



COUNCIL OF SUPPLY CHAIN MANAGEMENT PROFESSIONALS

The background of the cover is a photograph of a long, brightly lit aisle in a warehouse. On both sides, there are tall, blue metal shelving units filled with various goods, including large cardboard boxes and pallets. The perspective is from the end of the aisle, looking down its length towards a bright light source at the far end. The floor is a smooth, light-colored concrete.

THE DEFINITIVE GUIDE TO INVENTORY MANAGEMENT

Principles and Strategies for the
Efficient Flow of Inventory across
the Supply Chain

Council of Supply Chain Management Professionals and

Matthew A. Waller
Terry L. Esper

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THE EFFICIENT FLOW OF INVENTORY
ACROSS THE SUPPLY CHAIN**

**Council of Supply Chain Management Professionals
Matthew A. Waller and Terry L. Esper**

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This book is dedicated to my wife, Susanne, who is kind enough not to talk about the fact that she is out of my league, and to my children, Sophia, Grant, Luke, and Sarah.—MW

This book is dedicated to my wife, Mishi, whose love and support allow me to approach academic pursuits with joy, and to the memory of my colleague, mentor, and friend, the late Dr. John “Tom” Mentzer, whose examples and advice I still follow today.—TE

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Over the years I have studied and taught from a number of textbooks on inventory theory. Some of my favorites, which I have learned the most from, include the following: *Analysis of Inventory Systems* (Prentice Hall, 1963); *Foundations of Inventory Management* (McGraw-Hill, 2000); *Inventory Management and Production Planning and Scheduling* (Wiley, 1998); *Production and Operations Analysis* (McGraw-Hill, 2005); *Foundations of Stochastic Inventory Theory* (Stanford University Press, 2002).

I would like to thank the Council of Supply Chain Management Professionals for promoting logistics education of managers globally.

Thank you to Pearson for publishing this book.

—MW

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—TE

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Founded in 1963, the **Council of Supply Chain Management Professionals** (CSCMP) is the preeminent worldwide professional association dedicated to the advancement and dissemination of research and knowledge on supply chain management. With more than 8,500 members representing nearly all industry sectors, government, and academia from 67 countries, CSCMP members are the leading practitioners and authorities in the fields of logistics and supply chain management. The organization is led by an elected group of global officers and is headquartered in Lombard, Illinois, USA.

INTRODUCTION TO INVENTORY

In June 2013 the Council of Supply Chain Management Professionals (CSCMP) released its annual State of Logistics Report. The document consists of several key logistics-related trends and data analyses that provide the reader with a snapshot of the emerging issues in the discipline and a source for benchmarking supply chain activities of a firm. One of the primary aspects of the report was the discussion of inventory trends. According to the report, inventories in the retail, wholesale, and manufacturing sectors all rose in 2012. Interestingly, retail inventories increased by 8.3 percent, more than twice the increase of wholesale inventories and more than six times that of manufacturing inventories. Likewise, inventory-related costs increased, with inventory carrying costs up by 4 percent. Perhaps even more interesting was the fact that these inventories were not necessarily moving, as the retailers reported significant overstocks through the latter half of 2012.

As the CSCMP report highlights, inventory is a fundamental measure of the overall health of supply chain and logistics activities. Because supply chain management efficiencies and executional excellence have become core strategic goals for most major firms over the last two decades, there has been a surge in C-level executives who focus on inventory-related costs and measures. Inventory reduction initiatives have become commonplace, with many supply chain and logistics professionals indicating that inventory-related efficiencies have become a culture and mindset within their organizations.

With so much emphasis on inventory, we feel it necessary to start this book with the basic fundamentals and foundations of the concept. So, we open with a question...

What Is Inventory?

What is inventory?¹ This may seem like somewhat of a rhetorical question. Perhaps, at the very least, it could be considered a question with an obvious answer. However, inventory is one of the most interesting, intriguing, and misunderstood business phenomena. At the root of this misunderstanding are the various perspectives on what inventory represents. Thus, the next sections present the predominant definitional perspectives on inventory.

The GAAP Perspective

According to Generally Accepted Accounting Principles (GAAP), the primary framework for financial accounting standards, inventory is a current asset. In particular, inventory represents “tangible personal property which are held for sale in the ordinary course of business; are in process of production for such sale; or, are to be currently consumed in the production.” In other words, inventory (in the form of “work-in-process,” “raw materials,” or “finished goods”) is an asset because it represents property that is likely to be converted to revenue, as the ultimate goal of inventory is to facilitate sales for an organization. Thus, Accounting 101 would indicate that inventory is properly accounted for on financial statements by being reported in dollar value terms as a current asset on the balance sheet.

Several years ago, an undergraduate student asked one of the authors an insightful question. “If inventory is an asset, then why are so many firms engaging in ‘inventory reduction initiatives?’” This question underscores the intriguing nature of inventory. Yes, according to GAAP, it is an asset, as it represents potential revenues. However, the *management* of inventory renders it an asset that comes with a price tag. Thus, inventory *management* is why inventory is such an interesting business phenomenon. It’s the art of managing an asset that is often viewed as a liability even though it is an asset. Various measures of inventory in the supply chain are perhaps the most salient metrics for the efficiency and effectiveness of the supply chain.

The Supply Chain Management Efficiency Perspective

One of the primary goals of supply chain management is to ensure that operations within and across firms in a supply chain are efficient. In many cases, the means to ensure efficiencies is in inventory; more specifically, in inventory *reductions*. Considering this, inventory is often viewed as a liability to efficient supply chain management. While supply chain managers recognize the necessity of inventory, the unwritten (and in many cases, written) rule is to keep inventory at a bare minimum. This goal gave rise to many of the popular supply chain management frameworks that are ubiquitous today: just-in-time inventory management; lean inventory; and even collaboration initiatives like collaborative planning, forecasting, and replenishment (CPFR). Overall, these strategic



initiatives were all developed with the goal of streamlining inventories across the supply chain and keeping inventory investment as low as possible.

The concept of inventory investment is, perhaps, the underlying reason why supply chain managers attempt to keep inventories low. The cost investment associated with having inventories can be high. These costs are addressed in much more detail later in the book, but suffice it to say, for now, that these costs include the cash outlay required to actually purchase the inventory, the costs of holding the inventories (which includes the cost of having invested in inventories instead of something else), and the costs associated with managing the inventory. Considering this, the managerial approach of keeping inventories as low as possible is not necessarily because it's inventory, per se, but because it's money—money tied up in something that costs even more money as it sits idle. In addition, metrics such as return on assets are affected by inventory since inventory is in the asset category on the balance sheet.

The Risk Management Perspective

Perhaps another interesting answer to the “what is inventory?” question is the risk management perspective. An interesting shift occurred recently regarding inventory. Though most firms still attempt to keep inventories as low as possible because of the costs associated with holding and managing it, there has been a growing emphasis on the costs of *not* having or effectively managing inventories.² In other words, inventory has been increasingly viewed from a risk management perspective, where the costs and impacts of stockouts, missed service opportunities, and unforeseen supply chain interruptions have become a primary decision-driver for firms. This has resulted in firms becoming much more favorable to concepts (discussed in much more detail later in the book) such as safety stock. Their rationale has been the sentiment, “we can't afford to *not* have safety stock inventory!” Because of this, inventory has interestingly become a means of managing risks.

In general, there appears to be much more sensitivity to the risk of potential supply chain disruptions.³ In many cases, these disruptions are the result of some uncertainty involved in managing supply chain processes. Sometimes the uncertainty is because of poor information availability; sometimes it is associated with uncertainty in supplier lead times; sometimes it is uncertainty in execution of specific tasks in various supply chain processes. In any case, uncertainty is the primary culprit involved in supply chain disruptions. One way that many firms have chosen to deal with such uncertainties is to hedge against them with inventory investment. Although this philosophy is cause for much debate, the reality is that many businesses engage in this practice for various reasons and, therefore, view inventory as a means of managing and mitigating risks.

Another popular variation of the risk management perspective is investing in inventory as a means of hedging against currency and price fluctuations. Vendors often offer

short-term volume discounts, the prices of many raw materials are based on market value, and purchasing from global suppliers involves currency exchange rates. To hedge against these potential fluctuations and changes, many firms opt to invest in inventory as a means of locking in prices and currency valuations. Doing this ultimately prevents them from being susceptible to the risk of inventory costs going above budgetary and capital constraints.

The Balanced Perspective

As all the preceding definitional perspectives suggest, inventory has a variety of meanings and symbolic roles within supply chains. This understanding is perhaps the most important and fundamental starting point for effective inventory management. Inventory is an asset, but an asset that firms don't want too much of. Yet not having "too much" could put the firm at risk of potential supply chain disruptions and unforeseen extreme costs. As such, the key to effective inventory management is balance—maintaining adequate inventories to ensure smooth production and merchandising flows while simultaneously minimizing inventory investment to ensure firm financial performance. This balance is often referred to as optimal.

The quest for optimal inventory levels is not an easy undertaking. It involves an interweaving of several analytical methods and techniques. Moreover, several interconnected decisions must be made to maintain optimal flows and seamless exchange of inventories along the supply chain. These issues are the focus of this book and are discussed in much detail in the forthcoming chapters.

The Role of Inventory in Supply Chain Management

Managing customer and vendor relationships is a critical aspect of managing supply chains. In many cases, the collaborative relationship concept has been considered the essence of supply chain management. However, a closer examination of supply chain relationships, particularly those involving product flows, reveals that the heart of these relationships is inventory movement and storage. Much of the activity involved in managing relationships is based on the purchase, transfer, or management of inventory. As such, inventory plays a critical role in supply chains because it is a salient focus of supply chains.

Perhaps the most fundamental role that inventory plays in supply chains is that of facilitating the balancing of demand and supply. To effectively manage the forward and reverse flows in the supply chain, firms have to deal with upstream supplier exchanges and downstream customer demands. This puts an organization in the position of trying to strike a balance between fulfilling the demands of customers, which is often difficult to forecast

with precision or accuracy, and maintaining adequate supply of materials and goods. This balance is often achieved through inventory.

For example, a growing trend is the implementation of sales and operations planning (S&OP) processes.⁴ The fundamental purpose of S&OP is to bring the demand management functions of the firm (for example, sales forecasting, marketing) together with the operations functions of the firm (for example, manufacturing, supply chain, logistics, procurement) and level strategic plans. This often involves extensive discussions about the firm's on-hand inventory, in-transit inventory, and work-in-process. Such discussions allow the sales and marketing group to adequately plan for the forthcoming time horizon by gaining a realistic picture of the inventory levels available for sale. Additionally, the operations groups are able to get updated and direct sales forecasting information, which can assist in planning for future inventory needs. Such information may very well result in shifts in manufacturing plans or alterations to procurement needs because of the strategic decision to focus on specific units of inventory instead of others in the near future.

Another example of balancing through inventory is the use of point-of-sale⁵ (POS) data for perpetual inventory management in the retail industry. For many retailers, every “beep” of a cash register upon scanning of an item's bar code during checkout triggers a series of messages that another unit of inventory has been sold. This information is not only tracked by the retailer but is also shared with upstream vendors. As items are depleted from inventory, in some cases, both the retailer and vendor work collaboratively to determine when reordering is necessary to replenish the depleted inventory, especially at the distribution center level. This is a balancing of supply and demand because demand information is tracked to determine when to best place replenishment orders based on the time required to get the inventory to the store location. In essence, inventory decisions are used to effectively time when supply inflows are needed to handle demand outflows.

Why Inventory Is Such an Important Metric for Supply Chain Management

As initiatives like S&OP illustrate, inventory can be a vital part of managing supply chains. Because of this, the status of a firm's inventory is often used as a litmus test for the overall “health” of its supply chain management processes and decision-making. For example, consider the firm that has excessive amounts of inventory in the form of safety stock. Such high safety stock is indeed a problem in and of itself because of the costs of holding this inventory and the opportunity costs of having working capital tied up in assets that aren't being converted to sales. The larger issue here, however, is that this safety stock situation is likely a symptom of some sort of ineffective supply chain management decision-making. Perhaps demand forecasting is constantly and significantly inaccurate,

maybe supplier lead times are unnecessarily long, perhaps firm operations are laden with bottlenecks and inefficient inventory handling, or maybe transportation carriers are not providing quality service in the form of delivering inventory damage-free and on-time. These are but a few examples of supply chain management ineffectiveness that often manifest in the form of either extensive levels of stagnant inventory or consistent out-of-stocks. Hence, inventory is an important supply chain measurement tool because it is likely one of the first signs that some root cause(s) is causing supply chain inefficiencies.

This has resulted in industry analysts, supply chain consultants and researchers, and even Wall Street paying close attention to inventory metrics to glean insights about supply chain performance trends and changes. Measures such as inventory turns, days of inventory, and cash-to-cash cycle have become popular, as they are all indicators of how well a firm's supply chain is being managed. These inventory measures tell us, for example, how quickly inventory is moving through the supply chain, how likely the firm can handle the fulfillment of customer demands, how the firm's liquidity is impacted by its investment in inventory, and may even signal how effectively supplier relationships are being managed.

Overview of the Book

Considering that inventory management is clearly a fundamental aspect of supply chain management, this book has been developed to outline the concepts and techniques at the heart of effective inventory decision-making. As we established in this chapter, inventory management is a far-reaching and expansive subject. Because of this, we can't make claims that this book will be exhaustive, by any means. However, we have carefully pieced together what we consider to be the key frameworks and approaches to assist the reader in better understanding the "what, why, how, and by what means" of inventory management decision-making.

Chapter 2, "Inventory Management Fundamentals," builds on the definitional discussion in this chapter and provides foundational insights into the key terminology and concepts involved in inventory management. Chapter 2 highlights the different types of inventory and the various cost drivers and cost categories associated with these inventories. Because there is often confusion in discussions about inventory that is a result of lack of terminology, we carefully and thoroughly consider many different and overlapping inventory concepts. A thorough understanding of Chapter 2 facilitates your understanding of the remainder of the book.

Chapter 3, "Inventory Control," takes the inventory management discussion further by focusing on the analyses used to make well-informed inventory decisions. Chapter 3 presents frameworks that assist in determining when inventory should be ordered, how much should be ordered, and ultimately how the inventory ordered should be managed and accounted for. The chapter concludes with some examples of managerial issues that

firms have faced when implementing several of these inventory approaches. This portion of the chapter was developed to help contextualize the analysis techniques by sharing certain roadblocks, problems, and unique successes that some firms have realized when putting these theoretical concepts to practice.

Chapter 4, “The Link Between Inventory Management and Forecasting,” looks at forecasting within the context of inventory management. It is really impossible to even examine inventory management without thoroughly discussing forecasting and how it relates to inventory decisions. You need to know how many units you are expecting to sell if you want to order an appropriate quantity at the appropriate time. In addition, the error in forecasts also contains useful information, because it is an indicator of how much uncertainty there is in demand.

Chapter 5, “Discrete Event Simulation of Inventory Processes,” describes a tool that is useful for analyzing inventory processes, the effects of forecasting methods on inventory processes, and how execution failures affect the performance of the inventory system—namely, discrete event simulation. Discrete event simulation is used to study a wide variety of processes and systems, but we are discussing its use only within the context of forecasting and inventory management. Furthermore, many software packages are specifically designed for discrete event simulation, but we explain how to conduct discrete event simulation in Microsoft Excel.

Prior to Chapter 6, we primarily look at inventory management from the perspective of an individual stock-keeping unit (SKU), but in Chapter 6, “Additional Inventory Management Processes and Concepts,” we consider inventory management with multiple SKUs. One must clearly understand inventory management and theory from the single SKU perspective to be able to fully understand multi-item inventory management since many of the concepts from single item inventory management are used in the discussion of multi-item inventory management. In addition, up to Chapter 6, we only discuss single echelon inventory management, but in Chapter 6 we extend the discussion to include multi-echelon inventory management. Many other related concepts are discussed in Chapter 6, including distribution requirements planning, which is certainly a multi-echelon concept.

Chapter 7, “Managing Supply Chain Inventory Flows,” looks at a number of topics related to overall management of the flow of inventory, including who owns the inventory, who makes decisions about when and how much to order, where the product flows vis-à-vis where the marketing transactions occur, and other related topics. We also look at questions about where inventory should be held and how orders can cause additional uncertainty in demand as they move up the supply chain.

Although performance measurement is discussed both directly and indirectly throughout Chapters 2 through 7, Chapter 8, “Inventory Performance Measurement,” focuses on inventory management performance measurement, covering some metrics we do

not cover earlier in the book but are important in the discussion. We carefully include content regarding cost trade-offs and cost/service trade-offs throughout the discussion of performance measurement. This is important because many times companies focus on some set of performance metrics at the cost of others that are ignored or not measured.

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