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Impacts of supplier knowledge sharing competences and production capacities on radical innovative product sourcing

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ABSTRACT

An effective sourcing strategy leads to cost savings and value added collaborations. For radical innovative product sourcing (RIPS), the exact nature and demand of products are highly uncertain. As such, knowledge sharing competences and production capacities of potential suppliers are prerequisite capabilities. The main aim is to investigate the impacts of these considerations on sourcing strategies through the development of two optimization models. Under the assumptions of single product sourcing, single period time window, uncertain demand and stochastic supply, KKT conditions are used to solve a simplified nonlinear optimization model analytically. The model is then expanded and particle swarm optimization is used to solve numerically the number of suppliers, order quantities and the level of relationship investments that maximize the value of sourcing. Through extensive scenario and sensitivity analyses, we provide some key insights.

1. Introduction

Radical innovation product sourcing (RIPS), the practice in which firms outsource manufacturing of radical innovative products to third party suppliers, has proliferated in recent years. With the growing importance of RIPS, it is important for firms to determine and adopt the most profitable sourcing strategy. This paper adopts a supplier management optimization approach to address this issue. We first review the theoretical underpinnings of RIPS' rise in importance. This will be followed by a review of the advantages and disadvantages of reducing the size of supplier base. Lastly, relevant supplier management models would be discussed.

The proliferation of RIPS can be explained using the three views of the firm namely "Resource-based", "Knowledge-based", and "Relational". The resource-based view states that a firm's competitive advantage depends on how well it utilizes the resources that it has at its disposal (Penrose, 1959; Rumelt, 1984; Wernerfelt, 1984). Key resources should be valuable, rare, in-imitable and non-substitutable. The knowledge-based view further claims that knowledge, being an in-imitable resource that is generated from complex social and cultural firm structures, is the most strategically important resource of the firm (Conner, 1991; Conner & Prahalad, 1996; Demsetz, 1988; Grant, 1996; Kogut & Zander, 1992; Madhok, 1996; Nahapiet & Ghoshal, 1998). The relational view on the other hand argues that idiosyncratic inter-firm interactions are sources of relational rents which are defined as "supernormal profits jointly generated in an exchange relationship that cannot be generated by either firm in isolation and can only be created through the joint idiosyncratic contributions of the specific alliance partners" (Dyer & Singh, 1998). Knowledge sharing is identified as one of the main generators of this relational rent.

Both the resource-based and knowledge-based views provide understanding into the behavior of innovative firms as they focus on developing and utilizing their knowledge-based resources to develop innovative products. In so doing, some firms will lack the necessary manufacturing capabilities. The relational view then explains the proliferation of inter-firm collaborations between the innovative firm and third party manufacturers and suppliers (RIPS). For RIPS to be successful, effective knowledge sharing, where there is transparent communication of information and continuous sharing of explicit and tacit knowledge between the buying firm and the supplier, is necessary to enhance product reliability and conformance to product specifications (Nooteboom, 1999; Song, Berends, Van der Bij, & Weggeman, 2007). This is again in line with both the knowledge-based and relational views of the firm. Effective and unequivocal knowledge sharing requires firstly, suppliers to be competent in knowledge sharing practices; secondly, the establishment of a high level of trust between the buying firm and the suppliers; and lastly, a high absorptive capacity of suppliers to assimilate knowledge and information to produce high quality products (Song et al., 2007). In addition, the

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supplier must have adequate production capacities that can respond to high demand fluctuations associated with radical innovative products. In addition to these RIPS specific supplier selection criteria, many other qualitative studies on traditional product sourcing have identified several supplier selection considerations. These considerations are classified into seven groups as stated in Appendix A.

The advantages and disadvantages of supplier base reduction are well studied. Elmaghraby (2000) provides a review regarding sourcing strategies. Benefits of supplier base reduction are derived from the fact that companies can concentrate on building fewer suppliers. Cousins (1999) and Agrawal and Nahmias (1997) also argue that a smaller supplier base facilitates the development of a lasting buyer–supplier relationship. Cousins (1999) and Burke, Carrillo, and Vakharia (2007) further mention that deeper relationships lead to better knowledge sharing, cost reductions, shared benefits and enhanced flexibility in business strategies. However Burke et al. (2007) and Wilson (1995) concede that the level of trust and relationship required to have a successful collaboration and to obtain significant relationship-based benefits is difficult to attain as it requires much investments in relationship management. On the other hand, the disadvantages of supplier base reduction include increases in supplier default risks, overdependence on supplier and limitations in supplier capacities (Agrawal & Nahmias, 1997; Burke et al., 2007).

Several quantitative studies have been conducted regarding supplier management optimization. De Boer, Labro, and Morlacchi (2001) review methods of supplier selection by extending previous reviews in literature. Setak, Sharifi, and Alimohammadian (2012) review supplier selection and order allocation models in literature from 2000 to 2010. Dotoli and Falagario (2012) use a hierarchical extension of the data envelopment analysis (DEA) to perform optimal supplier selection in multiple sourcing environments. Costantino and Pellegrino (2010) use a real options approach to compare single and multiple sourcing strategies under supplier default risk. Xia and Wu (2007) integrate the analytical hierarchy process, rough sets theory and multi-objective mixed integer programming to determine the number of suppliers and order quantities under multiple products, multiple criteria, supplier capacity constraints and volume discount environments. Mirahmadi, Saberi, and Teimoury (2012) utilize a decision tree approach to determine the number of suppliers chosen for collaboration considering supply risk, costs of supplier development and management, costs of missing discount due to multiple sourcing and lost costs due to supply postponement. Sarkar and Mohapatra (2009) determine the optimal supplier base size under risks of supply disruptions which are due to super, semi-super and unique events.

Ramasesh, Ord, Hayya, and Pan (1991) compare the differences in single and dual sourcing under constant demand and stochastic lead times. Uniform and exponential distributions are used to model the lead times. Parlar and Wang (1993) investigate the tradeoff between diversification and single sourcing under yield randomness for both the EOQ and the newsboy models. Analytical results are obtained for the EOQ model while approximate solution techniques are used for the newsboy model. Dada, Petruzzi, and Schwarz (2007) analyze the problem of a newsvendor served by multiple suppliers which can be either perfectly reliable or unreliable. Perfectly reliable suppliers are not always chosen in the optimal set of suppliers and the most important criterion for supplier selection is the price charged by the suppliers. In addition, supplier reliability only affects the supplier's order quantity. Agrawal and Nahmias (1997) analyze the optimal sourcing decision under deterministic demand and stochastic supply. Their main assumptions are that fixed costs are zero and quality risks drop as number of suppliers increases. Burke et al. (2007) investigate the differences between single and multiple sourcing strategies; and integrate product prices, supplier costs, supplier capacities, historical supplier reliabilities and inventory costs into the mathematical model. They add a diversification function to account for diversification benefits when the size of supplier base increases. The results show that sole sourcing is the optimal strategy when there is no capacity constraints and if there were no diversification benefits. In other cases, multiple sourcing would be the optimal strategy.

Burke, Carrillo, and Vakharia (2009) created a mathematical model to find the optimal sourcing decision under stochastic demand and stochastic supply. Uncertain demand is modeled with a uniform distribution while stochastic supply is modeled with a probabilistic reliability multiplier. The main objective is to determine the optimal supplier set and the order quantities for each supplier. The assumptions and objectives of this paper are similar to ours. The missing elements relevant to RIPS are buyer–supplier knowledge sharing; additional costs of poor quality; buyer–supplier relationship elements; and supplier capacities.

To the best of our knowledge, there is no supplier management optimization model that incorporates all of the above elements. As such, this paper serves to bridge these gaps in literature through the extension of the Burke's model (2009) to incorporate these additional elements that are integral for RIPS. Two supplier management models, Burke's Model with Knowledge Sharing (BMKS) which incorporates knowledge sharing elements and additional costs of poor quality; and Innovative Sourcing Integrated Model (ISIM) which further introduces buyer–supplier interactions and supplier capacity constraints are proposed. These models enable us to investigate the impacts of these considerations on the optimal sourcing strategy which includes the order quantities for each supplier and also the set of suppliers that should be engaged. In addition, for the ISIM, the optimal level of relationship investments that the buying firm should undertake for each supplier is determined.

The remaining part of the paper is organized as follows. Section 2 introduces the modeling framework, the model assumptions and explains both the BMKS and ISIM. It also discusses some interesting analytical closed form solutions from the BMKS. The rationale behind the usage of certain mathematical functions to model the various sourcing considerations in the ISIM is also discussed. Section 3 then explains the numerical experiments in which particle swarm optimization is used to solve the ISIM. Subsequently, one factor sensitivity analysis is performed to observe trends and key insights. Section 4 then summarizes the above sections, provides several key managerial insights and provides suggestions for future research directions.

2. Modeling framework and analysis

We discuss the BMKS which incorporates knowledge sharing elements and additional costs of poor quality through the introduction of an additional quality multiplier to the model from Burke et al. (2009). This model makes use and extends certain properties of the Burke's model like global concavity which allows us to obtain global optimal solutions. We develop the ISIM by incorporating elements like buyer–supplier relationships which affects inter-firm knowledge sharing, and suppliers' production capacities into the BMKS. With the introduction of these considerations, the model becomes analytically intractable and particle swarm optimization (PSO) is used to numerically obtain the optimal solutions. The numerical experiments and results are discussed in section 3.

2.1. Burke's model with knowledge sharing (BMKS)

Burke's Model (2009) considers supplier management elements like uncertain supply due to quality considerations, uncertain