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Supplier segmentation using fuzzy logic

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ABSTRACT

Supplier segmentation means that the suppliers of a specific firm are categorized on the basis of their similarities. This supply-side business-to-business (B2B) segmentation is of special importance to companies with many suppliers. Supplier segmentation yields a manageable number of segments, each of which requires a separate strategy. Standard supplier segmentation methods have serious shortcomings, for instance because they fail to make a proper connection between supplier segmentation and other supplier-related activities such as supplier selection and development. Moreover, these standard methods typically use a limited number of segmentation criteria and different sets of criteria are suggested for each method. It is unclear for practitioners how to choose a particular method. The purpose of this paper is to form a practical tool for supplier segmentation taking into account all suggested segmentation criteria. The principal result of this paper is the design of a rule-based method to segment the suppliers of a firm based on two overarching dimensions: supplier capabilities and supplier willingness. The method is applied to a real-world situation to show how the results can be used in practice. A general sensitivity analysis procedure for fuzzy rule-based systems is proposed and then implemented, to identify the most important supplier capabilities and willingness criteria and to formulate better supplier development strategies. A major conclusion of the paper is that the fuzzy logic approach to supplier segmentation is simple to apply in practice, yet considers all available segmentation criteria and their inherent fuzziness in a way that is easily adaptable to a specific industrial context.

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1. Introduction

In today's world, where there is a growing trend towards outsourcing (McIvor, 2008), firms do not carry out all their activities themselves (Desai, 2009), but rely more and more on their suppliers, which are usually selected on the basis of several criteria that are important to the firm. Several multi-criteria and multi-objective methodologies have been applied to supplier selection (e.g. de Boer, Labro, & Morlacchi, 2001; Dickson, 1966; Ho, Xu, & Dey, 2010; Rezaei & Davoodi, 2011, 2012; Sawik, 2010; Weber, Current, & Benton, 1991; Wilson, 1994; Wu, Zhang, Wu, & Olson, 2010). Given a selected set of suppliers, supplier relationship management provides a basis for firms to develop and maintain relationships with these suppliers (Lambert, 2008). Especially when firms have many suppliers, it is difficult to manage all relationships individually, which is why in supplier relationship management, firms develop business-to-business (B2B) strategies for different groups of suppliers (Wagner & Johnson, 2004). Supplier segmentation, as a step between these two strategic activities (supplier selection and supplier relationship management), yields distinct groups of suppliers based on their similarities. Compared to customer segmentation, supplier segmentation has received relatively little attention and is in its infancy (Day, Magnan, & Moeller, 2010; Rezaei & Ortt, 2012b). While customer segmentation is aimed at the demand-side of the market, supplier segmentation focuses on the supply-side of the market (Erevelles & Stevenson, 2006). In fact, market segmentation can be divided in three sub-topics:

a) *Consumer segmentation* (e.g. segmentation of car users for a car parts producer);
b) *Industrial customer segmentation or demand-side B2B segmentation* (e.g. segmentation of car assembly plants by a car parts producer);
c) *Supplier segmentation or supply-side B2B segmentation* (e.g. segmentation of component manufactures used by a car parts producer).

While the first of these two sub-topics are relatively well-established and well-researched, the third has so far received less attention. Although a few approaches have been developed to supplier segmentation, these approaches are mostly normative and provide no practical tools for implementation in real-world situations.

The main objective of this paper is to provide a practical tool for supplier segmentation. To this end, we apply a fuzzy rule-based approach to implement a more comprehensive conceptual framework for supplier segmentation. We think that supplier segmentation – like many other marketing problems – because of its complexity and the high degree of fuzziness of variables involved, may be handled more effectively by intelligent systems, which so far have received little attention in

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marketing (e.g. Casillas & Martínez-López, 2010). We refer to Wierenga (2010) for a possible explanation for this state of affairs, and also the status of Artificial Intelligence (AI) in marketing in general.

Fuzzy rule-based approaches, such as the method for supplier segmentation developed in this paper, are interesting for marketing management because they enable building practical models even when a limited number of data is available. Moreover, these models can be built using the experience of marketing managers. The fuzzy rule-based approach forces these practitioners to discuss their priorities and preferences regarding decision criteria but at the same time allows the fuzziness that is inevitable in real-world management situations. Finally, by involving practitioners, this approach facilitates the implementation and use of the resulting models.

Our method of supplier segmentation builds on the existing methods by combining available segmentation criteria. The main contribution of the paper is the design of a rule-based approach to segment the suppliers of a firm based on two overarching dimensions that capture these available segmentation criteria. Another methodological contribution of the paper is to develop and apply a general sensitivity analysis procedure for fuzzy rule-based systems. This analysis is used to identify the most important supplier capabilities and willingness criteria and to formulate better supplier development strategies.

In the next section, the conceptual background is presented. In Section 3, a methodology is proposed, including the design and implementation of two fuzzy rule-based systems. In Section 4, we apply the proposed methodology to a real situation. In Section 5 the conclusion, implications and future research avenues are discussed.

2. Conceptual background

Industrial market segmentation or B2B segmentation as a sub-field of market segmentation is a well-researched topic in marketing, going back to 1970s (e.g. Choffray & Lilien, 1980; Johnson & Flodhammer, 1980; Wind & Cardozo, 1974). Mitchell and Wilson (1998, p. 431) state: "business-to-business market segmentation is an ongoing and iterative process of examining and grouping potential and actual buyers with similar product needs into subgroups that can then be targeted with an appropriate marketing mix in such a way as to facilitate the objectives of both parties. The process has strategic and tactical marketing implications and should be periodically reviewed to incorporate the lessons of experience and to maintain an optimal cost benefit ratio."

The focus in segmentation literature has been on the demand-side of the market, while the supply-side has received relatively little attention (Erevelles & Stevenson, 2006). The importance of segmenting the supply-side of the market – supplier segmentation – is recognized by Parasuraman (1980) and Kraljic (1983), two pioneers in this field.

Parasuraman (1980) proposed a four step process for supplier segmentations: (1) Key features of customer segments are identified; (2) Key characteristics of suppliers are identified; (3) Relevant variables for supplier segmentation are selected; and (4) Suppliers are segmented based on these variables. Although Parasuraman's approach (1980) makes a rational connection between customer segmentation and supplier segmentation, it does not specify the variables that are relevant to segment the suppliers. In contrast, Kraljic' approach (1983), the most popular approach to supplier segmentation (Day et al., 2010), specifies the variables required for segmenting suppliers. He proposes two dimensions: profit impact and supply risk, which are measured for different products that are supplied to a firm. Using two levels (low and high) for both of these dimensions, a 2 × 2 matrix can be constructed to distinguish four segments: (1) Non-critical items (supply risk: low; profit impact: low); (2) Leverage items (supply risk: low; profit impact: high); (3) Bottleneck items (supply risk: high; profit impact: low); and (4) Strategic items (supply risk: high; profit impact: high), after which different strategies for handling these supplier segments can be developed.

Most approaches to supplier segmentation in the existing literature are extensions of Kraljic's approach (1983). Olsen and Ellram (1997), for example, propose a supplier segmentation based on two dimensions: the difficulty of managing the purchase situation and the strategic importance of the purchase. Bensaou (1999) includes two other dimensions: the supplier's specific investments and the buyer's specific investments. The approach suggested by Kaufman, Wood, and Theyel (2000) is based on the two dimensions: technology and collaboration. Supplier commitment and commodity importance are the two dimensions of Svensson (2004). Hallikas, Puumalainen, Vesterinen, and Virolainen (2005) use supplier dependency risk and buyer dependency risk, while Dyer, Cho, and Chu (1998) use the differences between outsourcing strategies as a basis for segmenting suppliers into two distinct segments. For a discussion of supplier segmentation approaches, see Day et al. (2010) and Rezaei and Ortt (2012b).

To summarize, several two-dimensional approaches have thus far been proposed, each of which includes some important segmentation variables, while neglecting some other important variables. In other words, there is no general agreement and in fact, as pointed out by Day et al. (2010), as yet there is no integrated approach to supplier segmentation. Recently, Rezaei and Ortt (2012b), after reviewing the supplier segmentation and supplier selection literature, have proposed a framework that consists of two overarching dimensions: supplier capabilities and supplier willingness. By applying these two overarching dimensions, decision-makers do not have to be concerned that important segmentation variables are missing. If all the relevant variables are taken into account, it is likely that the resulting segments are internally homogeneous, externally heterogeneous in nature, and more applicable to the particular situation of a buying company. Rezaei and Ortt (2012b, p. 4598) define supplier capabilities, and supplier willingness as follows:

> "Supplier's capabilities are complex bundles of skills and accumulated knowledge, exercised through organisational processes that enable firms to co-ordinate activities and make use of their assets in different business functions that are important for a buyer."
> "Supplier's willingness is confidence, commitment and motivation to engage in a (long-term) relationship with a buyer"

Based on these two dimensions, they define supplier segmentation as follows:

> "Supplier segmentation is the identification of the capabilities and willingness of suppliers by a particular buyer in order for the buyer to engage in a strategic and effective partnership with the suppliers with regard to a set of evolving business functions and activities in the supply chain management."

By using two levels (high and low) for each dimension, four segments are constructed, as shown in Fig. 1. It is possible to consider more levels per dimension.

These two dimensions can be formed by including virtually all the variables that have been proposed in previous studies. Tables 1 and 2 contain comprehensive lists of these variables. It should be mentioned that, to construct the two dimensions (supplier capabilities and supplier willingness), it is not necessary to include all the variables. Instead, each firm, considering its own organizational and environmental situation, such as its sourcing strategy and competitive posture, can select a handful of variables to construct the dimensions as a self-designed segmentation base. Integrating the variables in each dimension results in a single score for each dimension. In this paper, we apply a fuzzy rule-based approach to construct the two dimensions.

3. Methodology

Fuzzy set theory, which was developed by Zadeh (1965, 1975), is an attempt to formalize/automate two remarkable human abilities:

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