Supplier selection-order allocation: A two-stage multiple criteria dynamic programming approach

Fereshteh Mafakheri a, *, Michele Breton b, Ahmed Ghoniem c

a Business School, University of Greenwich, London, SE10 9LS, UK
b GERAD & HEC Montreal, Montreal, QC, H3T 2A7, Canada
c Isenberg School of Management, University of Massachusetts Amherst, MA 01003, USA

1. Introduction

Supply chain management provides an integrated decision-making framework for the planning and control of firm assets, operations, transactions, and information channels in a fashion that maximizes business profitability and customer satisfaction. Purchasing constitutes one of the key strategic functions in supply chain management. For a typical manufacturer, purchased items (such as raw materials) may represent 60% of her total sales, and the purchasing share in the total turnover in industrial companies chain management. For a typical manufacturer, purchased items (such as raw materials) may represent 60% of her total sales, and the purchasing share in the total turnover in industrial companies normally ranges between 50–90% (Boer et al., 2001). It is therefore essential to carefully manage the supplier selection process and the order allocation strategy of the firm in order to establish a competitive and effective purchasing function.

Selecting the right supplier(s) gives a company a competitive edge and is instrumental in reducing costs and improving the quality of end products. As a consequence, there exists a continued interest in the development of suitable frameworks to evaluate and select suppliers. As far as the order allocation strategy is concerned, supply chain management practitioners seek to identify the optimal ordering quantities to be purchased from each supplier over a specified planning horizon. To this end, a wide spectrum of mathematical programming models has been investigated to gain insights into newsvendor-type settings or lot-sizing problems under various assumptions.

This paper develops a multi-criteria decision-making framework that incorporates supplier selection and order allocation decisions under time-varying prices/costs, capacity, and demand volumes and profiles. The novelty of the proposed approach stems from the fact that, to the best of our knowledge, all proposed supplier selection-order allocation frameworks in the literature are based on either static-multiple objective or dynamic-single objective models.

The remainder of the paper is organized as follows. In Section 2, we present a review of the relevant literature. Section 3 provides a formal problem statement, and elaborates on the application of the analytic hierarchy process (AHP) to rank potential suppliers and the proposed bi-objective order allocation model which is solved in Section 4 using an adequate dynamic programming approach. Section 5 discusses a small-sized illustrative example to gain insights into the proposed decision-making framework and the dynamic programming solution. Section 6 concludes the paper with a summary of our findings and directions for future research.
3. Supplier selection and order allocation

3.1. Problem statement

Consider a manufacturer who needs to fulfill her/his purchasing requirements from \( n \) potential suppliers over a planning horizon of \( T \) periods. Using AHP (as described next in Section 3.2), potential suppliers are ranked based on 4 utility criteria of price performance, quality, delivery performance, and environmental performance, which themselves are decomposed into 21 sub-criteria as shown in Fig. 1 (Humphreys et al., 2003; Kokangul and Susuz, 2009). Using this ranking, the manufacturer seeks to determine optimal ordering quantities from the different suppliers in a fashion that minimizes the total cost of purchase (TCP) and maximizes the total value of purchase (TVP), which represents a manufacturer’s utility function based on the ranks (scores) of potential suppliers as discussed in Section 3.3.

3.2. Supplier ranking using AHP

Once the set of criteria for assessing the performance of suppliers is identified (Fig. 1), the relative weights (scores) of suppliers can be obtained using a multiple criteria decision analysis framework such as the AHP based on qualitative and quantitative factors. Let \( i = 1, \ldots, n \) index the different potential suppliers and \( p_{ij} \) represent the extent to which supplier \( i \) is preferred over supplier \( j \) with respect to a given criterion. For illustrative purposes, Table 1 shows a pair-wise comparison matrix \( P = [p_{ij}] \) for four supplier selection criteria (Price Performance, Delivery Performance, Environmental Performance, and Quality) with respect to the overall goal of supplier selection. Pair-wise comparisons in Table 1 are obtained using a scale from 1 to 9, where 1 is for equal importance, 3 for moderate importance, 5 for strong importance, 7 for very strong importance, and 9 for extreme importance. In addition, the even values 2, 4, 6, and 8 are used to reflect intermediate nuances in this scale. Also, note that the condition \( p_{ij} = 1/p_{ji} \) (Saaty 2000) needs to hold, as shown in Table 1. Let \( \lambda_{m} \) be the largest Eigenvalue of matrix \( P \) (for a perfectly consistent pair-wise comparison matrix, one should have \( \lambda_{m} = n \)). To measure the inconsistency of pair-wise comparisons, Saaty proposes the following consistency index (CI):

\[
CI = \frac{\lambda_{m} - n}{n-1} \times 100\%
\]

To check if the value of CI corresponds to an acceptable level of inconsistency, it is compared with a random consistency index \( RI \), which is obtained as the average consistency index of a large sample of randomly generated reciprocal matrices (Saaty 1977) using a sample of 500 matrices. The level of inconsistency in the judgment matrix is considered acceptable if the consistency ratio (CR) satisfies

\[
CR = \frac{CI}{RI} \leq 10\%
\]

The second step is to obtain the score, or relative weight, of each alternative with respect to each criterion. This score is the average of the normalized comparisons, computed by

\[
w_{i} = \frac{\sum_{j=1}^{n} p_{ij}}{n} \quad \text{where} \quad p_{ij} = \frac{p_{ij}}{\sum_{k=1}^{n} p_{ik}}
\]

The upward composition of these weights (from the lowest level towards the top level) generates the ranking scores (weights) of elements at the lowest level (i.e., suppliers) in fulfilling the top-most objective (i.e., suppliers ranking).

3.3. Order allocation model

The suppliers’ weights (utility scores) obtained from AHP are used to build a utility function for order allocations called the total value of purchase (TVP), where the optimal allocation is the
دریافت فوری
متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات