Identifying the Relationship Between Knowledge Infrastructure, Knowledge Sharing and Innovation Capability: System Dynamics Approach

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ABSTRACT

In this research, we develop a conceptual model to explain the relationship between knowledge infrastructure, knowledge sharing (KS) and innovation capability, using system dynamics approach. This research is important since it will provide better understanding on what infrastructures are critical to support KS activities, and how KS will affect the capability of enterprise to innovate, and how the relationship dynamics occur among knowledge infrastructure, knowledge sharing, and innovation capability. The ultimate objective of this research is to understand how to improve the learning capabilities in order to develop KS activities in an organization.

Keywords

Knowledge infrastructure, knowledge sharing, innovation capability, system dynamics.

1.0 INTRODUCTION

One of the main goals of KM implementaion is to increase the innovation capability of enterprise through the optimization of knowledge management in the organization (Cong and Pandya, 2003; Anantatmula, 2005; Hall, 2005; Liao et al., 2007). Castells (2000) stated that KM initiatives play important roles in supporting the growth of enterprise, based on the arguments that enterprise growth depends on innovation, while innovation depends on the ability to implement and generate knowledge in the organization.

The most important aspect of KM is how to persuade people to participate in knowledge sharing by sharing what they know (Orr and Persson, 2003). Human capability factor in knowledge sharing has become very important because through sharing, knowledge can be disseminated, implemented and developed. On the other hand, sharing stimulates human to think critically and creatively; hence the capability of KS becomes one of the most valuable capital assets of an organization.

The improvement of enterprise's innovation capability through the development of KS activities needs to be managed and supported by appropriate facilities from the management. The key problem is that organization needs to understand and able to control KS activities in order to achieve the desired goals. The solution can be obtained only if the organization understands the knowledge infrastructure required to support KS activities.

The correlation between knowledge infrastructure, KS activities and corporate's innovation capability requires a complex and dynamic understanding. The existence of each variable has an interdependence relationship and influence with one another and forms a feedback mechanism. For instance, the knowledge infrastructure support will drive KS activities, and KS activities will eventually improve corporate's innovation capability. On the other hand, it can be said that an improvement on corporate's innovation capability will contribute to the improvement of the capability of the corporate's knowledge infrastructure. That illustration can imply that each of the components being explained has a feedback structure which forms a loop (closed-loop system), where the existing correlation is in fact not limited to the influence of the independent variables on the dependent variables (open-loop system), while each of the variables can interact with one another and form certain (interdependent) mechanism/behavior. Consequently, a discussion on the interaction and inter-relationship between infrastructre, its behavior and performace is needed. Eventually, this feedback structure can result in an important understanding on an effective and efficient policy design (Sushil, 1993).

2.0 LITERATURE REVIEW

2.1 Knowledge Infrastructure

Knowledge infrastructure is defined as a set of organizational apparatus aiming to facilitate the creation of an environment which enables employees to share their knowledge with one another intensively (Choi, 2002; Strohmaier, 2003). Pavesi (2003) suggested that knowledge infrastructure is a basic ability of organization or "preconditions" for an effective KM. Choi (2002) said that for a KS to be effective it requires support from knowledge infrastructure tools.

Pavesi (2003) wrote that knowledge infrastructure consists of technology, structure, and culture. Meanwhile, Strohmaier (2003) said that knowledge infrastructure consists of three main dimensions, namely: people, organizational and technological systems. Lin et al. (2002) classified knowledge infrastructure into *technological*, *organizational*, *cultural*, and *human resources*.

Knowledge infrastructure can be explained by its *socio-technical theory* (Pan and Scarbrough, 1998). This theory explains organizational support from both social and technical perspectives. Although these two perspectives are built independently, they will be interconnected to each other eventually. Social perspective focuses on the attributes of human (attitude, skill, and so on), relationship between human and organizational structure. Technical perspective focuses on the need for technology to transform input into output.

Based on the explanation above, the author suggests that knowledge infrastructure can generally be classified as: *organizational structure*, *people* and *information technology*, where the classifications are considered to provide explanation from either social or technological perspectives.

2.2 Knowledge sharing

Wah et al. (2005) stated that KS is a voluntary interaction between humans inside an organization or among organizations through a common institutional framework which covers law, ethics and norms, behavior, and basically contains knowledge.

Organizational knowledge is often classified as *tacit* and *explicit* (Nonaka and Takeuchi, 1995). Explicit knowledge is articulable, objective, and easy to modify. On the other hand, *tacit knowledge* is subjective and not easy to reveal (Nonaka and Takeuchi, 1995; Nonaka and Konno, 1998; Akamavi and Kimble, 2005). Table 1 describes the differences between *tacit* and *explicit* knowledge according to Keane and Mason (2006).

Table 1: Two types of Knowledge (Source: Keane and Mason, 2006)

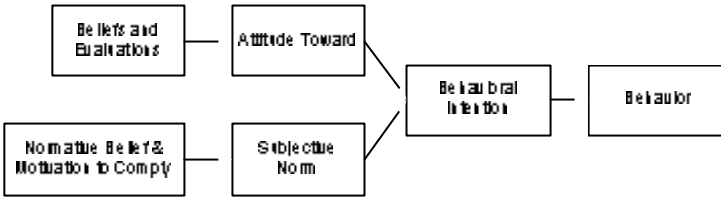
Tacit Knowledge	***Explicit knowledge***
Subjective	Objektive
Knowledge from experience (body)	Knowledge from rationality (mind)
Simultaneous knowledge (here and now)	Sequential knowledge (there and then)
Analog knowledge (practice)	Digital knowledge (theory)

KS types can vary according to the understanding of the knowledge itself (Hansen and Avital, 2005). However, in this paper we will classify KS into *tacit* KS and *explicit* KS.

KS is the behavior of exchanging knowledge by human. In order to understand the correlation between knowledge infrastructure and KS behavior, it is important to understand the fundamental factors of behavior. Ching-lin (2003) suggested that "*human's intention*" is the best predictor to behavior (i.e. KS behavior).

One of the most popular approaches in explaining and predicting someone's behavior is the *Theory of Reasoned Action* (TRA). TRA is the first widely accepted model in social psychology. TRA was designed to virtually explain human behavior, with ultimate goal to predict and understand individual's behavior (Ajzen and Fishbein, 1980; Bock and Kim, 2002).

TRA refers to the theory that human behavior is driven by two forms of belief; belief in the possible outcome of a behavior and in the evaluation of the outcome (*attitude*); belief in the normative expectations of others and the motivation to comply with those expectations (*subjective norm*). The basic idea is the more positive attitude and subjective norm one has, the stronger intention one has to conduct a behavior. Intention is assumed to be *antecedent* to actual behavior (Kankanhalli et al., 2006). The Theory of Reasoned Action model is presented in Figure 1.



management aspects, which are classified into *product innovation*, *process innovation*, and *management innovation*.

2.4 System Dynamics

System dynamics (SD) is a methodology to address certain problems which are complex. SD is suitable for either qualitative or quantitative researches. This model was proposed by Forrester in 1957 (Andersen et al., 2004). The basic idea is that dynamic behavior (its performance over time) is approaching a basic loop feedback structure (Cresswell et al., 2002; Andersen et al., 2004).

SD focuses on the dynamic system behavior. SD is a methodology to study and manage complex feedback systems in managerial, organizational, and socio-economic contexts. SD is the method to improve system learning. SD adopts holistic approach and helps understanding the basic structure of system and the resulting behavior (Osipenko and Farr, 2004).

Based on the explanation above, the author argues that SD methodology can be implemented properly in the context of this research. Since SD has the potential to explain a problematic system involving complex and dynamic interdependent relationship between components, it is therefore relevant to the nature of the problem presented in this research. Research framework developed focuses on the development of a model of qualitative system dynamics.

3.0 RESEARCH FRAMEWORK

The overall structure of conceptual model is presented in Figure 2. This model is developed from a broad range of literatures in KS field. Model constructs are developed from the relevant literature and studies. Each relationship presented in Figure 2 can be interpreted as follows: if dimension X increases, how will it affect dimension Y? Positive effect is represented by a plus sign (+) to denote there will be an increase on the target dimension. Negative effect is represented by a minus sign (-) to denote that there will be a decrease on the target dimension.

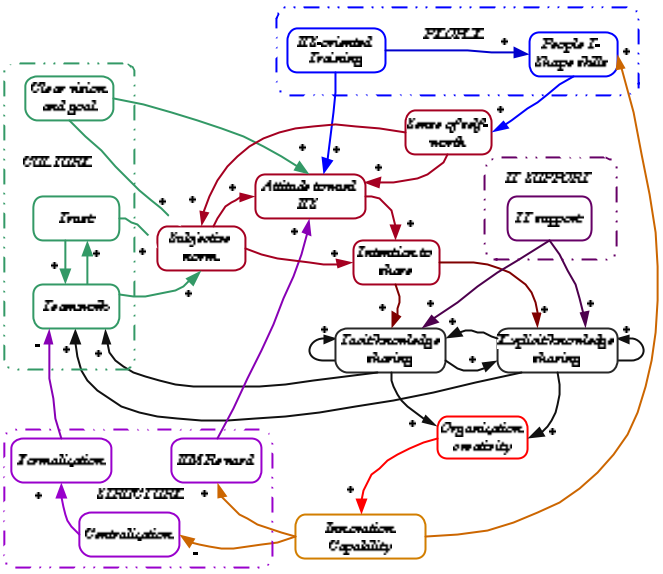


Figure 2 Knowledge Sharing Model Causal Structure

As can be seen in Figure 2, there are four major groups of constructs involved in the model, namely: organizational culture, organizational structure, people, information technology, factors of human behavior activator, Knowledge sharing, and innovation capability.

In the following section, each groups will be explained in more detail.

3.1 Organizational Culture

Culture is the normative glue which is a common agreement that unites the organization (Hughes, 1996). Culture determines individual's attitudes and subjective norms towards KS (Ching-lin, 2003; Bock et al., 2005; Hansen dan Avital 2005; Kwok dan Gao, 2005).

Trust and teamwork spirit among employees will enhance respect for each other, and in turn will improve subjective norms towards KS (Chin-lin, 2003). It can be said that *trust* and *teamwork* have positive influence on attitudes and subjective norms of an individual towards KS.

On the other hand, if one has trust for others, he or she will be willing to commit a teamwork, and this will motivate the employee to conduct KS (Brink, 2001). A culture of teamwork where people help each other in their work (Lee and Choi, 2003) will gradually develop trust among all members of organization. Here the existence of *trust* and *network* gives positive influence on one another.

Accordingly, clear organization vision and goal will drive employees' awareness and understanding of their roles and contribution, as well as their understanding of the benefits of KS (Kim and Lee, 2006). It can be concluded that clear organization vision and goal will have positive influence on attitudes and subjective norms of an individual towards KS.

3.2 Organizational Structure

Slund and Karlsson (2004) suggested that for an organization to have the capability to effectively manage and use information, it needs *non-hierarchical* communication channel and *non-centralized* organization structure. *Centralization* is considered to have negative impact on KS, since it will create further separable structures and will not motivate employees to face challenges (they tend to think for themselves and act autonomously). Consequently, in the transition to a knowledge-based economy, centralistic structure is becoming irrelevant (Castells, 2000; WP2 partners,2002). Centralization in an organizational structure will increase formalization and bureaucracy in the organization, and this will prevent the employees' freedom to interact with each other. In the era of knowledge, a structure with high degree of formalization and low bureaucracy is essential to drive cooperation in an organization (Brink, 2001). Based on this explanation we can see that higher level of centralization in the structure can result in a higher level of formalization in interaction, and higher level of formalization will in turn decrease the spirit of teamwork.

The existence of KM reward, or in other words recognition based on the knowledge, can affect the behavior of KS in an organization. Kim and Lee (2006) mentioned that a reward system gives a significant influence on employees' KS capability. On the other hand, Wah et al. (2005) argued that *reward* and *recognition* are the strongest factors in the creation of KS environment. This is understandable considering that all activities performed by employees are basically based on certain attitudes, it can be concluded that developing a KM reward system can motivate employees' positive attitude towards KS (Kwok and Gao, 2005).

3.3 People

For a KS to be effective, an organization needs to be supported by its members' skills in creating and sharing knowledge (Wah et al., 2005). Skills often associated with KM are the *T-shaped skills* (Wah et al., 2005). Furthermore, creating employee skills requires a process. Conducting knowledge-oriented trainings is an effort to prepare employees to acquire basic skills and positive attitudes required in KS (Lin Lu et al., 2006). KS-oriented training are expected to have positive influence on one's attitude towards KS. On the other hand, knowledge-oriented trainings are also expected to improve employees' KS skills.

Moreover, the more skilled one is, the more positive his or her sense of self worth in contributing to KS. Eventually, the higher confidence someone has to contribute to KS, the more positive his or her attitude and subjective norms towards KS (Bock et al., 2005).

3.4 Information Technology Support

IT support plays an important role in the success of KS, it functions to facilitate the knowledge flows in an organization (Chua, 2004). Kim and Lee (2006) suggested that IT applications give significant influence to the corporation's KS capability. The roles of IT have progressed rapidly; it originally served merely as a static data storage and now it is a connector of information flows among people. IT enables the processes of searching, accessing, and retrieving information quickly; as well as supports collaboration and communication among organization members (Alavi and Leidner, 2001; Lee and Hong, 2002). IT support is therefore expected to provide positive influence on KS behavior, both *tacit* and *explicit*.

3.5 Factors of human behavior activator (Subjective Norm, Attitude Toward KS and Intention to Share)

In the Theory of Reasoned Action (TRA), specific human behaviors are determined by their intentions. Intentions are driven by two forms of belief; belief in the possible outcome of a behavior and in the evaluation of the outcome (*attitude*); belief in the normative expectations of others and the motivation to comply with those expectations (*subjective norm*) (Kankanhalli et al., 2006). According to this perspective, we can conclude that the more positive attitude and subjective norms one has, the stronger his or her intention to share will be. Intention to share will in turn drive KS actual behaviors (Bock et al., 2005), in which these behaviors cover both tacit and explicit KS.

3.6 Knowledge Sharing Behavior

The type of KS behavior in this research will be described based on the form of interaction between tacit and explicit knowledge. Tacit knowledge is the knowledge attached to individuals and difficult to articulate or express, generally can only be shared through direct interaction. Explicit knowledge is the type knowledge that is objective and easy to articulate (for instance; document exchange, reports, procedures) (Nonaka and Takeuchi, 1995, Nonaka and Konno, 1998; Akamavi and Kimble, 2005).

Documented tacit knowledge will enhance explicit knowledge in the organization. On the other hand, implemented explicit knowledge in combination with individual knowledge will enhance tacit knowledge (Nonaka and Takeuchi, 1995). Hence, both tacit KS and explicit KS contribute to each other.

On the other hand, as the intensity of tacit and explicit KS grows higher, organizational teamwork spirit will improve gradually. We can conclude that KS activities have positive influence on the teamwork.

Next, the goal of KS is to create an environment in which innovative ideas can be captured, shared, and improved to become new knowledge; through interaction between existing knowledge and the change of the environment where the organization operate (W2P Partners, 2002). The main idea is how KS behavior aims to support employees to become more critical, intelligent, and creative (De Long, 1997; Liao et al., 2007). Based on the description above, we

can conclude that KS behavior (both tacit and explicit) will eventually have positive influence on innovation capability.

3.7 Innovation Capability

As we have discussed, corporation's innovation capability encompasses *product innovation*, *process innovation* and *managerial innovation* (Samson, 1991; Tsai et al., 2001; Liao et al., 2007). *Product innovation* is the corporation's capability to offer differentiation or new product/service to a market in order to provide satisfaction to their customers. Process innovation from the organizational perspective is the capability to produce a better manufacturing process or service than the existing ones. (Liao et al., 2007). Furthermore, innovation process is expected to reduce operational cost and improve productivity. Based on this explanation, it is understandable that corporation's capability in creating better processes over their existing ones, naturally will enhance employees' work skill.

Management innovation is corporation's capability to improve their performance through the implementation of new regulations, systems and managerial methods (Liao et al., 2007). Moreover, Tsai et al. (2001) explained that management innovation is corporation's ability to understand how to improve its managerial functions and mechanism in order to boost managerial efficiency to become innovative capability. In their research, Liao et al. (2007) included managerial structure change and employees incentive scheme. It can be said that corporation's innovation capability can have impacts on managerial structure (the centralization level in the organization) and the development of a reward system to the employees.

4.0 CONCLUSION

Understanding KS activities and their contributions to organization requires a comprehensive and integrated perspective by considering the dynamics of the relationships among components in the system. To get a comprehensive understanding on KS activities and its relation to innovation capability, we need to address several major group of factors, such as organizational culture, organizational structure, people, information technology, factors of human behavior activator, This understanding is essential to improve the ability to learn the development of KS activities in the organization.

The model presented in this research is still limited to the results obtained from literature studies and thus not practically proven. Further research to validate the result of this research empirically will be required.

Note:

This research is still progress until this paper written, the research has result in a conceptual model. The model developed based on thorough literature study. The next step to do in this research is collecting empirical data trough a survey.

REFERENCES

Ajzen, I, & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*, Prentice Hall.

Akamavi, N., & Kimble, C. (2005). *Knowledge sharing and computer supported collaborative work: The role of organizational culture and trust*, The University of York, Heslington. England.

Alavi, M., & Leidner, D E. (2001). Review: Knowledge kanagement and knowledge management systems: conceptual foundations and research issues, *MIS Quarterly*, vol. 25, no. 1, pp. 107-36.

Anantatmula, V 2005, Outcomes of knowledge management initiatives, *International Journal of Knowledge Management*, 1(2): 50-67.

Andersen, D., Cappelli, D. M., Gonzalez, J. J., Mojtahedzadeh, M., Moore, A. P., Rich, E., Sarriegui, J. M., Shimeall, T. J., Stanton, J. M., Weaver, E A., & Zagonel, A. (2004), Preliminary system dynamics maps of the insider cyber-threat problem, *Workshop of the System Dynamics Modelling for Information Security: An Invitational Group Modeling Workshop at Software Engineering Institute*, 16-20 February 2004, Carnegie Mellon University, Pittsburgh.

Bock, G W., & Kim, Y. G., (2002). Determinants of the individual's knowledge sharing behavior: The theory of reasoned action perspective, *paper presented at Pasific-Asia Conference on Information System* (PACIS), Meiji University, Tokyo, Japan, pp.1008-1023.

Bock, G. W., Kim, Y. G., & Lee, J. N. (2005). Behavioral intention formation in knowledge sharing: Examingthe roles of extrinsic motivators, social-psychological forces, and organizational climate, *MIS Quarterly*, vol. 29, no. 1, pp 87-111.

Brink, P. V. D. (2001). Measurement of conditions for knowledge sharing, Delft University of Technology and On The Brink, Published in: Proceedings 2nd European Conference on Knowledge Management, November 2001, Bled.

Castells, M. (2000). *The information age: Economy, society and culture*, Volume I: The Rise of the Network Society, Volume II: The Power of Identity , Volume III: End of Millennium, Oxford.

Ching-Lin, T. (2003). A dynamic view of knowledge sharing behavior in collaborative virtual team, in Program for Promoting University Academic Excellence Annual Prospectus Report for Year 2003 – An Integrated Study on Knowledge Economy and Electronic Commerce, National Sun Yat-sen University & National Central University. Guangzhou.

Choi, B. (2002). Knolwledge management enablers, processes, and organization performance: An integration and empirical examination, *Ph.D Thesis*, Division of Management Engineering, Korea Advanced Institute of Science of Technology.

Chua, A. (2004). Knowledge management system architecture: A bridge between KM consultants and technologists, *International Journal of Information Management*, 24, pp.87–98, (ELSEVIER).

Cong, X, & Pandya, K V. (2003). Issues of knowledge management in the public sector, *Electronic Journal of Knowledge Management*, vol. 1, Issue 2, pp. 25-33.

Cresswell, A. M., Pardo, T. A., Thompson, F., Canestraro, D. S., Cook, M., Black, L. J., Luna, L F., Martinez, I. J., Andersen, D. F., & Richardson, G. P. (2002). Modeling intergovernmental collaboration: A system dynamics approach, *Proceedings of the 35th Annual Hawaii International Conference on System Science*, 7-10 January 2002, Manoa, (IEEE Computer society).

De Long, D., & Fahey, L. (1997). Building the knowledge based organization: how culture drives knowledge behavior, *Working Paper*, Ernst & Young LLP, Center for Business Innovation, CBI 366.

Hall, H. (2005). KM, culture and compromise: Devising practical interventions to promote knowledge sharing in corporate environments. viewed 16 August 2007, http://www.dcs.napier.ac.uk/~hazelh/esis/hall_ebic_05.pdf.

Hansen, S., & Avital, M. (2005) Share and share a like: The social and technological influences on knowledge sharing behavior, *Sprouts: Working Papers on Information Environments, System and Organizations*, vol. 5, Issue 1 (1), pp 1-19. viewed 12 August 2007, http://sprouts.case.edu/2005/050101.pdf.

Hoegl, M., & Gemuenden, H. G. (2001). Teamwork quality and the success of innovative projects: A theoretical concept and empirical evidence. *Organization Science, 12*(4), 435-449.

Hughes, D. (1996). NHS managers as rhetoricians: A case of culture management?, *Sociology of Health and Illness* 18(3): 291-314.

Kankanhalli, A., Tan, B. C. Y., & Wei, K. K. (2006). Knowledge producers and consumers', in David, G. & Schwartz (eds.), *Encyclopedia of Knowledge Management*, Hershey, PA: Idea Group Reference, Pennyslvania, pp. 459-466.

Keane, B. T., & Mason, R. M. (2006). On the nature of knowledge: rethinking popular assumptions, *Proceedings of the 39th Annual Hawaii International Conference on System Science*, 3-6 January 2006, Manoa, vol. 7, 162b-162b, (IEEE Computer society).

Kim, S, & Lee, H. (2006). The impact of organizational context and information technology on employee knowledge sharing capabilities, *Public Administration Review; 66, 3*, ABI/INFORM Global, pp. 370-385.

Kwok, S. H., & Gao, S. (2005). Attitude toward knowledge sharing behavior, *The Journal of Computer Information Systems*; Winter 2005/2006; 46,2; ABI/INFORM Global, pp. 45-51.

Lee, H., & Choi, B. (2003) Knowledge management enablers, processes, and organizational performance: An integrative view and empirical examination, *Journal of Management Information System*, 20, 179-228.

Lee, S. M., & Hong, S. (2002). An enterprise-wide knowledge management system infrastructure, *Industrial Management & Data Systems*, vol. 102, no. 1, pp. 17-25.

Liao, S. H., Fei, W. C., & Chen, C. C. (2007). Knowledge sharing, absorptive capacity and innovation capability: An empirical study of Taiwan's knowledge-intensive industries, *Journal of Information Science*, XX (X), pp 1-20.

Lin, C, Hung, H. C., & Wu, J. Y. (2002) A Knowledge management architecture in collaborative supply chain, *The Journal of Computer Information Systems* 42, 5, pp. 83-94, (Proquest Computing)

Lin Lu, Leung, K., & Koch, P. T. (2006) Managerial knowledge sharing: The role of individual, interpersonal, and organizational factors, *Management and Organization Review* 2:1, pp. 15–41, (Blackwell Publishing Ltd.)

Money, W., & Turner, A. (2004) Application of the technology acceptance model to a knowledge management system, *Proceedings of the 37th Annual Hawaii International Conference on System Science*, 5-8 January 2004, Manoa, pp. 80237b, (IEEE Computer society).

Nonaka, I., & Takeuchi, H. (1995). *The Knowledge-creating Company*, Oxford University Press, New York.

Nonaka, I., & Konno, N. (1998). The concept of 'ba': Building a foundation for knowledge creation, *California Management Review*, vol. 40, no. 3, pp. 40-54.

Orr, E., & Persson, M. (2003). Performance Indicators for Measuring Performance of Activities in Knowledge Management Projects, Thesis Reseach, Department of Informatics, University Of Gothenburg.

Osipenko, L., & Farr, J. (2004). System dynamics and dynamic systems integration in regulatory environments, Stevens Institute of Technology, SEEM Dept. Burchard Bld, Hoboken, New Jersey, viewed 20 October 2007, http://www.systemdynamics.org/conferences/2004/SDS_2004/PAPERS/347OSIPE.pdf.

Pan, S., & Scarbrough, H. (1998) A socio-technical view of knowledge-sharing at Buckman laboratories. *Journal of Knowledge Management*, vol. *2*, no. 1, pp. 55-66.

Pavesi, S. (2003) Enabling knowledge processes in innovative environments, Ph.D. thesis, University of Twente, viewed 16 August 2007, http://www.tup.utwente.nl/

Samson, D. (1991) *Manufacturing and operations strategy*, Prentice Hall, Melbourne.

Slund, D. N., & Karlsson, S. (2004). From function to process: A logistics-based framework for transforming tetra pak business support, *Knowledge and Process Management*, vol. 11, no. 1, pp. 68–77, Wiley InterScience (www.interscience.wiley.com).

Strohmaier, M. B. (2003). B-KIDE: A Framework and a tool for business process oriented knowledge infrastructure development, *Ph.D Thesis*, Institute for Knowledge Management and Knowledge Visualization, Graz University of Technology, Austria.

Sushil. (1993). *System dynamics: A practical approach for managerial problems*, Wiley Eastern Limited, New Delhi.

Tsai, C. T., Huang, K. L., & Kao, C. F. (2001) The relationships among organizational factors, creativity of organizational members and innovation capability, *Journal of Management*, 18, pp. 527–566.

Wah, C. Y., Loh, B, Menkhoff, T., & Evers, H. (2005). Theorizing, measuring, and predicting knowledge

sharing behavior in organizations-a social capital approach, *Proceedings of the 38th Annual Hawaii International Conference on System Science*, 3-6 January 2005, Manoa, pp. 252b-252b, (IEEE Computer society).

WP2 Partners, (2002). Analysis of the state of the art, Deliverable D 2.1. "*State-of-The-Art of Knowledge Management"*, Information society technologies, ROCKET (Roadmap to Communicating Knowledge Essential for the indusTrial environment), Information society technologies, viewed 16 August 2007, http://rocket.vub.ac.be/public_drafts/ROCKET-D2.1-final-v1.pdf.