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Designing knowledge chain networks in China — A proposal for a risk management system using linguistic decision making

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ABSTRACT

Designing Knowledge Supply Networks (KSN) with universities and research institutes has become a key source of technological innovations in Mainland China. In order to explore the key design principles, we first present typologies within KSN and explain the factors that can push, guide, or support the innovation process in such a network. Second, we identify and classify the particular risks that prevail when KSN are designed in an emerging region. To assess these risks, we next propose an advanced method that takes into consideration typical problems in group decision-making processes by applying linguistic operators derived from the field of decision theory and fuzzy-sets theory. The risk evaluation method is illustrated with a case study. Fourth, we offer advice on the mitigation of risks in KSN. Finally, we provide insights into the implementation of the risk evaluation method and its automation using Stakeholder Information Systems.

1. Introduction

1.1. Problem situation

During the global economic downturns of 2008 and 2009, top managers have become increasingly aware of their (global) supply networks. They have to cope with longer lead times due to distant transportation from suppliers on the other side of the globe, customer demand forcing shortened product-life cycles, and increased risks and uncertainties streaming from technological changes. For example, managers need to decide upon: when to switch production from hard disk to flash memories; to what extent telecommunication technology should be integrated in cars to enhance passenger safety; which environmentally-friendly ("green") technology should be selected in a nuclear power plant or chemical plant; the pros and cons of having an advanced electronic payment system to allow customers to pay bills with mobile devices (financial services).

We have observed that many companies are hesitant to bear the risks of developing innovations or adopting leading-edge technologies, particularly 'strategic' innovations. There is evidence in Mainland China that companies are systematically under-investing in technologies and failing to commercialize technical products, and thereby losing business opportunities. In contrast to incremental product and process innovation, decisions about the development and/or usage of strategic innovations can particularly shape a company's future. Outcomes determine revenue growth, cash flow, and competitive position, especially in emerging or poorly defined industries. The same management decision also changes risk exposure because strategic innovations are expensive, research and development takes longer, and the proportion of results with ambiguity is high. To help reduce these risks, collaboration strategies can be employed. Although it is possible that when companies seek to cooperate with technology partners, there can be unintended

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knowledge "spillovers" that often prevent cooperation, or make it less successful, nevertheless, we have identified a real benefit to companies working with universities and research institutions in the dissemination of knowledge.

Technological innovations have another "drawback": the risks associated with such science-based innovations are often hard to verbalize, circumscribe, and quantify. As Larry Jarrett, Vice President of Witco Corporation (chemicals), pointed out, the quantification of technical risk is as much an art as it is a science [1]. Although assessment questions may sound simple, they are not so simple to answer; for top managers: What is the benefit of the innovation?; for government: What are the health and safety effects of innovations and technology? How safe is safe enough? (see details in [2]). The inherent risk can lead to inconsistent decisions best illustrated by the well-known example from the 1980s in the UK: spending on safety measures per life saved in the pharmaceutical industry was 2500 times and in the steel industry 1000 times that in agriculture. An additional challenge is to assign weights to risk factors that reflect the relative importance.

1.2. Research questions

In the face of the transition of Mainland China to a more market-oriented economy, the question arises about how to build up and ensure efficient national innovation processes while at the same time avoiding innovation that is managed in a largely random fashion. To cope with uncertainties and risks, we propose analyzing "knowledge networks" from a Supply Chain Management (SCM) perspective. Selected SCM methods and tools might prove to be useful in improving effectiveness and efficiency not only stage-by-stage but more importantly, over the entire chain or network.

The focal point of this paper is the Knowledge Supply Network (KSN) in which "knowledge" is the flow unit. Similar in concept to the familiar physical "supply chain", we can identify suppliers, i.e. technology and innovation sources, and customers. We also see analogies in dealing with risk situations because technology transfer alone does not automatically enable revenue or reduce costs. It is the design, configuration, and architecture of KSN that is crucial for the entire supply chain performance.

So far, research in the fields of KSN has been limited, especially when KSN are designed in Mainland China, using universities and research institutes as a source of innovation [3]. Recently, entrepreneurs are increasingly being identified as "enablers" in these networks. However, several particular risks are faced by young managers when they try to commercialize innovative products and services. They can very easily be overwhelmed by large and established companies if the latter enterprises manage the leveraging of their enormous assets and capabilities. Moreover, young entrepreneurs often lack necessary business relations ("guanxi"), communication skills, and business know-how because designing innovation processes and networks are a relatively new approach in China.

Important factors to consider are who are the entrepreneurs, and how to support the innovation process of these entrepreneurs in the described setting. Another vital question is how to establish a risk-mitigating mechanism in order to achieve the so-called win–win situation for business partners. A prerequisite for managing risks is that the overall risk value of a KSN can be measured. Having identified this research gap, we evaluated relevant decision methods, and present a model that identifies and evaluates risks for the design of KSN (Section 5). An example in this section illustrates the idea. In addition, we propose a mechanism to mitigate those risks (Section 6). Finally, we outline how to implement the proposed risk evaluation method with a special type of information system (Section 7).

2. Literature review on Knowledge Supply Networks (KSN)

Existing KSN research mainly focuses on concepts, mechanism, and components. KSN can be grouped in three levels (see [4,5]): (1) the *macro* level deals with activities fostering innovation at a national level in Mainland China [6]; (2) the *medium* level incorporates companies' business activities that are centered within knowledge flows [7]; and (3) the *micro* level deals with activities between functional areas [8].

Theoretical research on KSN primarily emphasizes its characteristics and models (see details in [9–12]), e.g., comparisons of KSN and the physical supply network (e.g., [13–16]). Research largely focuses on the overlapping area of knowledge management and supply chain management, i.e. the management of knowledge flows in manufacturing, how research, design and production interact, technology integration etc.

Analogous to the general idea of supply chain management and knowledge system engineering, we have further developed the concept of the knowledge supply network. Like a physical supply network, the KSN is comprised of matching supplies to customer demand. The network we focus on consists of universities, research institutions, knowledge intermediaries, producers, retailers, customers etc. In essence, KSN deals with the entire process of acquiring, making, or transferring knowledge. Although "knowledge" is represented in the form of data or information, we highlight this flow unit due to the potential value that it can add to a company, which in turn causes or creates focused action. Thus, we try to extend the common view of companies exclusively focusing on physical, information, or financial supply chains. The overall goal here is to increase the entire performance of the KSN (turning knowledge into commercially available products), not the performance of just one entity of the KSN. "Knowledge" here refers to the particular information in universities and companies that can lead to product or process innovation in the sense of Schumpeter's definition of innovation.

Recent research in supply and operations management also highlights the value of "knowledge" as a strategic resource — see the starting point on the resource-based view [17]. For example, [18] analyzes the intangible aspects of why some supply chains excel while others struggle. In an empirical study the authors demonstrate that a strategy-knowledge fit is associated with supply chain performance. Furthermore, [19] found in his study among 489 companies that performance is influenced by the degree of knowledge development capacity and intellectual capital efforts.