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Logistics Management
Logistics Management

An Analytics-Based Approach

Tan Miller
Matthew J. Liberatore

BUSINESS EXPERT PRESS
Dedication

This book is dedicated to my wife Jeanne and sons Lucas and Nate who have been so supportive and put up with me for all these years.

—Tan Miller

This book is dedicated to my wife Mary and my daughters Kathryn, Michelle and Christine for always being there for me.

—Matt Liberatore
Abstract

As we head into the ever-more globalized world of the 2020s, the critical role that logistics planning and operations plays in ensuring a firm’s financial well-being escalates in importance almost daily. Furthermore, the role of analytics in guiding both logistics planning and operational activities has spiked dramatically in the last decade, and this exponential growth shows no sign of slackening. As the phenomenon of Big Data has taken hold in the private sector, firms that as recently as 10 years ago devoted minimal resources to large-scale data mining and analytics have reversed course and invested heavily in data analytics.

In this environment, logistics professionals must have at their disposal, and must understand how to utilize, a broad array of analytic techniques and approaches to logistics decision making. Effective use of analytics requires a strong understanding of both fundamental and advanced logistics decision-making techniques and methodologies. Further, logistics professionals must organize and view these analytics-based decision support tools through well-structured planning frameworks.

In this book, based on more than 25 years of logistics industry practice, we illustrate and explain a wide range of practical logistics strategies and analytic techniques to facilitate decision making across functions such as manufacturing, warehousing, transportation, and inventory management. Further, we also describe how to organize these analytics-based tools and strategies through logistics frameworks that span strategic, tactical, and operational planning and scheduling decisions.

This book is intended for logistics professionals to use as a reference document that offers ideas and guidance for addressing specific logistics management decisions and challenges. In particular, it provides explanatory and “how to implement” guidance on foundational analytics that logistics professionals can employ to generate practical insights to facilitate their daily and longer-term logistics management activities. This book can also serve as a valuable resource or secondary text for graduate and advanced undergraduate students. Students will develop an understanding of leading edge, real-world approaches for logistics planning and scheduling, decision support, performance measurement, and other key logistics activities.
Keywords

logistics planning; logistics analytics; logistics planning frameworks; logistics management; operations management; logistics performance measurement; logistics metrics; transportation planning; transportation mode choice decision making; integrated inventory and transportation planning; strategic planning; production planning and scheduling; distribution planning; logistics; hierarchical planning; decision support systems; activity-based costing; collaborative planning, forecasting, and replenishment; the analytic hierarchy process; feedback loops
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CHAPTER 1
Introduction

To introduce a previous book published in 2012, we stated that “in today’s competitive global economy, a firm’s market position and bottom-line financial performance is closely linked to its logistics performance.” Today, as we head into the ever-more globalized world of the 2020s, the critical role that logistics planning and operations plays in ensuring a firm’s financial well-being escalates in importance almost daily. Furthermore, the role of analytics in guiding both logistics planning and operational activities has spiked dramatically since 2012, and this exponential growth shows no sign of slackening for the foreseeable future. Examples of this abound as in recent years many firms, both large and small, have launched new Data Science or similarly named groups. As the phenomenon of Big Data has taken hold in the private sector, firms that as recently as 10 years ago devoted minimal resources to large-scale data mining and analytics have reversed course. The fear of competitive disadvantage and the promise of gaining competitive advantages through data analytics have stimulated enormous internal investments in labor (i.e., data scientists), hardware, and software across industry.

In this environment, logistics professionals must have at their disposal, and must understand how to utilize, a broad array of analytic techniques and approaches to logistics decision making. Effective use of analytics requires a strong understanding of both fundamental and advanced logistics decision-making techniques and methodologies. Further, logistics professionals must organize and view these analytics-based decision support tools through well-structured frameworks.

In this book, we illustrate and explain a wide range of practical logistics strategies and analytic techniques to facilitate decision making across functions such as manufacturing, warehousing, transportation, and
inventory management. Further, we also describe how to organize these analytics-based tools and strategies through logistics frameworks that span strategic, tactical, and operational planning and scheduling decisions. Logistics professionals can use this text as a reference document that offers ideas and guidance for addressing specific logistics management decisions and challenges. In particular, this book provides explanatory and “how to implement” guidance on foundational analytics that logistics professionals can employ to generate practical insights to facilitate their daily and longer-term logistics management activities.

Objectives of the Book

In over 25 years of private industry and consulting experience, we have implemented numerous management decision support and performance measurement systems to manage logistics functions. Further, we have implemented these systems with a keen eye focused on how each system and technique fits into an overall framework for analytics-based logistics decision making in a firm. The implementation of one system or technique typically leads to additional related implementations over time, particularly if the initial implementation generates benefits highly valued by an organization. For this reason, it is critical that one view the development and installation of logistics decision support systems (DSS) within the context of the logistics organization’s overall long-term and short-term needs. Our experience has taught us that firms that take this approach make themselves significantly more competitive and agile relative to firms that bounce from one implementation to the next without an overall framework and vision for their logistics decision making processes.

We have several objectives in writing this book. First, we wish to communicate to other logistics practitioners and executives the value of investing in the logistics analytics tools that we describe. These methods served us well in practice, and we strongly recommend them. And as we will illustrate, all the analytics techniques we present can be readily implemented. Our second objective is to raise the visibility and, ultimately, the utilization of these methodologies. In this new age of analytics, one may question whether there remains a need to illuminate further the value of logistics analytics. However, despite the “buzz” about “big data” and the
“digital age,” and despite the rapid growth in this area during the last decade, many current surveys of practitioners find major logistics decisions still being made without appropriate decision support tools. For example, *Supply Chain News* recently conducted a survey across 23 countries and many industries ranging from “chemicals to manufacturing, metals, telecom, cosmetics, consumer goods, transportation and food.” This survey found that:

Most respondents rely on a combination of spreadsheets (nearly 60%), gut feel (15%) and previous experience (45%) to make supply chain network decisions. Only about 22% use network design software and … more than half of the professionals assessed indicated that they didn’t use some form of advanced analytics to support their network design process. (Further) none of these respondents share data across multiple applications … in an integrated way.¹

This leads to our third objective for this book, namely, by presenting analytics tools in easy-to-follow illustrations, we hope to facilitate the implementation of these methodologies by others who wish to utilize them.

**A Hierarchical Framework for Logistics Planning**

The planning activities and decisions that management must make for the logistics function range from the extremely long run to the short run day to day.² Further, the characteristics of these activities and decisions range from those requiring vast resources and managerial time (as measured by cost, required planning inputs, level of risk, and other attributes) versus those requiring relatively minimal time and resources. For example, consider the vast differences in the required inputs for, and implications of, a plant location and sizing decision versus a one-week production line scheduling decision. To effectively address this broad spectrum of management and operational control activities and decisions required in any

¹Supply Chain News (November 7, 2018)
²To be clear, this statement applies to supply chain management and all of its functional areas. Because the logistics function, a major subcomponent of supply chain management, is the subject of this book, we focus on this activity and its subcomponents.
major logistics function (e.g., manufacturing), it is necessary to separate the future planning horizon into three buckets:

1. Strategic Planning,
2. Tactical Planning, and
3. Operational Planning

These three planning horizons must be closely and hierarchically linked to ensure aligned decision making, and we will discuss analytic techniques and strategies that facilitate this alignment throughout the book. The interested reader is also referred to Liberatore and Miller (2012) to learn more about the theory and process of hierarchical planning, the types of decisions made at each level of the planning process, and techniques to facilitate the critical linkages required between the logistics management function and a firm’s business mission, objectives, and strategies.

Figure 1.1 displays a generic logistics planning framework. We describe this framework as generic because it illustrates that the planning activities of any individual logistics function can (and should) be linked to the overall business and logistics strategic planning process of an organization. Examples of significant individual logistics functions include:

- Manufacturing
- Distribution
- Customer service
- Inventory
- Transportation

The definition of what constitutes a major individual logistics function will vary by firm. For example, some firms may consider manufacturing as being separate from logistics. Some firms consider customer service as a component of their logistics organization, while other firms do not. Regardless of how many functions within a logistics organization a firm chooses to define as major individual units, the framework in Figure 1.1 provides a well-defined, holistic organizational approach.

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3The analytics decision support methods and strategies presented in this book will concentrate primarily on these five functional areas.
Figure 1.1 A logistics planning framework
The logistics planning framework is driven by a firm's business strategic planning process. The goals and objectives developed at the business unit level establish requirements and define capabilities that the logistics organization must provide to support business objectives. This facilitates the next strategic planning process, where the logistics organization formulates its overall mission, goals, objectives, and strategies. The outputs of this process generate high-level requirements and define capabilities that the individual functions within logistics must then deliver. At this point, individual functions such as manufacturing and distribution must initiate their own planning processes to map out the contributions that they will each make in support of the overall logistics plan.

The hierarchical planning framework requires that each individual function delineate the future planning horizon into strategic, tactical, and operational planning buckets. Thus, each logistics function has its own strategic, tactical, and operational planning processes. To illustrate the different types of decisions and management controls exercised at each planning level, note in Figure 1.1 that at the tactical level we use “scheduling” as a function descriptor while at the operational level “execution” is the function descriptor. In practice, at the tactical level one observes both planning and scheduling activities, while at the operational level, planning, scheduling and execution activities all occur. Finally, also note the following in the figure:

1. There are bidirectional vertical lines between the strategic, tactical, and operational planning levels of each logistics function (e.g., manufacturing). The lines flowing from higher to lower levels illustrate that decisions made at higher levels impose constraints or boundaries on decisions made at lower levels. Conversely, lines emanating from lower to higher levels are known as a “feedback loops” in a hierarchical planning system and illustrate the critical need for upward input and communications from lower to upper levels. We will discuss and provide examples of both top-down constraints and bottom-up feedback loops later in this book.

2. There are dashed horizontal lines between the individual functions. These lines illustrate that in practice, interactions in many forms should (and do) occur between individual logistics functions. These interactions can be both formal (e.g., joint planning sessions) and informal (e.g., day-to-day communications).
In summary, the generic logistics planning framework depicted in Figure 1.1 facilitates aligned planning, scheduling, and execution activities all the way down to the operational levels of each individual logistics function.

**Analytics Decision Support and Performance Metrics**

Now that we have introduced a framework for logistics planning, we turn to the central focus of this book, namely, the role of analytics-based DSS. Analytics decision support methods and systems for logistics planning span a broad array of methodologies and techniques ranging from spreadsheet-based analyses and statistical analyses, to database analyses and data mining, to sophisticated mathematical optimization and simulation models.

Performance measurement systems (PMS) provide managers with indicators of how efficiently and effectively their logistics network is operating. Additionally, good PMS also offer advance warnings or indications of potential future problems. A good PMS is also an absolute necessity to support the planning frameworks of a logistics organization.

Figure 1.1 depicts the integral role that analytics-based decision support and PMS play in a logistics planning framework.

As illustrated, each individual logistics function must have appropriate analytics tools at each level of its planning process. Similarly, each function must also have pertinent performance metrics to monitor its activities. And collectively, the logistics organization must have the DSS and PMS tools required to manage the entire process. A firm with strong analytics/DSS tools and PMS capabilities, but that lacks the appropriate logistics frameworks to organize and utilize these tools cannot succeed. Similarly, a firm with good logistics frameworks, but that lacks the proper DSS and PMS tools cannot succeed. However, a firm with all of these components in place positions itself to conduct effective logistics planning and successful operations.

**Logistics Planning: Analytics Methods and Time Horizons**

Analytics techniques to support logistics planning and operations provide support for the most highly strategic to the most granular operational
short-run decisions. The myriad planning methods and tools that a firm employs to facilitate its logistics decision making collectively comprise a firm’s logistics DSS. Figures 1.2 and 1.3 present an illustrative overview of selected methodologies and applications, respectively, frequently found in a firm’s logistics DSS.

**Figure 1.2 Logistics decision support tools**

- Optimization Models
- Simulation Models
- Forecasting Models
- Statistical Models
- Visualization Tools
- Spreadsheet Models
- Database Tools
- Smart Phone Apps (Applications)
- Artificial Intelligence Based Tools

**Figure 1.3 Illustrative applications of logistics decision support tools**

- Manufacturing and/or Distribution Network Planning
- Manufacturing and/or Distribution Network Scheduling
- Plant Capacity Planning and Scheduling
- Warehouse Capacity Planning and Scheduling
- Transportation Planning and Scheduling
- Inventory Network Requirements Planning
- Inventory Replenishment Scheduling
- Network and Location Long Run Demand Forecasting
- Network and Location Short Run Demand Forecasting

A firm’s logistics DSS must address all of its planning requirements from the very long run to the short run day-to-day, as previously noted. Whether a firm is in the initial stages of constructing its DSS or expanding a mature system’s capabilities, the ability of a DSS to support the full planning horizon represents a critical consideration. A firm that has excellent strategic planning tools but poor operational planning tools
will struggle with execution. Conversely, a firm with strong operational tools but weak strategic tools will experience inefficiencies in its logistics operations caused by such issues as inadequate long-run infrastructure planning.

Thus, a comprehensive logistics DSS supports all three planning horizons. Figure 1.4 provides a perspective on the planning horizons and product aggregations found in a hierarchical DSS.

Notice that the three planning horizons differ not only in time frame, but also in granularity. While operational planning time buckets range from weeks and months down to hours and shifts, strategic planning time buckets are more typically defined in years or often in one time bucket (e.g., a plan for the next 3 to 5 years viewed as one bucket). In terms of product aggregations, again the planning hierarchy flows from the highly granular at the operational level (e.g., end items) to the highly aggregated at the strategic level (e.g., an entire division or business unit’s products). In this book, we will review logistics DSS tools at each level of aggregation.
Scope of the Book

This book presents a broad variety of analytics-based approaches to logistics management. Functional areas addressed will include manufacturing, distribution, inventory management, transportation, and customer service. Within these functional areas, we offer analytical techniques to provide decision support for all planning horizons (i.e., from the operational to the strategic). Further, we describe the role that individual DSS methods play in an overall hierarchical logistics planning framework.

Organization of the Book

The remainder of this book is organized into three major parts followed by a final summary chapter. Part One presents a detailed methodology that logistics professionals can employ to make transportation modal choice decisions on a network. In particular, we demonstrate how and why long-run transportation modal choices (e.g., air vs. ocean) should incorporate network inventory plans and requirements into the decision making process. Thus, Part One is titled “Integrated Inventory and Transportation Mode Decision Making.”

This section of the book furnishes the reader with a complete, easy-to-use and easy-to-implement methodology for making transport modal choice decisions. All variables and equations are explained. The discussion guides the interested reader through all the details required to incorporate this straightforward methodology into a ready-to-use, spreadsheet-based transport modal choice DSS.

Part Two, titled “Logistics Decision Support,” examines a series of real-world cases where firms utilized a variety of methods to provide decision support for manufacturing, distribution, customer service, and inventory management. A consistent theme throughout this section and the rest of the book is the value of incorporating standardized planning processes into a firm’s business logistics operations. To introduce this concept, we briefly review how CPFR (Collaborative Planning, Forecasting, and Replenishment) evolved from a simple forecasting experiment between a manufacturer and retailer into a full-blown industry standard for collaborative planning and operations. We then review several case
studies that span logistics decisions ranging from strategic manufacturing and distribution network planning to daily warehouse operations and inventory deployment. Part Two concludes with discussions of several key methodologies such as activity-based costing and hierarchical planning feedback loops that serve numerous logistics decision support roles.

Part Three, titled “Metrics and Techniques for Logistics Monitoring and Control,” begins with a presentation of a framework to organize logistics metrics. This hierarchical methodology facilitates maintaining all the logistics metrics of a firm in an aligned, organized approach that monitors logistics performance from the strategic level down to the operational. Next, we illustrate a DSS technique that a firm can implement to construct a customized set of indices to monitor overall logistics performance. The discussion illustrates how a firm can develop weights to gauge the relative importance of each logistics activity to its overall logistics operations. Finally, this section closes with a review of additional techniques for monitoring day-to-day transport and other logistics operations. The book then concludes with a brief summary chapter.
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