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# Diffusion of Technology-enabled Value Innovation among Manufacturing SMEs

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## ABSTRACT

The research models the effect of firm characteristics and institutional environment on the implementation of technologies across a small or medium enterprise's (SME) entire value chain. The approach is motivated by two research streams, namely diffusion of innovation and institutional theory. Firm characteristics are based on diffusion of innovation literature and the role of external parties such as customers, vendors, and government agencies is based on institutional theory. An empirical study of SMEs in the Greater Boston area, based on this model, is in progress.

## Keywords

Innovation, diffusion, institutional theory, small and medium enterprise (SME), value-chain, value innovation

## INTRODUCTION

Contrary to popular beliefs, small and medium sized enterprises (SMEs) play a very important role in the U.S. economy. SMEs employ half of all private sector employees in the U.S. and generate 60 to 80 percent of new jobs annually (Small Business Administration [SBA], 2005). SMEs are not necessarily low-technology firms; cutting edge technology firms in bio-technology and in computer sector are often small or medium enterprises. In the U.S., SMEs employ about 39% of high technology workers such as scientists, engineers and computer workers, and they constituted 40% of highly innovative firms in the year 2002 while the share of elite inventors was about 30% (SBA, 2005).

Study of SMEs has therefore captured widespread interest among information systems researchers (Bharati and Chaudhury, 2006; Burgess, 2002), particularly in the area of information systems (IS) diffusion and adoption. The focus of this research program is the impact of firm-wide technologies such as enterprise resource planning, computer aided manufacturing and supplier management systems on firm performance.

The current research adopts a unique approach. First, it adopts a firm level approach. In MIS literature, technology adoption has often been treated as synonymous to user acceptance. For instance, Venkatesh *et al* (2003) provide eight different approaches to modeling an individual user's IT acceptance process. Compared to large firms, SMEs are price-takers in the market and as a result of low asset base are more vulnerable to competitive and business pressures emanating from the institutional environment (Davison and Dutia, 1991; Beck, Demircuc-Kunt and Maksimovic, 2005). Their weak institutional positioning is likely to be an important factor in technology adoption. Second, this paper uses an institutional perspective based on firm level analysis. As in Teo *et al* (2003), the research is based on diffusion of innovation perspective (Rogers 2003), and the institutional theory approach (DiMaggio and Powell 1983) which allow us to model influences and pressures that are imposed by various actors in the environment such as vendors, government agencies and customers. Concern has been raised about the lack of institutional perspective in IS research (Bjorck, 2004; Chiasson and Davison, 2005) and this paper attempts to address that lacunae.

Third, this paper focuses on cluster of technologies that have firm-wide impact in contrast to studying individual technologies. While much of the literature in technology adoption is based on single technologies, this paper models antecedents to technology adoption where whole clusters of technologies are involved. While this aggregation may hide the differences between impacts of different technologies, a confirmation also provides evidence of model robustness at aggregate level and makes policy recommendations more meaningful (Fichman, 2001).

Finally, this paper studies technology cluster adoption at firm level in the context of a particular strategic behavior, called value innovation. To survive in the competitive environment, SMEs not only need to continuously reduce cost but also to innovate in both product and process domains (Quale, 2002; Tse and Soufani, 2003; Levy *et al.*, 2005). Their strategic response is studied in the context of the notion of value-innovation (Kim and Mauborgne, 1997, 1999). Value-innovation is enabled by IT investment across multiple elements of a firm's value-chain (El Sway *et al.*, 1999). There is evidence that SMEs are engaged in value innovation and are investing simultaneously in multiple technologies that promote value innovation (Little, 1998).

The rest of the paper is organized as follows: The next section provides a background on the concept of value innovation in the context of SMEs. This includes Porter's (1980, 1998) concept of value chain and the different technology families that impact various elements of value-chain. Thereafter, we present the theoretical model and finally, our conclusions.

### **VALUE INNOVATION: WHAT AND WHY?**

Value-innovation is the creation value for the customer and the firm through innovation (Boehringer, 2005). It is a strategic response whereby firms continuously deliver innovative value-propositions to customers by using a radically low cost business model that also permits agility and flexibility. Here the value created is for both the customer and the firm.

The subject of strategy is concerned with explaining the sustained competitive advantages (SCA) that some firms enjoy (Rumelt, Schendel and Teece, 1991). Two major approaches have emerged in explaining successful competitive behavior. The first, provided by Porter, is called the industry structure approach where the unit of analysis is an industry and higher returns are explained in terms of characteristics such as superior bargaining power with respect to suppliers and erection of entry barriers (Porter 1980, 1998). This approach is characterized by generic strategies such as low cost leadership, differentiation, customer relationship and network effect approach that firms can adopt in the market place (Collis 2005). Here the focus is in market-based responses to industry structure.

The other approach which has become popular only in the last two decades, is called the resource-based-view (RBV) of the firm (Barney, 1991; Peteraf, 1993), where the unit of analysis is the firm. In turn, RBV has spawned other related specialized perspectives such as competency view (Prahalad and Hamel, 1994), knowledge-based view (Fransman, 1994), relational view (Hanson and Nohria, 2004) and value-innovation view of the firm (Chan and Mauborgne, 1999).

If the focus of Porter's school is on market-based behavior of firms, the focus of the RBV school is internal to the firm. According to RBV, superior performance is due to resource heterogeneity that the firm employs rather than to industry structure. For superior performance a firm is supposed to accumulate resources and capabilities that are rare, valuable, non-substitutable and difficult to imitate (Peteraf, 1993). But with globalization, deregulation and falling trade barriers in input resources all over the world, it became difficult to explain SCA in terms of long term resources rarity and heterogeneity. Most industries are characterized by almost universal access to resources (Hanson and Nohria, 2004).

With the advent and popularization of knowledge-based approaches in management, it was hypothesized that competencies resided in operational routines, specific ways of organizing business activities (Romer, 1998), and tacit and socially based understandings that firm employees shared (Fransman, 1994). Thus, we moved over from heterogeneous and immobile physical resources as a source of SCA to the knowledge-based view (KBV), where the focus is on a firm's ability to create, transfer, assemble, and exploit knowledge assets (Teece, 2000) and which is postulated to lead to SCA. According to Teece (page 3, 2000), the competitive advantage of a firm in today's economy comes not only from its difficult to replicate knowledge base but also from its "entrepreneurial and orchestration capabilities" of its knowledge assets, that he characterizes as dynamic capabilities. Thus KBV is similar to RBV but the interest here is knowledge resources and the deployment capability associated with it.

With the advent of globalization, freer movement of skilled-labor, and a developing market for intermediate and capital goods, there has been considerable relaxation in flow of knowledge and competencies across firms and national boundaries. Assets and competencies that were once rare and inimitable have become easier to replicate and firms cannot hide behind trade barriers in input resources and final goods to shelter profits. Resources that are unique and non-imitable are few and far between. The logic of sustained value creation has changed. With the stripping away of sources of competitive advantages through rare resources, competencies and knowledge-base, a new source of competitive advantage has emerged which is that of value innovation.

In value innovation, a firm is able to offer on continuing basis an exceptional and unique value-price combination that is driven by customers' needs, and which is based on a radically low-cost and flexible business model (Chan, Kim and Mauborgne,

1999). Unlike the RBV approach and the Porter's school approach, the focus of value innovation approach is balanced between the firm's market-based responses and the internal capabilities it brings into play. The value-innovation approach recognizes that in a competitive world where the value-proposition demanded by customers is constantly in flux, firms must be able to deliver ongoing innovation in its offerings to customers. Value-innovation is more than singular past efforts (e.g., one-time major business process engineering) to leap-frog competition and is an ongoing competitive effort woven throughout the corporate value-chain, i.e., supply chain, customer service, product design and business processes (Little, 1998). The logic of intensified competition due to falling trade barriers and globalization works as intensely in the case of SMEs as for large firms.

SMEs have reacted to this changed strategic scenario by investing in technologies that promote many elements of value innovation on their part. Firms of varying sizes including small ones view innovation as an on-going series of steps tied not only to strategy, but driving corporate business process and functions, technology and people (Little, 1998). In a similar vein, Quale (2002) and Quale and Richardson (2004) identify as drivers for Internet adoption reduced operating costs, improved service to customers, improved market intelligence and enhanced relationship with trading partners. Similarly, Tse and Soufani (2003) find the drivers affecting SMEs in their technology decisions to be improved services to customers, increased response speed and administrative cost reduction. Mehrtans *et al* (2001) find factors such as improved trading relationships and improved market intelligence among SMEs as motivators for investing in web-based technologies. In general, Levy *et al* (2005) find that strategic intent directed towards new products and markets on the part of SMEs drive adoption of various e-Business technologies.

### IS ENABLERS OF VALUE INNOVATION

IS researchers have been cognizant of IT playing multiple roles in a company and impacting its performance at many levels. Different firm level roles of IT and technology clusters have been identified. Venkatraman (1994) identifies five different roles in terms of range of potential benefits: localized exploitation, internal integration, business process redesign, business network redesign and business scope redesign. In Omar El Sawy *et al* (1999), Venkatraman's role typology is used to identify different technology clusters used by a firm called Marshall Industries. Our focus in this research is on technology clusters that promote value-innovation, that is, allow firms to have "low cost, high quality, and fast and flexible response to customer needs" (Venkatraman, 1994). Almost all firm activities and process functionalities across the value-chain are involved in delivering value-innovation.

We therefore adopt the value-chain framework of Porter (1985) to identify firm level activities, and Porter and Millar (1985) to identify all the enabling technologies. According to Porter (1985) a company's value chain "divides a company's activities into the technologically and economically distinct activities it performs to do business". In this framework, a firm's primary activities are divided into five activities: inbound logistics, operations, outbound logistics, marketing, and sales and service. The primary activities require support activities to provide inputs and infrastructure. These support activities are identified by Porter (1985) as firm infrastructure, human resource management, technology development, and procurement.

The value chain approach has been employed to elucidate the role of technology in value creation and innovation activities (Table 1). The table below lists the value-chain activity and the associated technologies that have been considered in our research.

### RESEARCH MODEL

The model ascertains the extent of technology usage by Boston SMEs across their entire value chain. It models the factors that promote and inhibit technology assimilation and the perceived effectiveness of different technology clusters.

Much of technology diffusion research conducted in IS employs the technology acceptance model (TAM) and other models that are at an individual level of analysis (Hu *et al*, 1999). This research focuses on technologies at different stages of information system assimilation such as awareness and implementation. According to Rogers (2003, p. 2), these types of innovation decisions are categorized as "authority innovation decision" where "choices to adopt or reject an innovation are made by relatively few individuals in a system who possess power, status and technical expertise". Firm level analysis is more appropriate in investigating IT diffusion in SMEs.

The innovation diffusion research literature has been concerned with nature of organizations that are innovative (Rogers, 2003) and there is a rich stream of research on organizational innovativeness (Mytinger, 1968; Meyer and Goes, 1988; Mahler and Rogers, 1999). The innovation diffusion approach was adopted as it related to investigation of organizational innovativeness.

<b>Value Activity</b>	<b>Information System</b>
<b>Inbound Logistics</b>	Supply Chain Management
	Supplier Management
<b>Operations</b>	Materials Management
	Production Planning
	Computer Numerical Control
	Computer Aided Manufacturing
<b>Outbound Logistics</b>	Supply Chain Management
	Order Processing
<b>Marketing and Sales</b>	Customer Relationship Management
	Website
<b>Service</b>	Customer Relationship Management
<b>Firm Infrastructure</b>	Accounting and Finance
<b>Human Resource Management</b>	Human Resource
<b>Technology Development</b>	Computer Aided Design
<b>Procurement</b>	Electronic Procurement

**Table 1: IS Enablers for Value Innovation**

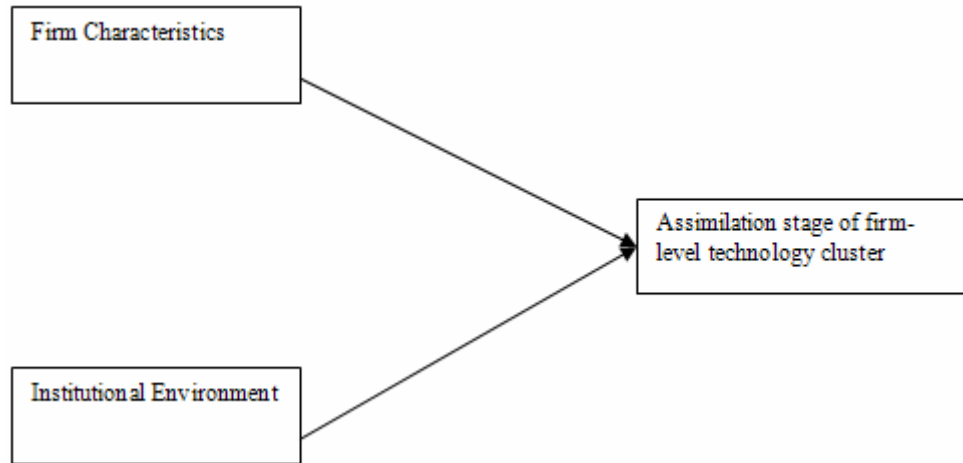
Economically, SMEs are small and weak players and are subject to numerous environmental pressures. Institutional theory focuses on institutions and how they influence each other in the context of an institutional field (Scott, 2001). Institutional theory is being employed to study influence of other institutions on SMEs.

The model has two sets of independent factors, organizational innovation characteristics motivated by organization innovation literature and institutional field influences motivated by institutional theory (Figure 1). The most common definition of SMEs, which is based on number of employees less than 500, was adopted (Burgess, 2002). Greater Boston Manufacturing Partnership (GBMP), a non-profit organization that helps SMEs, assisted in conceptualizing and formulating the research model.

#### Organizational Innovation

Rogers (1965, 2003) provided the popular framework for diffusion that led to over several thousand studies of innovation diffusion spread over different domains from technology to agriculture. Rogers' (2003, p. 11) diffusion theory is developed around four elements that constitute the process: (1) an innovation, (2) a channel through which the idea of innovation diffuses, (3) time, and (4) a social system in which the diffusion takes place. The focus of researchers has not been uniform over the four elements and the concern has been primarily with "product perspective" and the "people perspective" (Gourville, 2005).

The former is concerned with product features that promote rapid diffusion and the latter with features of people who are likely to be early adopters.



**Figure 1: Research Model**

As this research involves multiple technology clusters with varying and possibly conflicting features, the current research focuses on the “people perspective”. As the level of analysis is the firm, the concern is with firm level innovativeness. Rogers (2003) describes organizational innovativeness as a dependent variable that is dependent on independent variables such as leader characteristics, and internal characteristics of an organization such as organizational size and education. The model for studying adoption of technology clusters at the firm level is shown in Figure 2.

Assimilation stage of technology clusters (Dependent Variable):

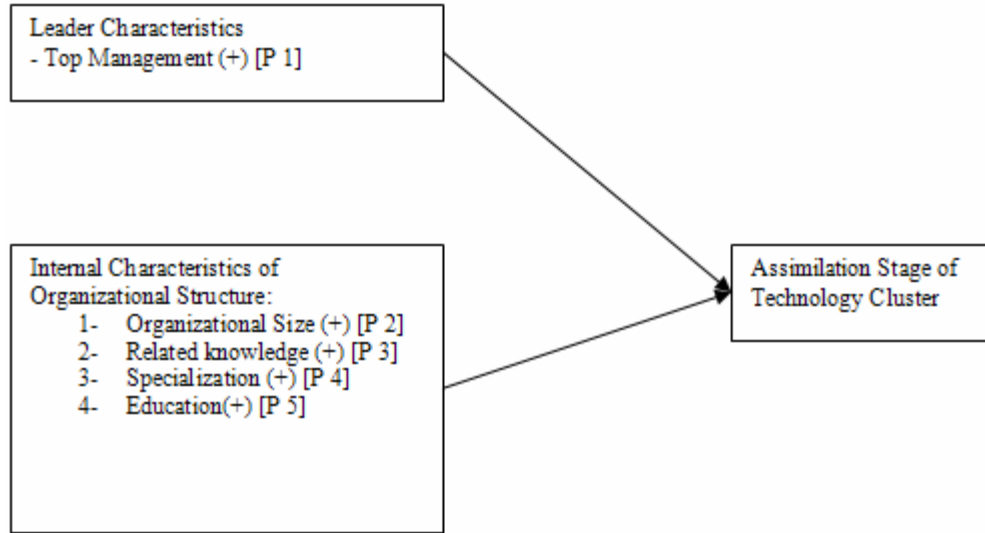
Rogers (2003, p. 20) describes a adoption process as an innovation- decision process having five steps- knowledge, persuasion, decision, implementation and confirmation. For IT software system, Fichman (1995, pg. 94) uses 6 point scale for measuring the assimilation stage. His stages were: not aware, aware, interest, evaluation/ trial, commitment, limited deployment and general deployment. After discussion with members of GBMP, it was decided to use a similar scale: no current activity, aware, interested, evaluated, committed, limited installation, general installation, acquired evaluated and rejected, do not know/other. The technology cluster adoption and assimilation of our model maps to Rogers (2003) theory. The research model employs a scale that is more granular than that of Rogers (2003) by mapping: no current activity and aware to knowledge phase; interest, evaluation and commitment to persuasion and decision phase; and limited deployment and general deployment to implementation phase of Rogers (2003) adoption process.

Rogers (2003, p. 408) refers to a study of organizational innovativeness where innovativeness is measured in terms of a “composite score of adoption of ten to twenty innovations”. Fichman (2001) lays out several conditions under which such cluster or aggregated study of technology adoption is legitimate. Many of the conditions are met here. The assimilation stage of technology cluster consists of Internet connection, email, website, electronic data interchange, supply-chain management software, customer relationship software, electronic procurement software, computer aided design, computer aided manufacturing, computer numerical control, manufacturing automation, production planning, human resource software, accounting/ financial, materials management, supplier management software, and order processing software.

Leader’s characteristic: Attitude towards change

IS research literature is replete with evidence that top management’s support is crucial for technology adoption. Jarvenpaa and Ives (1991), Chatterjee *et al* (2002) and Lane (1985) have established the role of senior management and their attitude towards technology adoption as a critical variable in determining organizational innovativeness.

*Proposition 1: The more positive the attitude of top management, the higher the assimilation of technology cluster.*



**Figure 2: Independent Variables related to Assimilation Stage of Technology Cluster [Model 1]**

Organizational Characteristics

Organizational Size

According to Rogers (2003), size is one of the most critical determinant of innovator profile. Mytinger (1968) provides evidence that organization size is one of the most important variable explaining innovativeness. Mahler and Rogers (1999) found that organizational size, revenue, and people employed are positively correlated with telecommunication technology adoption.

*Proposition 2: The greater the organizational size, the higher the assimilation of technology cluster.*

Related Knowledge

Rogers (2003, p. 411) credits organizational innovativeness to “high level of knowledge and expertise”. Cohen and Levinthal (1990) ascribe to existence of related knowledge to facilitating adoption of new technologies.

*Proposition 3: Greater the employees have related knowledge, higher the assimilation of technology cluster.*

Specialization

Kimberly and Evanisko (1981) ascribe innovativeness of organizations to specialization in related activities. Rogers (2003, p. 411) credits organizational innovativeness to “range of occupational specialties.”

*Proposition 4: The greater the employees have specialization, the higher the assimilation of technology cluster.*

Education

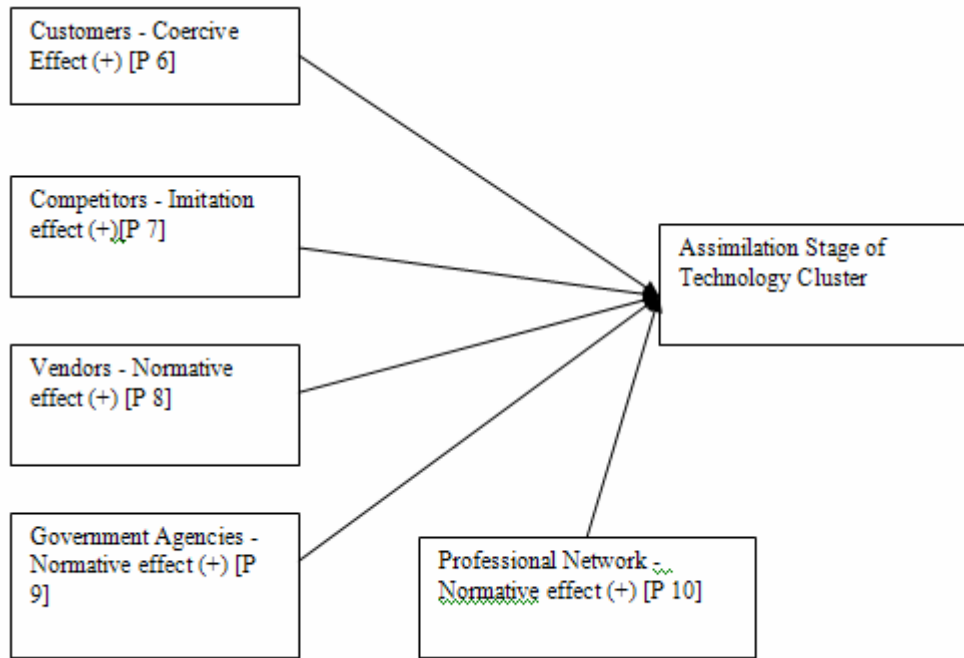
Pierce and Delbecq (1977) and Fichman (2001) relate education to professionalism and thereby the ability to innovate. Rogers (2003, p. 411) credits organizational innovativeness to a “degree of professionalism as expressed by formal training”

*Proposition 5: The greater the employee education and training level, the higher the assimilation of technology cluster.*

Institutional Theory

The second firm level theory employed is institutional theory (DiMaggio and Powell 1983). The institutional effects are diffused through a field of coercive (constraining), mimetic (cloning), and normative (learning) mechanisms. According to institutional theory, firms are part of an ecology consisting of other firms that consist of vendors, competitors, government agencies, and customers (Bjorck 2004). The survey is being designed to measure the impact of these actors in the environment that constitutes the second set of independent variables. Basic themes (Bjorck 2004) in the three modes of influencing are:

- (i) Coercive: Customer requirements and legal requirements are usually the source of coercive pressure.
- (ii) Mimetic: Leading members of the industry and competitors are the source of mimetic pressure.
- (iii) Normative: Consultants, trade association and other professional firms are usually the source of normative pressure.



**Figure 3: Effect of Institutional Environment on Assimilation Stage of Technology Cluster [Model 2]**

Customers

Knudsen *et al* (1994) and Webster (1995) relate effect on industry due to pressure from large customers such as GM and Ford respectively.

*Proposition 6: The greater the pressure from customers, the higher the assimilation of technology cluster.*

Competitors

Haveman (1993) and Clemon (1990) point to an imitation effect in firm behavior in the airline and banking industry.

*Proposition 7: The greater the influence from competitors, the higher the assimilation of technology cluster.*

Vendors

Burt (1982) and Markus (1987) point to pressures from dyadic channels. Teo *et al* (2003) find effect of suppliers on a firm’s intention to adopt inter-organizational systems. Attewell (1992) claims that consultants and vendors help reduce knowledge acquisition costs.

*Proposition 8: The greater the influence from vendors, the higher the assimilation of technology cluster.*

Government Agencies

King *et al* (1994) and Teo *et al* (2003) find evidence that participation with government agencies constitute pressure on a firm. Rogers (2003, p. 408) discusses the positive role of openness, defined as the “degree to which members of a system are linked to other individuals who are external to the system,” towards innovativeness.

*Proposition 9: The greater the influence from government agencies, the higher the assimilation of technology cluster.*

Professional Networks:



King *et al* (1994) and Teo *et al* (2003) also find evidence that participation in industry and trade associations constitute pressure on a firm.

*Proposition 10: The greater the influence from professional networks, the higher the assimilation of technology cluster.*

## CONCLUSIONS

The focus of this research is on the effect of firm characteristics and institutional environment on the implementation of technologies across a small or medium enterprise's (SME) entire value chain. The approach is motivated by two research streams, namely diffusion of innovation and institutional theory. Firm characteristics are based on diffusion of innovation literature and the role of external parties such as customers, vendors, and government agencies is based on institutional theory.

The research has several innovative features. Most technology adoption research in MIS is based on individual level of analysis. In contrast this research adopts a firm level analysis of SMEs. While the focus of technology adoption research is on a single technology, here the concern is with technology clusters that impact the entire value-chain of a firm. It is one of the few research efforts that employ institutional theory.

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