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Improving Innovation Performance through IS Enabled Knowledge Scanning

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INTRODUCTION

To remain competitive or even survive in today's highly uncertain environment, many firms are searching for a panacea that can solve all the problems. Some firms opted for business process reengineering (BPR), and even more chose the technology route by investing heavily in enterprise resource planning (ERP) systems, hoping for a quick fix. But the reality is that there are no magic pills to cure everything. Studies show that majority of BPR and ERP projects didn't achieve their original goals (Hammer and Champy, 1993; Sheer and Habermann, 2000). In the long run, the best guarantee for sustained competitiveness in today's unpredictable market is continuous innovation in products and processes to quickly adapt to the changing environment (Tushman and O'Reilly, 1997; McGrath, 2001).

Firm's capability for continuous innovation cannot be achieved by simply acquiring new technologies. It must involve constant accumulation of knowledge and information, and complex interaction among people, processes and technology (Sage, 2000). Given the importance of manufacturing innovation to the firm's long-term competitiveness (Cusumano, 1988), it will be interesting to identify the primary factors that affects a firm's innovation performance.

Previous studies have looked at the impact of some important content and process factors on innovation performance, such as types of innovation (Knight, 1967; Zaltman etc., 1973; Daft and Becker, 1978), attributes of innovation (Rogers, 1983), leadership styles (Van de Ven, 1986), champions of innovation (Howell and Higins, 1990), organizational culture and organizational structure (Nord and Tucker, 1987), absorptive capacity (Cohen and Levinthal, 1990), and organizational learning (McKee, 1992).

This is a large scale survey study focuses on innovation performance in manufacturing setting. Two new organizational level variables are introduced, i.e., information systems (IS) usage and knowledge scanning mechanism. The roles of information technology and knowledge have been discussed in innovation literature (Damanpour, 1991; Ettlie, 2000), but empirical studies concerning these important variables are scarce, especially at the organizational level (Berry and Taggart, 1994). This paper also made an effort to develop valid and reliable measurement instruments for organizational level IS usage, knowledge scanning and manufacturing innovation, which could be a valuable tool for future related studies.

THEORETICAL FRAMEWORK AND HYPOTHESES DEVELOPMENT

The theoretical model in Figure 1 suggests that a firm's innovation performance is directly affected by the firm's level of knowledge scanning and exploration activities, while the level of knowledge scanning activities is facilitated by effective organization- wide use of information systems. The three constructs in the model are described.

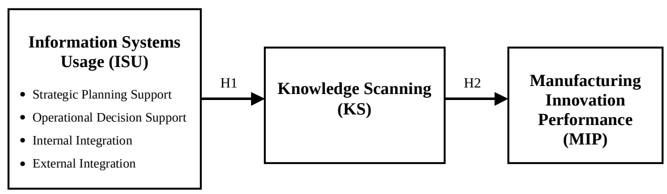

Figure 1:Theoretical Framework

Information Systems Usage (ISU)

While previous studies on IS usage are extensive (Szajna, 1996), their definition of IS usage are mostly at the individual or task level. Few studies look into the organizational level and inter-organizational IS usage effectiveness issues. Meanwhile, the measures for IS usage in many existing studies are either actual usage time logs or single item instrument with limited reliability and validity. Comprehensive and reliable measurement scales for IS usage at both individual and organizational level are necessary to facilitate research in this field.

Doll and Torkzadeh (1995) are the first to develop an instrument for IT usage patterns at the task level. They conceptualize the IT usage pattern into five dimensions: 1) problem solving: the extent that an application is used to analyze cause and effect relationships; 2) customer service: the extent that an applications is used to service customers; 3) decision rationalization: the extent that an application is used to improve the decision making processes or explain/justify the reasons for decisions; 4) vertical integration: the extent that an application is used to coordinate one's work vertically with superiors and subordinates; and 5) horizontal integration: the extent that an application is used to coordinate work activities with others in one's work group. Although this instrument focused primarily on individual and work group mechanisms, it did offer some useful directions for conceptualizing the organizational level IS usage construct. Using Doll and Torkzadeh (1995) instrument as starting point, along with comprehensive literature review, the organizational level IS usage construct in this study is reconceptualized as the extent to which IS is used by the firm to promote integration, support decision making and assist in strategic planning.

In summary, four major dimensions of organizational-level IS usage were proposed and their definitions are listed below:

Operational Decision Support. The extent that IS is used by the firm to help monitoring, justifying and improving daily operational decision processes (Doll and Torkzadeh - Decision Rationalization; Boynton and Zmud - Management Support).

***Strategic Planning* Support.** The extent that IS is used by the firm to help formulating, justifying, improving long-term business planning processes and establishing competitive advantage (Boynton and Zmud – Strategic Planning & Competitive Thrust).

Internal Integration. The extent that IS is used by the firm to facilitate information sharing and coordinate work activities within the organization (Doll and Torkzadeh – Vertical Integration & Horizontal Integration).

External Integration. The extent that IS is used by the firm to service and communicate with external constituencies, such as customers, suppliers, government agencies, research institutions, etc. (Doll and Torkzadeh – Customer Service).

Knowledge Scanning (KS)

Knowledge Scanning is defined as the organizational mechanisms that enable the firm to effectively identify and exploit relevant external and internal knowledge and technology. There are many activities that signify the existence of such a mechanism in an organization. An important dimension of Boynton and Zmud's (1994) conceptualization of firm's capability to absorb new knowledge is the IT-management-process, i.e., various routines and procedures that embody the pragmatic knowledge to foster appropriate IT use. Cohen and Levinthal (1990) suggest that absorptive capacity for new knowledge and technology is likely to be developed as a byproduct of routine R&D activities.

Employee training such as sending employees for advanced technical training, or encouraging them to monitor and read the technical literature in their areas of expertise, could be another important knowledge scanning activity (Cohen and Levinthal, 1994). Finally, inter-organizational learning activities, such as benchmarking of best practices, strategic alliances, and customer and supplier surveys may also serve as effective knowledge scanning activities (Levinson and Asahi, 1995).

Manufacturing Innovation Performance (MIP)

In their article describing the evolution of large scale manufacturing firms, Bolwjin and Kumpe (1990) noted that many large multinational firms have passed the efficiency, quality and flexibility phase. The ideal firm in the 1990s is the innovative firm that emphasizes uniqueness. Since the concept of innovation has both a content component and a process component (Wolfe, 1994), the conceptualization of manufacturing innovation in this paper will not only involve developing new products, but also creating new ways for customer service, shop floor management, and supply chain management (Cusumano, 1988).

Research Hypotheses

Swanson (1994) modified the dual core model of organizational innovation (Daft, 1978) by adding a third IS core as strategic linkage between the firm's technical core and administrative core, but the paper did not further elaborate how this IS core will actually function to improve organizational innovation. This paper proposes that use of IS can greatly facilitate the firm's knowledge scanning and exploration activities, which in turn impacts innovation performance (Corso and Paolucci, 2001).

In today's fast changing competitive environment, there's a strong need for easier and better knowledge sharing (Marshall, 1997). However, for many firms, a significant amount of organizational knowledge remains unmanaged, undiscovered, and unorganized, thus invisible to the firm when needed (Van den Hoven, 2001). Use of IS should greatly help the firm's knowledge management processes. Studies show that implementation of information technology can significantly enhance the knowledge workers and workforce learning (Gaimon, 1997). In fact, when the IS is fully integrated with the entire enterprise system, it becomes an organizational memory IS (Wang, 1999) that serves as a cumulative knowledge repository for the firm (Hackbarth and Grover, 1999). Therefore, it is hypothesized that:

Hypothesis 1: Firms with higher levels of IS usage will have higher levels of knowledge scanning.

Manufacturing innovations do not happen overnight. It requires years of learning and knowledge accumulation. There is consensus among researchers and practitioners that organizational learning is a key variable that drives innovation (Stata, 1989; McKee, 1992). Knowledge scanning and exploration are critical components of organizational learning. Empirical studies have shown that firms with higher levels of absorptive capacity, i.e., the capability to exploit and assimilate external knowledge and information, are typically more effective in new product development (Cohen and Levinthal, 1990). A survey study by Tsai (2001) also found that an organization unit's absorptive capacity has significant positive impact on its innovation performance. McGrath (2001) study of 56 new business development projects again confirmed that higher level of knowledge exploration is positively related to higher adaptation and innovation capacity. It is therefore hypothesized that:

Hypothesis 2: Firms with higher levels of knowledge scanning will have higher levels of manufacturing innovation performance.

RESEARCH METHODOLOGY

In this section, research methods are described for survey instrument development and hypothesis testing. The instrument development process for IS Usage (ISU), Knowledge Scanning (KS) and Manufacturing Innovation Performance (MIP) included several phases: item generation, pre-pilot study, pilot study, and large-scale data collection and analysis.

A comprehensive literature review was completed to define the constructs and identify an initial list of items. To improve content validity, a pre-pilot study was completed that involved structured interview with four manufacturing managers and six academic experts. The interview results were carefully analyzed and a common pattern of thinking was recognized, which formed the basis for further revision of the research constructs and measurement items. A pilot study was then completed by surveying senior manufacturing managers. The study provided valuable preliminary information about the reliability and validity of the measurement scales. It also gave a final opportunity to purify the scales. The final version of the questionnaire was administered through large-scale mailing to 2831 manufacturing managers who were randomly selected from SME's U.S. membership database. There were a total of 320 responses from the mailings, of which 303 were complete and usable.

Assessment of Measurement Properties

Tests of unidimensionality, discriminant validity, and reliability are important for establishing construct validity (Sethi and King, 1994). The assessment of these measurement properties will be discussed for ISU, KS and MIP.

Information Systems Usage (ISU)

The Information Systems Usage (ISU) construct was initially represented by four dimensions comprising 25 items in the large-scale survey, including Operational Decision Support (ODS) (4 items), Strategic Planning Support (SPS) (5 items), External Integration (EXI) (9 items), and Internal Integration (INI) (7 items).

Initial reliability analysis for each of the four ISU dimensions showed that the Corrected Item-Total Correlation (CITC) scores for all items were above 0.50. However, the "Alpha if deleted" score indicated that removing EXI1 would improve reliability of EXI dimension. Thus item EXI1 was dropped at this stage. Factor analysis of the INI dimension revealed two factors (Factor 1: INI1, INI2, INI3, INI6, INI7 and Factor 2: INI4, INI5). Referring to the contents of each item, Factor 2 does not make too much theoretical sense. It was thus decided that items INI4 and INI5 be removed.

The remaining 22 ISU items were submitted to construct-level exploratory factor analysis to check for discriminant validity of the measurement instrument. Four factors emerged from the factor analysis with all factor loadings above 0.50 and most above 0.60. Serious cross-loading occurred on item INI7. Hence item INI7 was dropped. Finally, construct-level exploratory factor analysis was done again. This time four clear factors emerged with all items loaded correctly on the expected dimensions. Most factor loadings were above 0.60. No cross-loading was observed.

Knowledge Scanning (KS)

KS was conceptualized as have a single dimension and 7 items. Reliability analysis showed satisfactory Alpha score of 0.80. CITC scores for all items were above 0.50 except KS7 (We seek to learn from conducting R&D activities) with a CITC score of 0.48, slightly below 0.50. Considering the importance of item KS7 to this construct, KS7 was retained. To ensure unidimensionality of the 7 items, exploratory factor analysis was performed and one single factor emerged with all factor loadings close to or over 0.70.

Manufacturing Innovation Performance (MIP)

The MP construct was conceptualized as having one dimension and 5 items. Reliability was good with an Alpha score of 0.78. CITC scores are all above 0.50. To ensure the discriminant validity of the five items, an exploratory factor analysis was performed using all 5 items that measure MIP. One clear factor emerged with all factor loadings above 0.70.

Hypotheses Testing Results

To check for the preliminary statistical validity of the two hypotheses, the Pearson correlation coefficients of the two hypothesized relationships were calculated using a composite score for ISU, KS and MIP. The composite scores were computed by taking the average score of all items in a specific construct. The results are presented in Table 1. More rigorous hypotheses testing using LISREL structural modeling can be done at a later stage.

Hypothesis 1, which claims that organizations with high-levels of ISU have high-levels of KS, is supported by the correlation analysis. The Pearson correlation coefficient is 0.561, which is statistically significant at the 0.01 level. Hypothesis 2, which states that KS will have a direct positive impact on MIP, is also supported. The Pearson correlation coefficient is 0.473, which is also statistically significant at the 0.01 level.

DISCUSSION AND CONCLUSION

As Swanson (1994) pointed out, the existing literature regarding the role of IS in innovation is both fragmented and limited. Dodgson (1993) also noted that the impact of recent technology on the processes and outcomes of organizational learning provide fertile ground for future research. This study is possibly one of the first large-scale empirical efforts to investigate and measure ISU and to examine its impact on the firm's knowledge exploration capacity and manufacturing innovation performance. Measures for ISU, KS and MIP were developed through very carefully designed large-scale data collection process and rigorous instrument validation methods. The content domain of the constructs has been covered adequately because care was taken during item generation. The instruments exceed generally accepted validity and reliability standards for basic research. The resulting instrument can be widely used in future research, and they should facilitate interdisciplinary studies in IS management and manufacturing management. The instruments can also be used as a valuable tool for practitioners to evaluate their firm's level of ISU, KS and MIP.

The results of this study show that ISU has a positive and statistically significant effect on KS. It indicates that extensive use of IS at various levels and functional areas of a firm is indeed a valid way to facilitate knowledge exploration and organizational learning. Advanced information systems, especially web-base systems, offer extremely powerful and flexible tools for storing, organizing, processing and retrieving complex knowledge and information. The results also confirmed the positive relationship between KS and MIP. The ability to scan the environment for new knowledge and ideas enhances the individual and organizational knowledge base and thus increases the opportunity for innovation success.

Downs and Mohr (1976) criticized innovation research for instability in empirical findings. Damanpour (1991) challenged the "instability" argument and suggested a contingency approach by evaluating the moderating power of various moderators. Future research can examine the proposed relationships in a contingent manner by incorporating some contextual variables such as environmental uncertainty level, industry type and size of the firm. It will also be interesting to further examine the differing impact of the four sub-dimensions of IS usage on knowledge scanning and manufacturing innovation.

Table 1: Construct Level Correlation Analysis Results

Hypothesis	Independent Variable	Dependent Variable	Pearson Correlatio
H1	Information Systems Usage (ISU)	Knowledge Scanning (KS)	0.561**
H2	Knowledge Scanning (KS)	Manufacturing Innovation Performance (MIP)	0.473**

** Correlation is significant at the 0.01 level

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