Chapter 11
Design of Robust Supply Chains:
An Integrated Hierarchical Planning Approach

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ABSTRACT

In a supply chain operating under uncertainty, a possible approach to reduce the complexity and scope of the planning process is to organize all involved critical planning decisions in a hierarchical structure. This chapter attempts to explore new ways of integrating production and scheduling plans in a complex supply chain taking into account effects of some specific uncertainty types. In particular, uncertainty types inherent to the demand and to the process or equipment are considered. To deal with demand uncertainty at the strategic level, the safety stock placement problem in supply chains with limited production capacities is investigated. Results of this analysis and its consequences at the design level are reported and discussed. At the tactical level, each stage in the supply chain generates its own aggregate plans in order to balance supply and demand. To deal with uncertainty at this level, some robust deterministic planning models are discussed. These models make use only of the readily available data, such as averages and standard deviations, related to the uncertain planning parameters. At the operational level, the issue of disaggregating the generated robust tactical plans into detailed plans is investigated. A model taking into account the progressive deterioration of the production equipment is discussed. The results of some simulations are also reported and discussed.

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INTRODUCTION

A supply chain consists of vendors, manufacturers, distribution centers and customers that are connected by flow of materials, money and information as shown in Figure 1. A manufacturer transforms either raw materials into semi-finished products or semi-finished products into finished products. A distribution center is responsible for receiving, sorting, picking and dispatching products into inventories without physically transforming the products. Supply chain management consists of all activities necessary to plan, control and monitor the movement of materials as they flow from their source to the end customer. The aim of a supply chain is naturally to satisfy customer demands in the right level of quantity, quality, and on the right time. We refer the reader to the book “Modeling the supply chain” by Shapiro (2001) for a thorough introduction to modeling in supply chains.

Hierarchical Planning

As mentioned before, supply chain management consists of activities such as planning, procuring, producing, transporting, and selling. A procurement plan decides on what to buy, when to buy, from whom to buy, and so on. A production plan determines when to produce, how much to produce, and so forth. A distribution or transportation plan consists of decisions on what and where to transport, which transportation mode to use (truck, train, et cetera). It is worth noting that all other supply chain activities are driven by the first activity, that is: demand and supply planning, also known as supply chain planning.

Based on the significance and extent of the involved planning decisions, the complete planning process in a supply chain can be categorized hierarchically (see Shapiro, 2001). At the highest level, decisions are typically made for strategic matters for a planning horizon of one to five years and revised periodically (each two years). Strategic decisions have significant impact on the long-term success of the supply chain as they involve a substantial amount of investments and are future oriented with multifunctional consequences. This last fact makes these decisions rather difficult to revise if something goes wrong. Typical strategic decisions involve the design of the logistics network, including facility locations,