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Generating a causal model of supply chain collaboration using the fuzzy DEMATEL technique ☆

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ABSTRACT

Supply chain collaboration is usually adopted by manufacturers as a strategic measure to increase overall supply chain performance. However, such collaborations arguably have the highest failure record of the various supply chain management practices that are currently being applied. Part of the problem has been the uncertain external environment, an overreliance on technology, and lack of trust among partners. Based on Transaction Cost Economics (TCE) and Relational Exchange Theory (RET), it is clear that environment, asset specificity, and trust are key determinants for the success of collaborations among firms. However, the fuzziness of the interdependency among these determinants and their influences on supply chain collaborative processes still remains unknown. This study thus focuses on Taiwanese manufacturing firms as an example case, and empirically probes the relationships among these dimensions and their effects on these processes. To accommodate the vagueness of human opinions, the fuzzy Decision Making Trial and Evaluation Laboratory (DEMATEL) technique is applied to examine this issue, and to produce a causal relations map. This study also provides a discussion and insights for supply chain practitioners.

1. Introduction

Intensive market competition and increasing customer awareness has obliged companies to seek greater levels of efficiency and responsiveness when addressing customer needs (Simatupang & Sridharan, 2008), and this has driven many firms to collaborate with other members of their supply chains. Supply chain collaboration, which involves cooperation among various parties to reach a common objective, has recently drawn the increased attention of both academics and practitioners (Barratt, 2004). Collaborating firms thus shift their strategic focus from short-term company gains to increasing the satisfaction of their end consumers. Given the increasing importance of supply chain collaboration, managers and analysts need to better understand the casual relations that exist in current supply chain practice in order to more effectively formulate and implement their supply chain collaboration strategies.

The value created by collaboration in supply chains is based on how it can help firms to more effectively match supply and demand to enhance overall supply chain performance (Simatupang & Sridharan, 2008). However, along with the benefits that it brings, collaboration can makes firms vulnerable to the opportunistic behavior of partner firms, as it is possible for these to make decisions that are guided by self-interest, such as lying, cheating, and more subtle violations of agreements (Grover & Malhotra, 2003). Due to this risk, a rational course of action for managers is to monitor and make sure of a partner firm's fidelity to the collaboration agreement. However, these monitoring activities increase the cost of transacting with a partner firm, thus reducing the benefits and profits of such collaborations. To address this issue, various studies have been conducted to examine other methods to enforce agreements. For example, Anderson and Weitz (1992) found that idiosyncratic investments have a substantial impact on the commitment between firms.

Communication plays an important role in collaboration among supply chain partners, and Li and Lin (2006) stated that it is a key element in obtaining seamless supply chains, and tested the determinants of information sharing and information quality. Furthermore, Heide and John (1990) argued that joint action between firms is one way that they can protect themselves against opportunistic behavior. In addition, relationship depth, characterized by the level of trust between partner firms, has become an increasingly important issue for both scholars and practitioners, and Joshi and Stump (1999) investigated the moderating effect of trust on the relationship between asset specificity and joint actions

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in a manufacturer–supplier setting. However, joint action is only one dimension of collaboration (Simatupang & Sridharan, 2005), and Lui, Wong, and Liu (2009) proposed that more direct relationship exists between trust and collaboration. While they examined the effects of asset specificity on the collaborative behavior of firms, they did not consider the influence of environmental uncertainty, which has been shown to be a critical force driving cooperation among companies (Krause, Handfield, & Scannel, 1998). Collaborations in supply networks may suffer from a number of disadvantages, such as loss of flexibility, loss of control by individual supply chain members, high coordination costs, anti-trust problems, and potential consolidation of the supply market in the long run (Bahinipati, Kanda, & Deshmukh, 2009). There is thus a need for further research that empirically tests the relationships among trust, asset specificity, and environmental uncertainty, as well as their influences on the collaborative processes.

Causal analysis is important in decision-making, as the use of an accurate model of causal relations can lead to more effective and efficient decision-making. The current stream of research examining causal models mainly adopts Structural Equation Modeling (SEM). While the statistical data collected in such works can enable researchers to obtain good fitting models, SEM is often misapplied when the data are merely fitted to a model, and the theory is then extended from the analytical results based on the presumed hypotheses (Wei, Huang, Tzeng, & Wu, 2010).

On way to overcome this problem is to use the Decision Making Trial and Evaluation Laboratory (DEMATEL) technique (Gabus & Fontela, 1973), which can help in gathering group knowledge for forming a structural model, as well as in visualizing the causal relationships that exist in sub-systems through a causal diagram. However, in many cases the judgments of decision-making are given as crisp values, but these are an inadequate reflection of the fuzziness of the real world (Bellman & Zadeh, 1970; Zadeh, 1975). Human judgments about preferences are often unclear and hard to estimate by exact numerical values, and fuzzy logic is needed to handle problems that involve these (Zadeh, 1975). There is thus a need to extend the DEMATEL technique with fuzzy logic in order to make better decisions in fuzzy environments (Lin & Wu, 2004).

The aim of this paper is to apply the fuzzy DEMATEL technique to explore the causal relationships among key dimensions in supply chain collaboration to enable better strategic development of manufacturing firms. The data used in the empirical study are collected from Taiwanese manufacturers.

The rest of this paper is organized as follows. In Section 2, the prior literature is reviewed to form the dimensions and criteria of supply chain collaboration. In Section 3, the conventional and fuzzy DEMATEL techniques are described. In Section 4, an empirical study is presented to examine the causal relations. Section 5 discusses the research findings and their managerial implications. Finally, the concluding remarks are presented in Section 6.

2. Theoretical foundations and literature review

This study aims to establish a causal model of the factors that influence supply chain collaboration based on Transaction Cost Economics (TCE) and Relational Exchange Theory (RET). This section first reviews the theoretical foundations of this research, and then discusses the dimensions and criteria that have been presented in the related literature.

2.1. Theoretical foundations

TCE (Williamson, 1985) has been applied to various fields, including sociology, organizational theory, marketing, and more recently, operations management (Grover & Malhotra, 2003), and is the main theoretical framework that researchers use to consider whether firms should perform activities in-house or outsource them (Lee, Yeung, & Cheng, 2008). Scholars have also applied TCE to examine the willingness of firms to create alliances or to cooperate with each other (Heide & John, 1990; Joshi & Stump, 1999; Lee et al., 2008), and this approach proposes that asset specificity and uncertainty positively affect the level of collaboration among firms.

One basic assumption of TCE is that firms make decisions in order to minimize transaction costs, which include the direct costs of transacting with another firm and the opportunity costs from making sub-optimal decisions (Rindfleisch & Heide, 1997). According to TCE, environmental uncertainty will force transacting firms to incur higher transaction costs due to frequent requirement changes and renegotiations regarding these (Grover & Malhotra, 2003). David and Han (2004) stated that cooperative strategies, such as supplier alliances, can reduce these problems. Asset specificity is another fundamental construct in TCE. According to TCE, when a firm invests in partner-specific assets, it puts itself at risk with regard to the opportunistic behavior of its partners. Collaborative practices, such as information sharing and joint decision-making, reduce the chance for partner firms to practice opportunistic behavior due to easier monitoring of decisions and joint control over assets. Heide and John (1990) supported this perspective by considering joint action as a means of safeguarding firms from opportunism.

RET posits that all exchanges have some relational elements (Zaheer & Venkatraman, 1995), and it adopts a socialized view of transactions between firms by looking into the social determinants of collaboration. Macneil (1985) suggested that there are norms that are necessary for relations to continue, including role integrity, which he defines as the likelihood that the parties involved will behave properly in all situations. In addition, Zaheer and Venkatraman (1995) considered trust as a key sociological determinant for joint action between firms, and according to Lui et al. (2009), RET predicts that trust is positively related to cooperative behavior.

Based on the complementarity between TCE and RET, this research aims to investigate the interrelationships among asset specificity, environmental uncertainty, trust, and collaborative processes between manufacturing firms and their suppliers.

2.2. Literature review

2.2.1. Environmental uncertainty

Environmental uncertainty has been identified by Achrol and Stern (1988) as the level of unforeseen changes in the environment within which a firm operates. Due to the uncertainties that exist within a firm's industry, as well as the wider environment, managers have difficulties in making the accurate predictions that are critical for sound decision making. As a result, practitioners have been working to increase the flexibility and responsiveness of their organizations in relation to the dynamic environments they operate within, in order to compensate for inaccurate market forecasts. For example, high uncertainty has been a critical factor driving the development and use of supply chain management practices, such as just-in-time (JIT) and enterprise resource planning (ERP) systems.

Gupta and Wilemon (1990) enumerated four sources of perceived environmental uncertainty: (1) increased global competition, (2) technological change, (3) changes in market demand, and (4) an increasing need for the involvement of suppliers and customers. Scholars have defined environmental uncertainty based on two criteria: market and technological uncertainty. For example, Krause (1999) examined the effects of the rates of increasing