

# Chapter 28

## Multi-Tier Supplier Selection Using Total Cost of Ownership and Data Envelopment Analysis

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### **ABSTRACT**

*Quality management across multiple tiers is vital to minimize cost of quality in global supply chains. In this chapter, the authors address the problem of supplier selection in multi-tier global supply chains with the purpose of overall quality management. A hybrid approach based on total cost of ownership (TCO) and network data envelopment analysis (DEA) is proposed. The TCO looks beyond the quoted cost to cover additional true costs related to the entire purchasing cycle. The cost categories included are quoted price, manufacturing costs, quality costs, design costs, logistics costs, after sales service, and social/environmental costs. Network DEA is used to rank the suppliers based on the TCO cost categories. The advantage of network DEA is its ability to investigate intermediate linkages between different stages of the supply chain. The results of network DEA are efficient suppliers and improvement targets for inefficient suppliers for improving overall quality in global supply chains. A numerical application is provided.*

### **INTRODUCTION**

With the complexity of today's supply chains; firms have difficulty keeping track of all the activities happening in the supply chain. Less visibility and control of key processes have become the result of manufacturing, logistics and other roles such as outsourcing (Morehouse and Cardoso, 2011). As a result, the supply chain is now more vulnerable to frauds than before. Due to poor traceability of supplier quality across multiple tiers in global supply chains, several serious incidents have occurred in recent years. Babies got poisoned by contaminated milk in China (Bradley, 2008) due to use of melamine instead of protein nitrogen by one supplier to gain some extra profit. In 2007, Canadian pet food manufacturer and retailer, Menu Food, had a massive recall of one popular pet food product because it caused sickness and death of animals due to presence of high melamine level in some ingredients imported from Chinese

DOI: 10.4018/978-1-5225-9570-0.ch028

suppliers (Chen *et al.*, 2014). Mattel recalled millions of toys in 2007 due to the use of contaminated paint containing high levels of lead content which is harmful for children health (Viswanadham and Samvedi, 2013).

To minimize the occurrence of such incidents, firms have strived to achieve successful supply chain collaboration. Collaboration can improve the traceability and visibility among the supply chain (Sarpong, 2014), which in turn improves the quality of the final product or service. Moreover, collaboration can deliver significant benefits to all parties such as excess inventory reduction, bullwhip avoidance, business synergy enhancement, flexibility and increase joint innovation (Cao and Zhang, 2011). Supply chain performance enhancement (Vereecke and Muylle, 2006) by leveraging the knowledge and resources of suppliers (Cao and Zhang, 2011) are some results of a successful collaboration.

Although product design, warehousing, and distributions centers can all be the subject of quality improvement programs; purchasing emerges on top in the list being the biggest contributor to the cost of quality. Effective purchasing decisions are necessary to achieve an acceptable level of cost and quality trade-off and gain overall efficiency in the supply chain. Supplier evaluation process is very critical to purchasing management and therefore essential for the success of the focal firm (Choi and Hartley, 1996; Singh, 2014). It is a complex multiple criteria decision making problem that requires careful selection of criteria (Omurca, 2013). Both qualitative and quantitative criteria should be used in evaluating the supplier performance. Additionally, it should speak the language of business, or money, to ensure acceptance among purchasing managers. It must also reflect the network structure of the supply chain. As a result, all the  $n$ -tier suppliers and the linkages between them should be evaluated for overall quality management in supply chains. We argue that evaluation of suppliers is only the first step towards a successful collaboration relationship. Evaluation will reveal the weak areas of each supplier and recommend methods for improvement. Moreover, this evaluation will be the basis for supplier development programs.

In this paper, we are addressing the problem of supplier selection in multi-tier global supply chains with the purpose of overall quality management. A hybrid approach based on total cost of ownership (TCO) and network data envelopment analysis (DEA) is proposed. The strength of TCO is that it looks beyond the quoted cost to cover additional true costs related to the entire purchasing cycle. In addition to the quoted price, it includes order placement costs, research costs, transportation costs, receiving costs, inspection costs, holding costs, and disposal costs (Bhutta and Huq, 2002). DEA is a powerful linear programming based technique to measure the relative performance of decision making units (DMUs) with multiple inputs and multiple outputs. It can handle both quantitative and qualitative input/output data. DEA does not require the decision maker to assign weights to each indicator but calculates weights from the given data. Additionally, DEA finds the efficient decision making units (suppliers) and provides improvement targets for inefficient suppliers to become efficient.

The rest of the paper is organized as follows. In section 2, we present the literature review. Sections 3 and 4 contain the proposed solution approach and its numerical application. The conclusions and future works complete the paper in section 5.

## **LITERATURE REVIEW**

In today's world it is not possible for a single organization to own its entire supply chain like the Ford Company in the first half of the 20th century (Gelderman, 1989). To stay competitive in global market; organizations have to outsource many critical business processes and value chain activities to suppli-

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