

Profit Maximization Modeling for Supply Chain Planning

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INTRODUCTION

In a large firm with a presence spanning multiple countries, one often finds an organization consisting of many different manufacturing and distribution units. Developing integrated strategic, tactical and operational manufacturing and distribution plans for the global supply chain of such a 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 and guidance for management decisions regarding sourcing, production, distribution, inventory and demand management on supply chain networks. 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. Examples of

other analytic tools and techniques used in supply chain network planning include simulation, data mining, database management, and forecasting to name a few (see Liberatore & Nydick, 2003; Shapiro, 2010, for additional examples and background).

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 review why optimization modeling based analytics will continue to play an increasingly important role in supply chain network decision support and management.

BACKGROUND

Advanced analytics for manufacturing and distribution planning is the application of supply chain management models and descriptive models to data in order to develop and analyze information, and to generate management decision support and recommended solutions to the process of planning, sourcing, making and delivering products and services to end customers and consumers.

Supply chain management mathematical optimization models, which include linear programming, mixed integer programming and nonlinear programming 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 private industry supply chain 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). Descriptive models such as forecasting, data mining, management accounting and others, are utilized to process the data acquired from transactional databases such as a firm’s Enterprise Resource Planning (ERP) System and stored in the Supply Chain Management (SCM) database. 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:

1. Until the last 10 to 15 years, employing these techniques required that a firm have employees with advanced operations research skills (- note this is no longer a requirement because of commercial software advances)
2. Many senior managers remain relatively unfamiliar and/or uncomfortable with the true benefits of this mathematical technique
3. Many senior managers believe they can make effective network planning decisions without investing resources in optimization tools (- this is related to factor 2 above).

MAIN FOCUS

A well-constructed and maintained decision support system (DSS) supported by advanced optimization analytics represents a critical tool to facilitate coordinated supply planning and execution. A supply chain planning DSS typically has numerous components (Liberatore & Nydick, 1998, 2000; Liberatore & Miller, 2012) and will vary significantly by firm and supply chain. For global manufacturing and distribution planning, the inclusion of mathematical optimization models within a DSS structure can represent the difference between a DSS that provides information and a DSS that truly facilitates integrated planning and execution.

Specifically, advanced analytics for global manufacturing and distribution that utilize optimization models which consider all of a firm’s manufacturing facilities, distribution locations, transportation routes and modes, and customer demands can facilitate the development, implementation, and maintenance of globally coordinated plans and schedules. A cost minimization methodology represents the most common optimization modeling approach for integrated manufacturing and distribution planning. Particularly in single

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