Chapter 88
Profit Maximizing Network Modeling With Inventory and Capacity Considerations

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ABSTRACT

Developing integrated strategic, tactical, and operational manufacturing and distribution plans for the global supply chain of a large, international firm represents a formidable planning, as well as organizational undertaking. Moreover, to develop and execute plans that are not only integrated but which maximize profits on a global basis presents a challenge of far greater magnitude. The use of advanced optimization modeling-based analytics can generate keen insights for management decisions regarding sourcing, production, distribution, inventory, and demand management on supply chain networks. This includes scenario and contingency planning analyses of complex strategic trade-offs such as the optimal balance between inventory levels and reserve manufacturing capacity on a network. In this chapter, the authors illustrate how optimization models can support a firm's planning efforts for these and related supply chain business decisions.

INTRODUCTION

Developing integrated strategic, tactical and operational manufacturing and distribution plans for the global supply chain of a large, international firm represents a formidable planning, as well as organizational undertaking. Moreover, to develop and execute plans that are not only *integrated*, but which *maximize profits* on a global basis presents a challenge of far greater magnitude. The use of advanced optimization modeling based analytics can generate keen insights for management decisions regarding sourcing, production, distribution, inventory and demand management on supply chain networks. This includes scenario planning analyses of complex strategic trade-offs such as the optimal balance between

DOI: 10.4018/978-1-5225-7362-3.ch088

inventory levels and reserve manufacturing capacity on a network. The use of these techniques can bring clarity to the complex decisions that make integrated manufacturing and distribution planning both difficult and important (Shapiro 2010).

For purposes of this chapter, we will define "optimization modeling based analytics" as the utilization of mathematical optimization models to provide decision support for supply chain network decisions and management (i.e., models employing linear, mixed integer and nonlinear programming and related heuristic algorithms). Thus, optimization based modeling techniques represent an important component of the overall set of analytic decision support tools that can help facilitate efficient and effective supply chain network planning and management.

In summary, the objectives of this chapter include the following:

1. To review the role of optimization modeling based analytics in supporting a firm's supply chain planning and management activities,
2. To discuss how mathematical optimization models with profit maximizing objective functions fit into a hierarchical framework for a firm's supply chain network planning and scheduling processes,
3. To illustrate how optimization models can support key strategic network design decisions such as the appropriate balance between inventory and manufacturing capacity investment,
4. To review why optimization modeling based analytics will continue to play an increasingly important role in supply chain network decision support and management.

BACKGROUND

Supply chain management mathematical optimization models are the optimal tools for analyzing complex supply chain management problems (Shapiro 2010). In this chapter, we will focus on "deterministic" mathematical optimization models where a model solution is driven by an exogenously given (i.e., pre-determined) forecast. We note that in industry practice, the vast majority of optimization models employed are deterministic. Practitioners typically address the potential limitations of using a single, fixed forecast by running their optimization planning models under multiple forecast scenarios, where often probabilities are assigned to each scenario. This approach alleviates the potential limitations of developing a planning solution based upon just one, deterministic forecast (Shapiro, 2010). Examples of potential uses of advanced optimization based analytics are as follows: in planning, the analysis of data to predict market trends of products and production capacity requirements; in sourcing, the use of an agent-based procurement system; and in delivering products, the applications of business analytics in logistics management to bring the products to the markets more efficiently (Trkman et al. 2010).

The methodologies and technology to support integrated profit maximization planning are well established, and the required resources are not exorbitant. In fact, the use of mathematical optimization to support logistics and supply chain management practice can be found in such industries as the oil and chemical industry as early as the 1960s (Miller, 2002) Yet despite early pioneering work in certain industries, this remains an area of terrific opportunity for many firms because surprisingly few employ these techniques in their current strategic and tactical planning processes.

There are several reasons for the underutilization of optimization techniques in supply chain planning. Briefly, factors that have contributed to this relatively slow uptake include: