The Impact of Industrial Characteristics and Organizational Climate on Knowledge Management Process and Business Innovation Performance

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Abstract

The aim of this paper is to examine how bioscience industry exploits KMS to effectively manage intellectual property, especially patent documents. A majority of Taiwan's bioscience firms are small and medium-sized start-up companies that possess many valuable intellectual property and patents/licenses. Nevertheless, due to lack or distortion of information, they are more likely to be charged of patent infringement by overseas companies who own the invention or technology. Four constructs are developed in this research: KMS, business innovation performance, and Bio-KMS benefits. Seven propositions are developed.

Keywords: Knowledge management system (KMS), Knowledge management process (KMP), Business innovation performance (BIP), Organizational context factors

1. Introduction

1.1 Research Background and Motivation

Biotechnology industry has grown rapidly since 1978. Nowadays it has become the focus of high-tech development for developed countries. With the decoding of human genome maps, which have brought about tremendous revolution for the development of medicine, pharmacy, agriculture, and food, the profit incurred is so immense that attracts a great number of countries to invest capital in the industry. It is estimated that the capital amounted to US$$228 hundred million dollars in biotechnology and pharmaceutical industry (Biotechnology and Pharmaceutical Industries Program Office, 2004), which is the highest capital that has ever invested over the last decades.

A large majority of Taiwan's biotechnology firms are small and medium enterprises, with its capital less than 5 hundred million dollars, and employees under 50 people. Nevertheless, these firms possess a wide variety of research and development discoveries, legal property rights and patents. Biotechnology is R&D oriented, not production-oriented, In particular, biotechnology firms are competitive advantageous only by knowing how to acquire, accumulate, and make effective use of knowledge in the face of competitive global markets (Leonard, 1995; Whitehill, 1997).

As Liebowitz (2000) points out in his research, managers believe knowledge assets or intellectual capital is the most important asset to separate their firms from other competitors. Alavi & Leider (2001) posit that knowledge is intangible asset. The knowledge-based perspective, which was expanded from previous literature [28], refers to the firms' know-how rendered by tangible resources through coordination. The organizational knowledge is carried out through multiple forms/entities, including organization culture and identity, routines, policies, systems, and documents, as well as individual employees [1][11][12][20]. Because knowledge-based perspectives are difficult to imitate or duplicate, and will be able to produce long-term sustainable competitive advantage [20]. Meanwhile, they further posit that information technology is a force to effectuate the knowledge-based perspectives of the firm [1][4][21]. Advanced information technologies, such as the Internet, intranets, extranets, browsers, data warehouse, data mining techniques, and software agents, can be used to systemize, enhance, and expedite knowledge management [1][14].

Previous studies have shown that organizational context is a determinant of the implementation of organizational knowledge management processes or systems [24][32][38]. Nevertheless, due to the scarcity of empirical research on hand, this paper attempts to examine the behavior and influence of organizational context factors on knowledge management and knowledge creation.

1.2 Research Purpose

Over the past few years, there is an increasing interest in organizational context, organizational knowledge management processes, KMS effect, and business innovation performance in the study of knowledge management processes and organizational informatics technology, yet the availability of evidence is not well explained. The purpose of this paper is stated as follows:

1. To examine whether organizational context has positive impact on the firm's improvement of knowledge management processes.
2. To examine whether the implementation of knowledge management processes has positive impact on the firm's 'innovation performance'.
3. To examine whether the effect of Bioinformatics management systems enables the knowledge management

activities and promotes the firm's innovation performance.

2. Literature Review

2.1 Industrial Characteristics

Prior literature has been focusing on the market structure and business sectors. Market structure consists of industry concentration, market share, entry barriers, profits, growth, labor and knowledge intensity, firm size and so forth. In terms of industry concentration, Schumpeter (1950) postulates higher market concentration enables enterprises' R&D and innovation. In 1967, Camanor posited that when there is not little discrepancy between products, concentration of industry has positive impact on the firm's R&D activities. In contrast, Angelmar (1985) asserts the reverse opinion. On the other hand, Levin et al. (1985) postulate that industrial concentration and research expenditure are in U-form relationship. In terms of entry barrier, Schumpeter (1950) asserts that firms with higher barriers to entry into markets will not have new competitors emerging, and will proactively doing R&D to sustain competitive advantage.

The term 'Biotechnology' became popular in the mid 1970th, and the word was coined the start-ups in the early part of the 20th century. In Taiwan, the word is just in the stage of naming the uprising technologies. The term 'Biotechnology' comes from 'Bio' and 'technology', meaning 'biological science when applied especially in genomic engineering and recombinant DNA technology'.

Biotechnology is a synthetic technology comprising of natural science and engineering, and requires multiple techniques and research for product improvement or research. Oakey (1993) points out small-sized firms often create key techniques, and government should provide funding to ensure they have long-term research resources. When the new techniques have the protection of patents, government should enact a law to protect the product rights. With the liberalization of trade (Gibbs, 2000), which creates a large free trade market, products not only earn a high rate of return, but also a long product life cycles. Nevertheless, bioscience products are strongly related to our health, and require non-compromised quality control, a strict regulatory governance and supervision of nation's government. In a word, biotechnology is a technology-intensive, integrate, and multi-dimensional knowledge industry [13].

2.2 Organizational Climate

Organizational climate helps management understand employees' conduct and performance, and foster the effectiveness of management (Litwin & Stringer, 1968). In other words, climate can be thought of as a reflection of organizational and individual attributes. Previous studies in the study of informatics supplemental to organizational innovation have observed that a successful IT system not only has to be functional, but also concern the effect of organizational climate. As a result, organizational climate plays a dominant role in information and resource management [15].

Moreover, it is an important factor in organizational learning [9][10][14][24][32]. As tacit knowledge interacts with explicit knowledge to generate a knowledge spiral [30], the organizational climate will motivate individual's creativity, throughout the three levels, individual, work unit, and organizational levels, and creates an innovative climate. To make this happen, organizations will create a climate or culture for innovation, and support innovative activities with reward systems [30]. In other words, organizational structure, culture, and context factors affect information resource management [10][15], even the organizational innovative activities [1]. In this paper, we choose 'organizational structure', 'innovation and reward system', and 'management style' as the analytical model of this study.

2.2.1. Management Style

In principle, the traditional management style can be divided into two kinds: "up-down management" and "bottom-up management". They were firstly proposed by Max Weber and Frederick Wilson Taylor, and developed by Herbert Simon. The role of top management in 'up-down management' is the providers of concepts within the organization. The task of middle managers is to justify these emerging concepts and define the mission. Group members at the bottom level obey middle managers' policy and carry out the task. On the other hand, "bottom to up management" emphasizes autonomy; in other words, knowledge creation is no longer dependent upon top management, but upon employees. The formation of organizational business 'vision' and 'concepts' are not totally stated by top management; instead, it is given to employees who are self-contained at work. Nevertheless, these opposite management styles are not without problems. Nonaka and Takeuchi (1995) point out respective drawbacks. Up-down management is suitable for handling explicit knowledge. Top management level easily overlooks the real value of tacit knowledge inherent in the bottom level. Hence, this type of management style can only be used in combination (from explicit knowledge to more complex set of explicit knowledge) and internalization (from explicit knowledge to tacit knowledge) process. Bottom-up management, in contrast, is suitable for handling tacit knowledge. Nevertheless, overemphasis on individual autonomy and lack of interaction among individuals hinder the dissemination and sharing of knowledge within an organization. Hence, bottom-up management style only encompasses socialization (from tacit knowledge to more complex set of tacit knowledge) and externalization (from tacit knowledge to explicit knowledge) of knowledge conversion.

2.2.2. Organizational Structure

Nonaka and Takeuchi(1995) propose 'hypertext organizational structure' that offer solutions for

organizations in data mining, knowledge creation, discovery and accumulation through a cycle of the socialization-externalization-combination-internalization patterns, converting tacit knowledge into explicit knowledge, and then reconverting it into tacit knowledge.

Hypertext organizational structure combines the advantages of 'hierarchical structure' and 'task force', and enables knowledge to be dynamically transferred at various levels. In a hierarchical structure, tacit and explicit knowledge are internalized and combined to generate novel knowledge, which can be queried, accumulated and implemented in the knowledge creation process. In the task force structure, in contrast, tacit and explicit knowledge are socialized and externalized to generate the new knowledge. In terms of job responsibilities of each layer, the business system layer of hypertext organizational structure mainly processes (through internalization) and systemizes (through socialization) knowledge; project team layer conceptualize (through externalization) and socializes (through socialization) knowledge; knowledge-base layer mixes knowledge of all layers, re-classify it and organize it, and converts it into new knowledge useful to the entire organization. In a word, hypertext organizational structure is ideal for continual innovation.

2.2.3. Reward System

Another important factor of organizational context is reward system. The role it plays in the organization is significant and fundamental to the work performance. Since the time of Hawthorne's studies (1923-1932), behavioral science has been applied to understand, explain or predict human's behaviors in an organization, and made great contributions to the study of individual's behaviors. At that time, the Hawthrone's studies showed that job satisfaction, rewards, teamwork and motivation occurs at affiliation, esteem, and self-actualization levels, not just security, physiological levels, recognition, security and sense of belonging, self-actualization, informal groups within the work plant exercise strong social controls over the work behaviors and attitudes of the individual worker, and communication channels cover both logical/economic aspects of an organization and feelings of people. Meanwhile, many scholars investigated the factors for the contributions and sharing of organizational knowledge, and also discovered reward system is important to the organizational activities [10][24][32]. These factors (rewards, social and psychological) strongly affect organizational individuals' support to the knowledge management activities, and willingness to participate in the knowledge sharing and creation (Alavi, 1999; Davenport et al., 1998).

2.3 Knowledge Management Process, KMP

Knowledge assets have become one of the most important assets in today's enterprises. The transformation of knowledge into assets relies on knowledge management processes. Nonaka (1994) explicates two kinds of knowledge in organizations: explicit and tacit knowledge. Explicit knowledge is easier to explicate, so knowledge can be externalized in the form of documentation. On the other hand, if tacit knowledge is to be made explicit, then it must be extracted through socialization [28].

Nevertheless, knowledge is created and held not by an organization itself, but by individuals; it can be disseminated through individual's interactions, sharing and learning. Huber (2001), having compiled studies on the topic of KM and organizational learning, develops four constructs: knowledge acquisition, information distribution, information interpretation, and organization memory. Nonaka and Takeuchi (1995) also propose 'Organizational Knowledge Creation Theory' for knowledge creation process. Alavi and Leidner (2001) having drawing on studies over the past few years, state that IT plays a crucial role in KM, since IT tools (such as Internet, data warehousing, data mining, and so forth) can systemize, increment, and facilitate KM within and outside the organizations to a great extent. Based on prior literature in the study of organizational management process, Alavi develops a framework that classifies socially enacted knowledge process into four sets: (1) creation, (2) storage/retrieval, (3) transfer, and (4) application [31]. These four sets of knowledge processes will be explained in the following section.

2.3.1. Knowledge Creation

Organizational knowledge creation, as referred by Pentland (1995), involves developing new knowledge or replacing existing knowledge within the organization's tacit and explicit knowledge. Knowledge is created, shared, amplified, enlarged, and justified through social activities [27]. As a consequence, knowledge creation is divided into four modes: socialization, externalization, internalization, and combination [27]. In order to speed up the process of knowledge transfer and creation, four types of "ba" are identified in support of knowledge conversion: (1) Originating ba, (2) Interacting ba, (3) Cyber ba, (4) Exercising ba [29]. Nonaka and Konno (1998) suggest awareness of the characteristic of each ba can facilitate successful support of knowledge creation, when the organization has a better understanding of how each ba is formed. For instance, the use of on-line networks enhances interacting ba. In interacting ba, group support systems, email, or information systems supplemental to joint activities between individuals increase knowledge creation [29].

2.3.2. Knowledge Storage/Retrieval

Past studies have shown that organizations create knowledge, but they also forget [2][8][36]. Thus, storage of the organizational knowledge is also referred to as organizational memory [33][35][36]. Organizational memory is stored in various forms, such as human brains, written documentation, electronic mail, structured information in databases, expert systems, and

organizational procedures [34]. Advanced computer storage technology and query languages effectively enhance knowledge storage and efficiency of data retrieval, so that the work can be done at any time and any place.

2.3.3. Knowledge Transfer

Knowledge transfer is a much important element in KM, since innovation comes from this part [21]. Knowledge transfer occurs at various levels; it can occur between individuals, from individual to groups, between groups, across groups, and from the group to the organization [1][36]. Nevertheless, knowledge transfer requires transmission channels for distribution, such as communication and information flows. Knowledge flows mainly consist of five elements: (1) perceived value of the source unit's knowledge, (2) willingness to share knowledge, (3) existence and richness of transmission channels, (4) willingness to acquire knowledge from the source, and (5) the ability to acquire, assimilate, and use knowledge [6]. Previous literature has been focused on the third element. Moreover, knowledge transfer can be formal and informal (Holtham & Courtney 1998).

2.3.4. Knowledge Application

Knowledge must be applied to the management activities in the organizations to achieve optimal effects. Grant (1996) identifies three mechanisms in coordinating specialized knowledge: (1) rules and directive, (2) routine, and (3) self-contained task team (Grant, 1996).

In addition, Yang & Wan (2004) identify four types of knowledge management activities: (1) Discovery and Creation. Existing knowledge developed from experience is turned into new knowledge and experience utilizing induction and analysis techniques. (2) Collection and Codification (codification of tacit or explicit knowledge, and documentation), (3) Storage. Knowledge is videoed, and categorized according to organizational structures. (4) Dissemination and Application. Knowledge is properly disseminated through IT tools to appropriate individuals. In order to retain the organization's tacit and explicit knowledge, a better understanding of knowledge collection and codification is required. Knowledge mining / extraction is one of the key points in today's knowledge management [21][36].

2.4 Business Innovation Performance, BIP

Previous studies have shown that a majority of senior IT managers consider creativity and innovation as the most important tasks in IT management [7][22][25], since it is the prerequisite for a manager having the ability to transform individual knowledge into organizational resource, and manage intellectual assets (Sunassee & Sewry, 2002). Drucker (1993) postulates that innovation is not only a process, but also a combination of innovative elements including incongruity, the unexpected, innovation based on process need, changes in industry structure or market structure, demographics, changes in perception, mood, and meaning, and new knowledge. Other studies have identified business innovation in four perspectives: resource-based, economic, industrial and revolutionary, and historic perspectives.

Business innovation refers to the change of organizational resource output, and the activities that are innovative and may bring profits to the firm (Souder, 1988). Business innovation can also refer to a series of innovative representation or activities contributory to resource output through interactions with/between individuals, groups or organizations (Gattiker & Larwood, 1990). Hence, both internal and external forces drive business innovation. The nature of business innovation includes techniques, product and process innovation. Organizational climate, in particular, involving good training, motivation of innovative organizational culture and systems, drives organizational innovation and performance (Rosenbloom & Cusumano, 1987). Hence, business innovation performance can be measured in two perspectives: customer-oriented and resource-oriented. The customer-oriented performance includes reports or publication of patent documents, ratio of patents approved, product comparison with competitors, market share, and so forth (Moser, 1985).

2.5. Techniques and Benefits of Knowledge-oriented Bioinformatics Systems

With the ever increasing quantity and complexity of biological data that is submitted, it is becoming more and more important for a firm's knowledge workers to know how to transfer it into knowledge in an effective way [4][14][24][27][28][32]. Kretschmann et al. (2001) discovers that the role of information technology in support of manual annotation has been shifted from knowledge storage and management (sequence analysis data) to knowledge-based management (automatic annotation, literature connection, and unannotated sequences). Baker (2001) also emphasize the important role algorithm plays in biological analysis, especially in genome sequencing annotation.

Previous literature has shown that information technology can be applied to optimizing the knowledge management. Hence, in the study of Bioinformatics, Bazzan et al. (2002), Kretschmann (2001) and King et al. (2000a, 2000b) use the decision trees approach of a standard data mining algorithm and databases support traditional manual annotations automatically. Rules generated from the data-mining algorithm helps detect inconsistencies in the manually generated annotations. They also suggest Bioinformatics can be applied to a more extensive data analysis approaches (such as expression profiles, pathway analysis) utilizing advanced computation-supported tools, such as knowledge maps, knowledge extraction, knowledge elicitation, ontology, EIP (Enterprise Information Portal), video-conferencing, grid computing, E-mail, groupware, mobile communication, content management, information discovery, text/data mining, collaboration, knowledge

discovery [1][4][34][36]. Supplementary technological potential should cover people and technology and relationship models in different contexts (inside of an organization, teamwork and processes [36].

Evidence of extant literature discussed in the previous section shows biological data is increasingly complex such that IT applications evolve in a new age of knowledge transformation (explicit to tacit). In the knowledge transfer process, more advanced and automated tools complementing existing applications are needed to assist knowledge workers in extracting knowledge, which is how the knowledge-based Bioinformatics is evolved. Bioinformatics is an enabler to sustaining an organization's competitive advantage and innovation. KPI (Key Performance Indicator) is a useful to evaluate the performance of Bio-KMS. KPI refers to a set of tools to measure, monitor and manage the quantitative and qualitative, or tangible or intangible organizational assets, such as the effectiveness, efficiency and sustainability of organizational force. It compares tangible and intangible profits against the costs of KMS implementation. Tangible profits refer to the net profit margin of product, memberships, advertising and services. Intangible profits, which are gauged by organizations beforehand, involve knowledge sharing, documents classification, competitions among individuals, and increase in efficiency. Top management will measure the item of job satisfaction of individuals. When each item is weighted, the figure will be converted into intangible assets. The percent of tangible and intangible profits against overall performance should be defined and agreed to beforehand by organizational managers.

3. Research Model and Propositions

3.1 Research Framework

With 'Organizational Context' and 'KM' as theoretical fundamentals, we develop a research model shown in Figure 1.

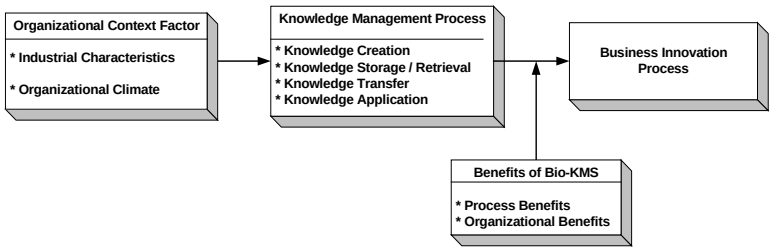

Figure 1. Research Model

This model consists of four constructs: organizational context factors, KMS, business innovation performance, and Bio-KMS benefits. Organizational context can be classified into industrial characteristics and innovation climate. KMS is divided into knowledge creation, storage/retrieval, transfer and application. Bio-KMS effects will be thought of having process and organizational improvements. This research model is developed in the attempt to examine:

1. The impact of organizational management process on organizational context.
2. The impact of BIP on organizational management process.
3. Bio-KMS is an enabler to improved organizational management process and business innovation performance.

3.2 Questions and Propositions

3.2.1. Correlation between Organizational Context and Knowledge Management Process

In view of the correlation between knowledge and context [24][32][36], Massey et al. (2002) believe that knowledge management processes produces utmost effects when applied to a specific fields (knowledge-intensive, or technology-intensive, in particular), new product development, for instance. Biotechnology industry, a highly knowledge-intensive industry, which requires both individual and groups competencies, has close relation to knowledge creation and SECI style. In addition, management style and organizational structure enables organizations to create knowledge. As a result, Nonaka and Takeuchi (1995) propose the most ideal environment for knowledge creation, middle-up-down management style, and hypertext organizational structure. Goodman and Darr (1998), on the other hand, suggest reward system is a driver for improved knowledge management, which influence organizational members' support for the knowledge management activities, and individual's willingness to participate in the knowledge sharing and creation [24][32]. Up to date, there has been little research on the relationship between reward systems and knowledge management processes hence, this study has developed following propositions that are stated below:

P1: Industrial characteristics have a positive impact on knowledge management processes.

P2: Organizational innovation climate has a positive impact on knowledge management processes.

3.2.2. Correlation between KMP and BIP

Purcell and Gregory (1998) indicate the development of business competency relies on knowledge acquisition and integration of internal knowledge. Meanwhile, Chattell (1998) postulates the firm's core competency must be developed through (1) instant knowledge acquisition, (2) knowledge screening and application, (3) knowledge regeneration, (4) knowledge applied to work, and (5) performance. He also emphasizes that the firm's core competency fosters business performance, enhances knowledge interpretation and acquisition fundamental to business operations. Nevertheless, there are still other elements that can be taken into consideration, for instance, the ability to predict and systems application. Grant (1996) posits the importance of commonality of specialized knowledge. The realization of commonality of

specialized knowledge relies on organizational learning and shared understanding of individuals.

Mansfield (1983) postulates innovation derives from absorptive knowledge of departments other than R&D Department. Liebowitz (2002) also addresses that knowledge sharing improves innovation. Hence, knowledge sharing, acquisition, and application are the core elements of innovation. Cohen and Levinthal (1990)、Nonaka and Konno (1998) and Yang & Wan (2004) agree that learning process and knowledge interpretation, accumulation, and expansion are not only crucial to organization's innovative capabilities, but also to the continual product and process improvement and competitive advantage [5]. In a word, knowledge development and accumulation have positive impact on innovation thus this study has developed the following propositions:

P3: Knowledge creation has a positive impact on BIP.

P4: Knowledge accumulation and retrieval have a positive impact on BIP.

P5: Knowledge transfer has a positive impact on BIP.

P6: Knowledge application has a positive impact on BIP.

3.2.3. Correlation between Bio-KMS and KMP and BIP

In humans, a gene contains 3,000 million bp (A, T, C, G-adenine, thymine, guanine and cytosine). The flood of genomic data is just like randomly scattered telephone directories, and the data was not organized. In 2000, when a human genetic map was created, the magnitude of data had to be analyzed, stored, organized, and converted into useful knowledge. The presence of Bioinformatics serves the need. Through the aid of Bioinformatics, these value-added incremental genome databases can provide research institutes, biotechnology firms, or pharmaceutical firms for further analysis [19][26].

Information technology is designed to process flood of data, integrate heterogeneous databases, analyze complex data, and makes data extraction a lot easier. In terms of knowledge management, conversion of explicit knowledge to tacit knowledge is one of the most important processes in knowledge management [14][22][24][27][28][32][36][37]. In the meantime, information technology expands its application from explicit knowledge storage and management to the transformation of explicit knowledge to tacit knowledge. The transformation characteristic is in the mainstream of Bioinformatics [28]. Based on the above rationale, this study has developed the following proposition:

P7: Process and organizational improvements foster knowledge management processes and enhance BIP.

3.3. Research Design and Tools

This paper aims to investigate the small and medium-sized biotechnology firms in Taiwan, adopting the organizational context, knowledge management process, bio-KMS effects and BIP as major constructs. According to Yin (1989), descriptive or exploratory research techniques only apply to case study analysis. Benbasat (1987) also postulates that case study approach only applies to the early stage of theories and research formulation. Hence, we will use case study as the approach, and interview members in biotechnology firms in the attempt to investigate the characteristics of knowledge innovation and management, and operations modes of these firms. Two biotechnology firms were selected. The business scope of Firm A is the R & D transgenic fish. Firm B is an R & D Chinese herbal medicine manufacturer.

4. Conclusion & Managerial Implications

4.1. Conclusion

We conclude has the following four conclusions:

1. Knowledge-Based Perspective. Both case study firms are knowledge-intensive industries. A very large percentage of people in the firm are R&D researchers, while marketing, accounting, laws and general assistants the next. These people have professional expertise, so they value information and knowledge very highly. Their information or knowledge, which conveys conceptual problems, solutions, even the experimental procedures, is mainly written in free-style, and is put in simple words. Meanwhile, knowledge stored in KMS is immediate information. To reduce the complexity of information, the information system will filter massive data according to the experiences (individual, work group, or organization) or business rules, and turn it into organizational knowledge as the reference for the practice of future project or experiments.

2. Technology-Based Perspective. Biotechnology firms give much attention to patents and IP rights, and searches for information such as genetic data, patents, prescriptions, even competitors' information become relatively essential. Hence, both case study firms employed information technology to assist KM processes implementation (knowledge creation, storage/retrieval, transfer and application), by which knowledge can be distributed among individual, group and organizational levels. The IT tools these two firms employed involve Internet (such as on-line database of patents /genetic data), databases (storage), data mining (gene mapping, decision making systems), and knowledge maps. With these tools, both firms not only systemize and codify information, but also enhance knowledge sharing and R&D and innovation capabilities.

3. Climate-Based Perspective. In addition to information source and information technology, organizational climate is also an essential element for effective use of knowledge. After the implementation of knowledge management process and KMS, both firms started to re-design the existing organization structure and culture. Top management delivered the importance of knowledge management, and included it as one of the important strategic activities within the organization. In

the organizational structure, the firm organized a task force team, in which team members are selected from all departments to achieve high-quality development in new products. When the project is completed, they return to respective departments, and distribute the knowledge and experiences generated from the finished R&D project to others. The taskforce team with top managers heading the project team shortens the response time and distance between team members and managers, and facilitates knowledge creation and information flow. The firms created a supportive or nurturing environment which motivates employees to communicate with others. Further, the firms use incentive plans or rewards as mechanisms to encourage employees to share knowledge and experiences with others. Through individuals' learning, communications, and establishment of patents, organizational knowledge accumulates and the spirit of teamwork is enhanced.

4.2. Managerial Implications

1. The use of KMS enables knowledge-intensive industries to improve business innovation competence.
2. The implementation of KMS helps a firm establish its unique knowledge assets and overcome the brain drain of professional personnel.
3. Previous literature and empirical studies in this paper shows that 20% of the topics concern information technology, while 80% of the topics are concentrated on organizational context. In other words, when the organization deems knowledge the most important intangible assets of the firm, it should start reforming the existing organizational structure, culture in compliance with the industrial characteristics and market structure. More importantly, it is suggested that the set up of an environment that supports knowledge sharing and transfer will play an important role. Under the supportive environment employees would love to share and communicate, which improves the knowledge innovation and transfer and corporate competence.

References

[1] Alavi, M. and Leidner D. E. "Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues," *MIS Quarterly*, 2001, 25(1), pp 107-136.

[2] Argote, L., Beckman, S. and Epple, D. "The Persistence and Transfer of Learning in Industrial Settings," *Management Science*, 1990, 36, pp. 1750-1763.

[3] Bazzan, A., Engel, P. M., Schroeder, L. F. and da Silva, S. C. "Automated Annotation of Keywords for Proteins Related to Mycoplasmataceae Using Machine Learning Techniques," *Bioinformatics*, 2002, 18, pp. 35-43.

[4] Chou, D. C. and Lin, B. "Development of Web-Based Knowledge Management Systems," *Human Systems Management*, 2002, 21(3), pp. 153-158.

[5] Chuang, S. H. "A Resource-Based Perspective on Knowledge Management Capability and Competitive Advantage: An Empirical Investigation," *Expert Systems with Applications*, 2004, 27(3), pp. 459-465.

[6] Cohen, W. M. and Levinthal, D. A. "Absorptive Capacity: a New Perspective on Learning and Innovation," *Administrative Science Quarterly*, 1990, 35(1), pp. 128-152.

[7] Couger, J. D. "Key Human Resource Issues in the 1990s: Views of IS Executives versus Human Resource Executives," *Information & Management*, 1988, 14(4), pp. 161-174.

[8] Darr, E. D., Argote, L. and Epple, D. "The Acquisition, Transfer and Depreciation of Knowledge in Service Organizations: Productivity in Franchises," *Management Science*, 1995, 41(11), pp. 1750-1613.

[9] Goodhue, D. L., Quillard, J. A. and Rockart, J. F. "Managing the Data Resource: a Contingency Perspective," *MIS Quarterly*, 1995, 12(3), pp. 373-391.

[10] Goodman, P. S. and Darr, E. D. "Computer-Aided Systems and Communities: Mechanisms for Organizational Learning in Distributed Environments," *MIS Quarterly*, 1998, 22(4), pp. 417-440.

[11] Grant, R. M. "Prospering in Dynamically-Competitive Environments: Organizational Capability as Knowledge Integration," *Organization Science*, 1996a, 7(4), pp. 375-387.

[12] Grant, R. M. "Toward a Knowledge-based Theory of the Firm," *Strategic Management Journal*, 1996b, 17, Winter Special Issue, pp. 109-123.

[13] Hsieh, C. T., Yang, H. and Lin, B. "Roles of Knowledge Management in Online Procurement Systems," *Industrial Management & Data Systems*, 2002, 102(7), pp. 365-370.

[14] Huber, G. P. "Transfer of Knowledge in Knowledge Management Systems: Unexplored Issues and Suggested Studies," *European Journal of Information Systems*, 2001, 10(2), pp. 72-79.

[15] Jain, H. Ramamurthy, K., Ryu, H. S. and Yasai-Ardekani, M. "Success of Data Resource Management in Distributed Environments: An Empirical Investigation," *MIS Quarterly*, 1998, 22(1), pp. 1-29.

[16] King, R.D., Karwath, A., Clare, A. and Dehaspe, L. "Genome Scale Prediction of Protein Functional Class from Sequence Using Data Mining. In Ramakrishnan, R., Stolfo, S. & Bayardo, R. (eds)," *The sixth ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*. The Association for Computing Machinery, New York, 2000a, pp. 384-389.

[17] King, R.D., Karwath, A., Clare, A. and Dehaspe, L. "Accurate Prediction of Protein Functional Class from Sequence in the Mycobacterium Tuberculosis and Escherichia Coli Genomes Using Data Mining," *Yeast Comparative and Functional Genomics*, 2000b, 17(4), pp. 283-293.

[18] Koh, J. and Kim, Y. G. "Knowledge sharing in virtual communities: an e-business perspective," *Expert Systems with Applications*, 2004, 26(2), pp. 155-166.

[19] Kretschmann, E., Fleischmann, W. and Apweiler, R. "Automatic Rule Generation for Protein Annotation with The C4.5 Data Mining Algorithm Applied on SWISS-PROT," *Bioinformatics*, 2001, 17, pp. 920-926.

[20] Liebowitz, J. *Addressing the Human Capital Crisis in the Federal Government: A Knowledge Management Perspective*; Butterworth-Heinemann Business Books / Elsevier (Knowledge Management Series), 2004.

[21] Liebowitz, J. "Facilitating Innovation through Knowledge Sharing: A Look at the US Naval Surface Warfare Center-Carderock Division, Special Issue on Knowledge Management in E-Commerce," *Journal of Computer Information Systems*, 2002, 42(5), 1.

[22] Liebowitz, J. *Building Organizational Intelligence: A*

Knowledge Management Primer. CRC Press, Boca Raton, FL, 2000.

[23] Lin, C., Hung, H. C., Wu, J.Y. and Lin, B. "A Knowledge Management Architecture in Collaborative Supply Chain," *Journal of Computer Information Systems*, 2002, 42(5), pp. 83-94.

[24] Massey, A. P., Montoya-Weiss M. M. and O'Driscoll, T. M. "Knowledge Management in Pursuit of Performance: Insights form Nortel Networks," *MIS Quarterly*, 2002, 26(3), pp. 269-289.

[25] Niederman, F., Brancheau, J. and Wetherbe, J. "Information Systems Management Issues for the 1990s," *MIS Quarterly*, 1991, 15(4), pp. 475-500.

[26] Nowak, R. "Entering the Post Genome Era," *Science*, 1995, 270, pp. 368-371.

[27] Nonaka, I. "A Dynamic Theory of Organizational Knowledge Creation," *Organization Science*, 1994, 5(1), pp. 14-37.

[28] Nonaka, I. *The Knowledge-Creating Company*, Harvard Business Review, 1995.

[29] Nonaka, I. and Konno, N. "The Concept of 'Ba': Building A Foundation for Knowledge Creation," *California Management Review*, 1998, 40(3), pp. 40-54.

[30] Nonaka, I. and Takeuchi, H. *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*. Oxford Univer-sity Press, New York, 1995.

[31] Pentland, B. T. "Information Systems and Organizational Learning: The Social Epistemology of Organizational Knowledge Systems," *Accounting, Management and Information Technologies*, 1995, 5(1), pp.1-21.

[32] Schultze U. and Leidner, D. E. "Studying Knowledge Management in Information Systems Research: Discourses and Theoretical Assumptions," *MIS Quarterly*, 2002, 26(3), pp. 213-242.

[33] Stein, E. W. and Zwass, V. "Actualizing Organizational Memory with Information Systems," *Information Systems Research*, 1995, 6(2), pp. 85-117.

[34] Wagner, W. P., Chung, Q. B. and Najdawi, M. K. "The Impact of Problem Domains and Knowledge Acquisition Techniques: a Content Analysis of P/OM Expert System Case Studies," *Expert Systems with Applications*, 2003, 24, pp. 79-86.

[35] Walsh, J. P. and Ungson, G. R. "Organizational Memory," *Academy of Management*, 1991, 16(1), pp. 57-91.

[36] Yang, J. T. and Wan, C. S. "Advancing Organizational Effectiveness and Knowledge Management Implementation," *Tourism Management*, 2004, 25, pp. 593-601.

[37] Yim, N. H., Kim, S. H., Kim, H. W. and Kwahk, K. Y. "Knowledge Based Decision Making On Higher Level Strategic Concerns: System Dynamics Approach," *Expert Systems with Applications*, 2004, 27(1), pp. 143-158.

[38] Zack, M. H. *Developing a Knowledge Strategy. California Management Review*, 1999, 41(3), pp. 125-145.

"References available upon request from Li-Ling Hsu"