y_i = k \mid x_i) = \frac{\Gamma(k+\alpha^{-1})}{k!\Gamma(\alpha^{-1})}\left(\frac{\alpha^{-1}}{\alpha^{-1}+\mu_i}\right)^{\alpha^{-1}}\left(\frac{\mu_i}{\alpha^{-1}+\mu_i}\right)^{k}$$

With the probability function specified, a likelihood function can be generated and estimation can proceed via maximum likelihood. I add industry and year variables to all regression to control for industry and time specific effects. Next steps for this paper include further theoretical development, variable construction, model estimation and analysis of results.

PAPER 3: THE INNOVATION IMPLICATIONS TO FIRMS OF ENGAGING IN BUSINESS PROCESS OUTSOURCING

For the third paper of my dissertation, I propose to evaluate the innovation implications to firms of engaging in business process outsourcing (BPO). There are a number of reasons to expect that engaging in BPO should enable firms to be more innovative. I introduce a number of these reasons in the next section and specify a study, modeled after traditional studies of firm-level innovation from the economics and public policy literature, that should enable me to assess the degree to which outsourcing affects firm-level innovation. In the next section I explain the rationale for expecting BPO to affect innovation and I close this section with a discussion of methodological considerations.

Resource Benefits to the Focal Firm

I propose that engaging in BPO enables firm innovation by affecting the levels of three types of critical firm resources. First, BPO is thought to confer *monetary resource benefits* to firms by lowering costs for key business functions. Second, BPO can affect innovation by conferring *cognitive resource benefits* to the focal firm. Employees of firms that engage in BPO theoretically should be able to focus their mental effort on core business activities by reducing (or eliminating) time spent on non-core activities. Third, BPO can enable innovation by conferring *labor resource benefits* to the focal firm. While the second line of reasoning addresses the quality of employee engagement with core business problems, this one addresses quantity. Specifically, firms that effectively outsource non-core business tasks should be able to reassign more employees to focus on core business activities. Having these monetary, cognitive and labor resource benefits conferred by BPO should positively affect a firm's ability to innovate.

Engaging in BPO extends a focal firm's network by giving the firm access to new strategic partners. Prior research has shown that both direct (e.g. strategic alliances) and indirect (e.g. access to information from a partner's partner) ties promote innovation, though to varying degrees (Ahuja, 2000). While engaging in BPO, focal firms establish direct ties to BPO firms, but additionally establish indirect ties to (a) other BPO firms and (b) other firms that use the same BPO firm.

From a network standpoint, BPO firms can be viewed as highly centralized nodes in information networks. Effectively they function as weigh-stations for information that could be a source of competitive advantage to client firms. The extent to which such information moves in BPO firm networks and the value which the information carries will directly affect the innovation effects on focal firms of engaging in BPO.

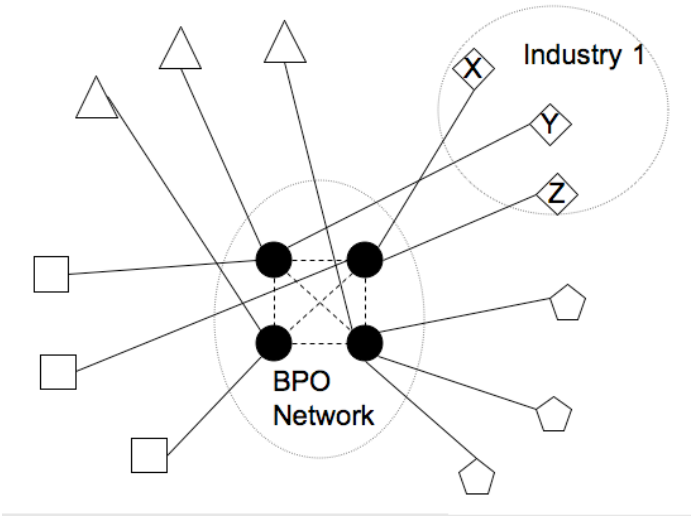

Figure 2: BPO Networks & Indirect Ties

In Figure 2, the centralized shaded circles represent BPO firms and the outer white shapes represent focal firms (different shapes represent firms in different industries). Nodes X, Y and Z represent competing firms within the same industry who do not have information sharing agreements established with each other. All three of the firms engage in BPO and firms X and Z use the same BPO firm. In this network structure, firms X and Z have indirect ties to each other through their common BPO firm. Indirect ties have been shown to be a source of information that drives innovation (Ahuja, 2000) leading to the hypothesis that firms that use BPO firms (particularly those connected to other firms in their industry) will experience higher rates of innovation. For these reasons it is reasonable to expect that in addition to the resource impacts of BPO on innovation that network effects could enable focal firms engaging in BPO to be more innovative. The main hypotheses I wish to test in this paper are the following:

H1: *Firms that engage in business process outsourcing will have higher levels of innovative output*

H2: *The effect of business process outsourcing on innovative output will be higher for firms with higher levels of IT investment*

Methodology & Data

I propose to create a data set from a number of sources on which to test my hypotheses. BPO data can most easily be obtained from the *InformationWeek 500* surveys as respondents were explicitly asked if they engaged in BPO. Control data could be obtained from publicly available data sources of firm financial information (e.g. COMPUSTAT). Patent data can be obtained from the US Patent & Trademark office.

Once I have the data set compiled, I plan to estimate econometric models examining the direct impact of engaging in BPO on firm innovation (measured by patent applications) as well as the hypothesized moderating effect of IT investment on the innovation effects of engaging in BPO. These models will allow me to address the question of whether engaging in BPO

enables firm-level innovation. Next steps for this paper include further theoretical development, final construction of the data set and variables, model estimation and analysis of results.

CONCLUSION

In this paper I have presented a proposal for a three paper dissertation examining the relationship between information technology investments, outsourcing and innovation. The first paper will be a theoretical contribution to the IS literature that develops a model of firm-level innovation and proposes theory with respect to how information technology investments and outsourcing enable innovation in firms. The remaining papers will empirically evaluate hypotheses related to IT investments (paper 2) and outsourcing (paper 3) on unbalanced panel data sets of large US firms using patent counts as the measure of innovative output. The empirical papers will contribute to our understanding of how IT creates value in firms regardless of whether the hypotheses are confirmed or rejected. If confirmed, these findings will open up new opportunities for research aimed at better understanding the mechanisms by which IT and outsourcing enable innovation in firms. If rejected, this work will provide an answer to an open question in the domain of IT and firm performance and will invite investigation of the relationship between IT, outsourcing and innovation using different measures or levels of analysis. The findings of my dissertation research will help advance our understanding of these relationships in either case.

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