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# Supply chain focus dependent supplier selection problem

Gangaraju Vanteddu [a,*], Ratna Babu Chinnam [b], Oleg Gushikin [c]

[a] Department of Accounting, Harrison College of Business, Southeast Missouri State University, One University Plaza MS 5815, Cape Girardeau, MO 63701, USA
[b] Department of Industrial & Manufacturing Engineering, Wayne State University, 4815 Fourth Street, Detroit, MI 48202, USA
[c] Ford Research and Advanced Engineering, 2101 Village Road, Dearborn, MI 48121, USA

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ABSTRACT

Increasing globalization, diversity of the product range, and increasing customer awareness are making the market(s) highly competitive thereby forcing different supply chains to adapt to different stimuli on a continuous basis. It is also well recognized that overall supply chain focus should be given an overriding priority over the individual goals of the players, if one were to improve overall supply chain surplus. Among all the possible order winners, 'cost' and 'responsiveness' seem to be the most significant metrics based on which majority of the supply chains compete with each other. Supplier selection problem is one of the crucial problems that need to be addressed in configuring a supply chain that could have far reaching ramifications on the total supply chain costs and order winnability. Our model, that considers inventory costs and the supply chain 'cycle time' reduction costs, would aid a supply chain manager to make informed decisions with regard to supplier selection problem at any stage, dependent upon the priorities attached to supply chain costs and cycle time. Inventory related costs and responsiveness related costs are the two primary cost elements that are considered in this model. We are also making use of a novel dimensionless quantity called the 'coefficient of inverse responsiveness' that not only facilitates the introduction of responsiveness related costs into the model but also improves the scalability and simplifies the analysis and interpretation of the results. Based on the strategic model developed, we offer some very interesting managerial insights with respect to the effect of cost efficient operations and/or location and cost of volume related flexibility at a stage on alternate suppliers, which in turn affects the overall supply chain performance.



## 1. Introduction

"Purchased products and services account for more than 60% of the average company's total costs. For steel companies, it may go up to 75%; it is 90% in petrochemical industry, etc. Bringing down procurement costs can have a dramatic effect on the bottom line—a 5% cut can translate into a 30% jump in profits" (Degraeve and Roofhooft, 2001). As the emphasis shifts from vertical integration to horizontal interconnectivity in today's competitive markets, supplier selection turns out to be one of the key issues that affect the product's competitiveness.

The reduction of the manufacturing depth leads to an increase of the proportion of the purchased parts and consequently increases the dependency on suppliers (Maron and Brückner, 1998). Kagnicioglu (2006) opines that supplier selection is a critical activity of purchasing management in a supply chain due to the key role of supplier's performance on cost, quality, delivery and service in achieving the objectives of a supply chain.

An efficient supplier management that begins with the identification of potential suppliers is of central importance for successful supply chain management (Lasch and Janker, 2005). Also, proper supplier selection significantly reduces the purchasing costs and improves corporate competitiveness (Ghodsypour and O'Brien, 2001). Lin (2009) opines that supplier selection for reducing supplier base is an important goal in supply chain management (SCM).

Majority of the supplier selection literature focuses upon the selection of relevant performance metrics, supplier rating for a chosen set of performance metrics and optimization models. In today's competitive markets, it is a known fact that it is the respective supply chains that are competing and not the individual business entities. Lack of supply chain focus, planning horizon, inclusion of subjective performance metrics, multiple goals vs. unitary goal, consideration of interrelationships among the performance metrics chosen for supplier evaluation are some of the key issues that distinguish our model from the models presented in existing literature. Under this category the emphasis is primarily on delineating different performance metrics for supplier selection not the supplier evaluation itself.

The number of performance metrics that one could consider to aid in supplier selection is not only large but also depends on the context (strategic, operational, etc.), type of the product, nature of the markets,

* Corresponding author. Tel.: +1 573 651 2915; fax: +1 573 651 2992.
*E-mail addresses:* gvanteddu@semo.edu (G. Vanteddu), r_chinnam@wayne.edu (R.B. Chinnam), ogusikhi@ford.com (O. Gushikin).

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etc. Among the possible order winners cost and responsiveness turn out to be more crucial than others. In the context of our model, responsiveness is the ability of the supply chain to respond quickly to changing customer needs, preferences, options, etc. in terms of supply chain cycle time, emphasis being on volume related flexibility. Majority of the existing models are cost focused and do not address the responsiveness aspect in an explicit fashion. Also interrelationships between cost and responsiveness are not sufficiently explored. Both of these issues are addressed in our model. Another major difference is that the model works on the strategic perspective with the aim of developing managerial insights that would aid supplier selection at a particular stage in a supply chain.

We are modeling the supplier selection problem as a supply chain configuration problem in the sense that we are assuming that product design and supply chain topology are already fixed and there are competing suppliers at a stage who differ only in terms of cost and responsiveness. A typical configuration for a supply chain consists of defining components of the system, assigning values to characteristic parameters of each component and setting operation policies for governing the interrelationships among these components (Truong and Azadivar, 2005).

There are primarily four drivers of cost in a supply chain, namely, infrastructure, inventories, transportation and information (Chopra and Meindl, 2004). Since we are assuming that the necessary network topology is already in place, it obviates the necessity to include infrastructure related cost elements and transportation related aspects explicitly into our model. However, these issues are addressed in an indirect fashion in our model. For example, cost added at a stage can be considered to be a function of fixed costs associated with infrastructure such as location, buildings, machinery, etc. Even though we are developing the model assuming that all the stages are involved in manufacturing, a stage purely dealing with transportation could be easily accommodated. We are also assuming information symmetry at all the stages and leave information asymmetry related issues for future research. That leaves us with inventory as our primary cost driver. We are considering both cycle stocks (in-process inventory) and safety stocks in our model.

For a stochastic service model (Graves and Willems, 2003; Simchi-Levi and Zhao, 2005; Lee and Billington, 1993; Ettl et al., 2000), which we have adopted in our model, we assume that the increase in cost at a stage depends on the opportunities that exist for resource flexibility. We model it as a continuous function of a novel dimensionless parameter called the 'coefficient of inverse responsiveness' (*CIR*) that also enhances the scalability of the model, with the focus being to develop managerial insights with regard to supplier selection at a stage. With the introduction of *CIR*, research gaps in terms of addressing the interrelationship between the costs and the responsiveness and the scalability limitation are addressed. Also, lack of explicit consideration of the processing time variability is one of the key issues in the existing literature. We have included both the demand variability and the processing time variability in our model thereby mimicking the reality as closely as possible.

The rest of this manuscript is organized as follows. In Section 2 we present the relevant literature review. Section 3 deals with the development of the overall cost expression for the supply chain. Section 4 offers managerial insights in regards to the supplier selection problem in a serial supply chain. Section 5 offers an illustrative example involving the selection of a wiring harness supplier for an OEM facility. Finally, conclusions and limitations are offered in Section 6.

## 2. Literature review

Primarily, the literature dealing with supplier selection/management can be broadly classified into three categories. First category deals with choosing the appropriate performance metrics that aid in supplier selection and evaluation. The number of supplier performance metrics varies from 13 to 60 in different publications (Huang and Keskar, 2007). Huang and Keskar (2007) opine that cost and quality have been the most dominant factors along with on-time delivery and flexibility. Hsu et al. (2006) develop and validate a supplier selection construct and demonstrate that underlying the documented supplier selection criteria there is need to assess a supplier's quality and service capabilities as well as its strategic and managerial alignment with the buyer. Quality, delivery, price of materials and services, responsiveness and service consistently emerge to be the important criteria for supplier selection (Kannan and Tan, 2002; Verma and Pullman, 1998). Huang and Keskar (2007) present an integration mechanism in terms of a set of comprehensive and configurable metrics arranged hierarchically that takes into account product type, supplier type and OEM/supplier integration level. The introduction of degree of alignment with the buyer is a novel feature in Hsu et al. (2006) and Huang and Keskar (2007). Under this category the emphasis is primarily on delineating different performance metrics for supplier selection not the supplier evaluation itself, which is the primary theme that we are trying to address in our research.

Second category in supplier selection/management literature deals with supplier rating/evaluation methods for a given set of performance metrics (Lasch and Janker, 2005; Timmermann, 1986; Weber et al., 1991). Lasch and Janker (2005) designed a suppler rating system that uses principal component analysis to create a classification and ranking of the potential suppliers by means of ellipsoid clusters. Huang and Keskar (2007) is a useful reference for literature review for supplier selection using Analytical Hierarchy Process (AHP), Multi Attribute Utility Theory (MAUT) and outranking methodologies. A thorough description of supplier rating methods with respect to their popularity and other features can be found in Lasch and Janker (2005). Reader can also refer to AHP models (Barbarosoglu and Yazgac, 1997; Nydick and Hill, 1992) that deal with supplier selection problems. In this category the primary emphasis is on supplier rating for a given set of performance metrics using different quantitative approaches. Importance attached to the interrelationships between difference performance metrics and how those interrelationships affect the competitiveness of an organization is one of the key differences between this line of research and the model presented in this research paper.

In the third category, suppler selection problem is treated as a part of an optimization problem. To account for many conflicting and vague objectives and constraints in making supplier selection decisions, Kagnicioglu (2006) proposes a fuzzy multi-objective model, where both the objectives and some of the constraints are fuzzy. Morlacchi (1997) developed a model that combines the use of fuzzy set theory with AHP and implements it to evaluate small suppliers in engineering and machine sectors. Kumar et al. (2004) used fuzzy goal programming to deal with the effect of information uncertainty in supplier section problems. Application of different weights to the chosen set performance metrics to aid in supplier selection is another established procedure. Reader can refer to linear weighting models (Cooper, 1977; Mazurak et al., 1985) for more information. Use of fuzzy variables and linear weighting models bring an element of subjectivity into the model, which is always not desirable. Also, emphasis on too many factors might sometimes dilute the significance of important performance metrics, which could be the order winners for the product in context.

Ghodsypour and O'Brien (1997) used an integrated AHP model with mixed integer programming to reduce the number of suppliers. Integrating AHP model into the optimization architecture is the distinguishing feature of this model. Ghodsypour and O'Brien (2001)