Chapter 78
Complex Real-Life Supply Chain Planning Problems

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ABSTRACT

Supply chain planning concerns the selection of strategies and methodologies to facilitate the optimal flow of material from raw material suppliers to end-users through procurement, production and distribution activities. Supply chain (SC) implementation has significant impacts on the financial performance of manufacturing and distribution companies. Developing real-life SC models with centralised planning naturally leads to complex models which are difficult to solve optimally. This chapter firstly presents a comprehensive review on the current literature of SC planning and optimisation and classifies the published models based on their complexity. Next, a mixed-integer non-linear formulation is presented for modelling complex real-life SC planning problems which accommodates the identified gaps in the current literature. Evaluation of the available tools and techniques for the optimisation of the proposed SC model will conclude this chapter.

1. INTRODUCTION TO SUPPLY CHAIN PLANNING

A supply chain (SC) can be defined as an integrated system synchronising a series of interrelated business processes in order to: (1) acquire raw materials and parts, (2) transform these to finished products (adding value), and (3) distribute final products to retailers or final customers. A SC plan facilitates the flow of information among SC participants including suppliers, manufacturers, distributors, retailers and final customers (Min & Zhou, 2002). Today, under the threat of increasing competition, firms must use effective planning and optimisation models and algorithms, decision support systems (DSS), and computerised analysis tools to improve

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their operational performance along SCs (Yilmaz & Çatay, 2006). For this, researchers and practitioners have developed and implemented many SC planning models and methods for optimising their entire operations to win business (M. Chen & Wang, 1997).

The two core partial optimisation problems in the SC network are production planning and distribution planning problems. In production planning, decisions regarding hiring and firing of labour, regular time and overtime production, subcontracting, as well as machine capacity levels are made for a definite planning horizon (i.e. usually a one year period). Distribution planning decisions, on the other hand, pertain to determining which facility(ies) would cater to the demands of which market(s) (Mohamed, 1999). In a conventional SC, independent manufacturers, wholesalers, and retailers are separate business entities seeking to maximise their own profits although this goal is known to eventually produce profit for the system as a whole (Barbarosoglu & Ozgur, 1999). However, it is now widely acknowledged that production and distribution decisions are mutually related problems and need to be dealt with simultaneously in an integrated manner (Park, Choi, & Kang, 2007).

Unfortunately, developing real-life integrated SC models with centralised planning naturally leads to complex, large-scale models which are difficult to solve optimally. For this reason many alternative solution techniques developed in the literature are only able to provide near optimal solutions for small and medium-size integrated models (Barbarosoglu & Ozgur, 1999). This chapter presents a comprehensive review on the current literature of SC planning and optimisation. To accommodate the identified gaps in the current literature a mathematical formulation is presented for modelling complex real-life SC planning problems.

2. SUPPLY CHAIN PLANNING PROBLEM

A SC network includes procurement, manufacturing and distribution organisations working together to profitably provide the right product to the right customer at the right time (see Figure 1). Supply planning concerns with the selection of strategies and methodologies by the participating organisations (i.e. procurement, manufacturing and distribution) for satisfying the SC's short and long-term objectives (Gavirneni, 2006). From this definition, a SC manager is responsible for numerous decision makings such as the amount of raw material to purchase, production planning and inventory control issues, as well as transportation planning and warehousing decisions. In this chapter, SC is referred to as a production-distribution network in which the procurement activities are not incorporated and the SC network includes a set of manufacturers, warehouses and end-users.

SC planning is generally accomplished in 3 stages (Torabi & Hassini, 2009). The first stage is the strategic level or long-term planning where the SC configuration is determined (e.g. the location of manufacturing plants and warehouses). The objective at the second stage—tactical level or mid-term planning—is to determine the procurement, production and distribution quantities in order to minimise the overall SC costs while satisfying the customer demands. Finally, the third stage is the operational level or short-term planning where the day-to-day activities are managed according to the work plan drawn at the tactical level.

Over the last two decades, the importance of SC planning and optimisation at tactical and operational levels has been recognised as a competitive advantage for the growing production/distribution firms. There is also a growing recognition that these companies may not be able to compete without a global integration of all activities across SC (Sarmiento & Nagi, 1999). It is widely acknowledged that in order to achieve a globally