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Supplier selection in agile supply chains: An information-processing model and an illustration

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ABSTRACT

Agile supply chains need to be highly flexible in order to reconfigure quickly in response to changes in their environment. An effective supplier selection process is essential for this. This paper develops a model that helps overcome the information-processing difficulties inherent in screening a large number of potential suppliers in the early stages of the selection process. Based on radial basis function artificial neural network (RBF-ANN), the model enables potential suppliers to be assessed against multiple criteria using both quantitative and qualitative measures. Its efficacy is illustrated using empirical data from the Chinese electrical appliance and equipment manufacturing industries.

1. Introduction

The task of supplier selection has always been considered a key one within purchasing and supply management (Dickson, 1966; Kraljic, 1983; Weber et al., 1991; Choi and Hartley, 1996; De Boer et al., 2001; Sarkar and Mohapatra, 2006). Indeed, some consider it to be the most important of all the responsibilities of the function, as the choice of supplier has a significant impact on the optimisation of the quality, quantity, timeliness and price of purchased goods and services (Dulmin and Mininno, 2003; Sarkis et al., 2007). Furthermore, suppliers have a direct and significant impact on the quality, cost and lead time of new products and technologies needed to meet new market demands (Vokurka and Fliedner, 1998; Meade and Sarkis, 1999; Humphreys et al., 2007).

Three recent trends in purchasing and supply practices have further served to emphasize the importance of selecting the right supplier. Firstly, the increased use of outsourcing has led to more firms spending a greater proportion of their total revenue on externally sourced goods and services, thereby increasing the impact of suppliers' performance on purchasers (Weber and Ellram, 1993). Secondly, the trend towards supply base reduction increases the impact that any given supplier is likely to have on a purchaser's performance (Power et al., 2001). Thirdly, and perhaps most importantly, the trend towards closer relationships between vendors and purchasers based on collaboration and co-operation increases the role and contribution of suppliers in the operations of the purchaser (Heide and John, 1990). This is especially the case where purchasers adopt a 'partnership sourcing' (Macbeth and Ferguson, 1994) approach, increasing the purchasers' dependence upon their suppliers to the extent that suppliers can become integral to their core competences (Gadde and Snehota, 2000). This can have a significant impact on competitiveness because it facilitates the mobilisation of resources to track evolving changes in markets, technologies and material development as well as customer demand. Interdependent partners can focus and rapidly replicate narrow aspects of the value creation process where competitive advantage is greatest (Quinn, 1992).

The task of selecting the right suppliers is also an extremely demanding one for three key reasons. Firstly, today's business environments are typically seen as becoming inherently more unstable due to fast-changing market conditions, customer demands, actions of competitors, and so on (Hakansson and Snehota, 2006). In more dynamic markets, the response of many firms has been to adopt the concept of the agile supply chain (ASC) (Christopher, 2000). An agile supply chain is a dynamic alliance of member companies, the formation of which is likely to need to change frequently in response to fast-changing markets. In ASCs, the task of supplier selection is thus not a one-off infrequent activity. Rather, changing market requirements and customer preferences require a broader and faster supplier selection process (Sarkis, 2001; Arteta and Giachetti, 2004), which requires the use of a wide set of selection criteria (Yusuf et al., 1999; Cagliano et al., 2004). The adoption of ASCs may increase the frequency with which a purchaser needs to seek out a new strategic supplier. Although the partnership sourcing approach

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envisages a long-term relationship between purchaser and supplier, the requirements of more dynamic markets may even lead a purchaser to re-evaluate the basis of these relationships more frequently. Secondly, the increasing globalisation of world trade and Internet-facilitated communications provides purchasers with increased opportunities for sourcing goods in foreign countries. Indeed, many businesses have seized such opportunities. In particular, China has become the 'world's factory' (Nassimbeni and Sartor, 2007), the source of some one-third of the West's manufactured goods. Global sourcing increases the number of potential suppliers considerably when compared to restricting the choice to domestic suppliers. However, it can also increase the difficulties of obtaining meaningful information about potential suppliers. Purchasers may have to rely solely on publicly available information, especially in the early stages of a search for new suppliers. Thirdly, potential suppliers are likely to need to be assessed against multiple and often conflicting criteria, between which trade-offs are typically required (Chen et al., 2006). Furthermore, selection is complicated by the fact that different potential suppliers may have different performance characteristics for different attributes (Xia and Wu, 2007). For example, the potential suppliers who can provide a raw material at the lowest price may not have the best quality or after-sales service among the competing suppliers. Therefore, supplier selection is an inherently multi-objective decision, which seeks to minimise some evaluation criteria whilst and, at the same time, maximising others (Dickson, 1966).

These factors combine to make supplier selection in ASCs a very complex problem. It might be expected that purchasing and supply managers would look to use quantitative methods to help inform their decision-making. However, until recently quantitative methods have typically been found to be inadequate and limited. Many decision-support models emphasize the final stages of the supplier selection process (e.g. Weber et al., 1991; Weber and Ellram, 1993; Dulmin and Mininno, 2003). However, De Boer and Van der Wegen (2003) have argued for the need to shift the emphasis to earlier stages, such as pre-classification and the formulation of criteria, as the quality of decision-making at the final choice stage is largely dependent on decisions that have already occurred in the previous stages. Secondly, relatively little attention had been paid to the task of selecting new suppliers (De Boer et al., 2001), which is particular important in ASCs. Thus, more and more managers have fallen back on the use of purely qualitative methods, often based on subjective judgements, to address the problem of supplier selection (Gencer and Gurpinar, 2007).

Recent advances in computer programming have provided opportunities to develop new quantitative approaches that can help decision-makers. In particular, artificial neural networks (ANN), especially radial basis function artificial neural networks (RBF-ANNs) appear to have the potential to help in supplier selection. RBF-ANN is a system with strong adoption ability, which can consider and adopt new restrictions over time. This characteristic is particularly important in ASC supplier selection, which typically takes place under the condition of information imperfection and distortion. Despite its apparent suitability for use in fast-changing economic and competitive environments, few researchers have tried to apply RBF-ANN to the supplier selection problem in ASC.

This paper seeks to contribute to the advancement of methods available to improve the supplier selection process in two ways. Firstly, it aims to build on existing literature, (notably the work of De Boer et al., 2001; Lin and Chen, 2004) to develop a practical model of the supplier selection process. Secondly, it aims to develop a quantitative method of classifying potential suppliers into one of four different types (using the classification of Kraljic, 1983), based on RBF-ANN, which is able to overcome the information-processing difficulty inherent in assessing large numbers of potential suppliers against multiple criteria. The development of such a model would help purchasers to select suppliers from amongst those most appropriate to their supply strategy.

The paper is structured as follows. Section 2 reviews the existent literature on supplier selection, pointing to the deficiencies in current models and methods used to tackle the problem. Using this literature, Section 3 develops a conceptual model of the supplier selection process. Section 4 draws on the computational literature to develop and present an information-processing model that uses RBF-ANN for classifying potential suppliers in an ASC. By way of illustration, the model is developed for application within the Chinese electrical appliance and equipment manufacture industry. Section 5, then shows how the model can be applied in practice by applying it to firms within that industry, using publically available data. Section 6 closes the paper with a short discussion of the issues raised and pointing the way to future research requirements.

2. Literature review

Researchers have applied both qualitative and quantitative approaches in considering supplier selection. On the qualitative side, arguing that the supplier selection and evaluation process is multi-objective in nature, Dickson (1966) identified 23 attributes that decision-makers could use when choosing suppliers. Weber et al. (1991) concluded that quality was the most important factor, followed by delivery performance and cost. Lorange et al. (1992) developed a two-stage supplier selection approach: first evaluating the degree of match with a candidate supplier and then analysing the market potential and main competitors and simulating worst-case scenarios after the formation of the relationship. Macbeth and Ferguson (1994) and Maloni and Benton (1997) concluded that the adoption of a supply chain perspective necessitates a significant shift from the conventional adversarial relationships between purchasers and vendors to one of openness and trust. They also pointed out that operational research has both the capacity and competence to help pave the way for this attitudinal shift through effective supply chain modelling in the form of simulation, heuristics and optimisation.

Much more research has been done on the quantitative side than the qualitative side. Reviewing the existent literature in this field, it is possible to identify four main categories of methods and models, namely:

1. Linear weighting/mathematic programming
2. Analytic hierarchical process (AHP)
3. Fuzzy set theoretic analysis
4. Other methods and models

These are now discussed in more detail.

(1) *Linear weighting/mathematic programming*: Hajidimitriou and Georgiou (2002) employed a goal-programming technique for the supplier selection problem that was able to achieve multiple goals for different levels of performance of the corresponding attributes. Talluri and Baker (2002) proposed a three-phase mathematical-programming approach for supplier selection by combining the pairwise efficiency game model with integer and linear programming. Although this model overcomes the limitations of unrestricted weight flexibility, it risks producing a sub-optimal solution as the filter phase might filter the optimal one.