manufacturing and logistics activities may pose enormous challenges to overcome if business is to contribute to the sustainability agenda.

Interestingly, in the last few years, sustainable and green supply chains have increased in importance because of financial incentives in Europe, expected new regulations in the United States, demanding customers and supply chain partners, and the relationship between carbon footprint and supply chain efficiency. Indeed, manufacturing related logistics is a large and growing emitter of carbon dioxide that contributes about 5.5 percent of the total greenhouse gas emissions generated by human activities. Of that figure, transportation is responsible for 89 percent, and warehouses and distribution facilities are responsible for the rest. And logistics is only one—not necessarily the largest—contributor of greenhouse gas during the product lifecycle. Manufacturing, for example, contributes around 18 percent of the total greenhouse gas emissions.

With all these challenges, it is no longer clear how companies should design, manage, and operate their supply chains. Equally important, it is not obvious what the relationship should be between a company's customer value proposition and its operations strategies.

1.2 The Need to Focus

Consider Zara, the large Spanish clothing company known for fashion, stylish designs, and product diversity. Since 1974, when Amancio Ortega Gaona, Zara's chair, opened his first store, the company's objectives have been to provide customers with trendy fashion products at a reasonable, not necessarily low, price. These goals require a business model that is quite different from Zara's competitors, such as Gap Inc., one of the world's largest specialty retailers.

While retailers such as Gap reduce costs by outsourcing manufacturing (mostly to Asia), Zara owns its entire supply chain—from manufacturing through distribution centers to retail outlets. Because of its focus on fashionable, trendy products, for which demand is highly uncertain, Zara procures capacity from its fabric suppliers but does not commit necessarily to a specific color or print until it has a clear picture of consumers' preferences. Retail stores provide direct feedback to the company headquarter through its information technology (IT) infrastructure, allowing designers to identify trends and new styles.

Using this strategy, Zara has reduced time to market for new styles to three to four weeks, significantly shorter than the competition has been able to achieve. In comparison, Gap's focus on low-cost

Table 1.2
Five ways to compete in the market

Customer Value Proposition	Example	Operations Strategy
High fashion content at a reasonable price	Zara	Speed to market
Customer experience	Dell Direct	Responsiveness through configure-to-order
Product innovation	Apple	Efficiency through outsourced manufacturing and logistics
Everyday low pricing	Wal-Mart	Cost efficiency
Product selection and availability	Amazon	Efficient and reliable order fulfillment

manufacturing in Asia implies a long pipeline that is typically loaded with inventory and hence diminishes the company's ability to frequently introduce new products to the market.

The stories of Zara and Gap communicate a powerful message. Firms operating in the same space but providing different customer value propositions need different operations and supply chain strategies. Gap's focus on competitive pricing demands an operations strategy that is dedicated to efficiency—that is, a strategy where the primary goal is *reducing operational costs*. By contrast, Zara's value proposition, which provides customers with trendy fashion products at affordable prices, requires an operations strategy that is focused on speed—that is, a strategy where a vertically integrated supply chain is dedicated to *responsiveness*.

To highlight the strong connection between customer value proposition and its related operations strategies, consider five Fortune 500 companies: Zara, Dell Direct, Apple, Wal-Mart, and Amazon (table 1.2). Every one of these five companies has had superior financial performance over a long period of time, each provides a unique value proposition, and each company's operations strategy directly matches its customer value proposition.

Dell outperformed the competition by over 3,000 percent in shareholder growth from 1988 to 1996.[6] Dell's success over this eight-year period can be attributed to its virtual integration, a strategy that blurs the traditional boundaries between suppliers, manufacturers, and end users. Dell's decision to sell computers built from components produced by other manufacturers relieved the firm of the burden of owning assets,

investing in research and development, and managing a large workforce. At the same time, its direct sales model allows consumers to configure their own computers and requires Dell to fully customize an order with a short response time.

Dell's recent struggles are in part due to a change in the personal computer market. Growth in the PC market has shifted from online to retail and from developed countries to emerging markets, where consumers are not used to or not comfortable with online purchasing. Such a shift requires a rethinking of operations and supply chain strategies. Indeed, the frameworks developed in this book show that Dell's responsive configure-to-order strategy is a mismatch with the characteristics of the retail channel.

Apple, another example from table 1.2, has outsourced almost all its PC manufacturing and logistics activities. The firm focuses mainly on research, development, and product innovation as well as marketing and sales. Apple's product portfolio, unlike Dell's, is limited and hence its operations strategy emphasizes efficiency rather than responsiveness. For this purpose, Apple serves as the supply chain coordinator, integrator, and provider of operations best-practices, innovations, and strategies for all its partners.

Finally, Amazon and Wal-Mart are direct competitors in the retail space, each of which focuses on a different channel and a different value proposition. Amazon, the world's largest Internet retailer, provides its customers with a huge variety of products—including books, DVDs, electronics, and other merchandise—and has established itself as the most trusted online retailer through an efficient and reliable order-fulfillment strategy. By contrast, Wal-Mart has built its reputation as the brick-and-mortar master retailer by focusing on squeezing cost and increasing efficiency in its supply chain, thus providing its customers with competitive pricing but not necessarily with extraordinary service.

Looking at the customer value propositions and the corresponding operations strategies for these successful companies reveals an important insight: No firm can compete successfully on all dimensions of customer value, such as innovation, choice, price, and experience. Management needs to pick its goals, since operations and supply chain strategies, the market channel, or even the skill sets required to be successful depend on the specific value proposition.[7]

Similarly, no firm can be both extremely efficient, and thus compete on price, and at the same time highly responsive, and thus provide its customers with a large set of choices in a speedy manner while

maintaining an extraordinary service level. These are conflicting objectives, an issue that is discussed in the next section.

1.3 The Challenge

Traditional operations strategies have often focused on efficiency or responsiveness or a combination of the two. In operational efficiency, the firm focuses on low-cost strategies across all functional areas. This includes supplier selection, manufacturing, product design, and distribution and logistics. Typically, in such a strategy, production and distribution decisions are based on long-term forecasts, inventory of finished goods is positioned close to market demand, and supplier selection is based mostly on component costs. Hence, sourcing from low-cost countries is often the mantra.

By contrast, a responsive strategy focuses on speed, order fulfillment, service level, and customer satisfaction. Here, the objective is not necessarily to squeeze as much cost out of the supply chain as is humanly possible but rather to eliminate stockouts and satisfy demand by competing on response time and speed to market. Typically, in such a strategy, product variety is high and product lifecycle is short, manufacturing or product assembly is based on realized demand rather than forecast, products may be customized, a buffer inventory of components is emphasized, and sourcing, supplier selection, and transportation strategies all rely on speed rather than only on low cost.

Although seasoned operations and supply chain executives understand the difference between efficiency and responsiveness, many are confused about when to apply each strategy. Worse still! Senior managers typically spend a considerable amount of time and energy on customer value but may be ignorant about the connection between the consumer value proposition and operations strategies.

At the heart of the problem is the question "What drives operations and supply chain strategies?" The research reported in this book shows that the customer value proposition, channels to market, and product characteristics are the key drivers of an appropriate operations strategy. Implementing a strategy that does not match these drivers leads to inefficiencies, unnecessary expenses, and poor customer service at best or to an eventual business failure in the worst case.

Even those who understand the need to match operations strategies with the drivers reported above are faced with three independent challenges. The first is the existence of mismatches between the strategies

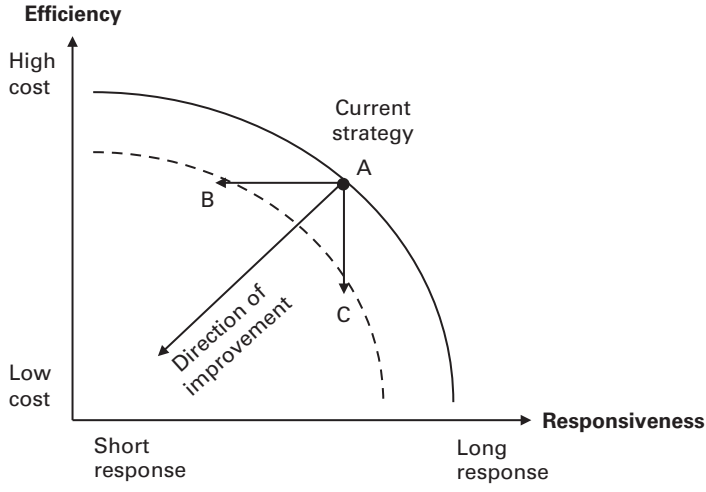

Figure 1.3
Trade-offs between efficiency and responsiveness

suggested by different product characteristics. That is, managers often find that some product attributes push the operations strategy in one direction while other attributes pull the strategy in a different direction.

The second challenge exists after identifying the appropriate strategy. At that time, executives often discover that different products, channels, or even customers require different types of supply chains. Thus, they need to decide whether operations should establish a single supply chain and, if so, which one. If multiple supply chains are required, should these supply chains operate independently, or is there a way to take advantage of synergies across the various supply chains?

The third challenge emerges as executives grasp for a better understanding of the drivers of their operations strategy. Operations affect three measures of performance: cost, time, and service levels. Unfortunately, these are conflicting objectives, as is illustrated in figure 1.3, where the solid curve represents trade-offs between efficiency and responsiveness. This curve, sometimes referred to as the *efficient frontier,* represents a range of possible strategies, each with a corresponding cost (efficiency) and response time (responsiveness). Indeed, a high efficiency level, that is, a low-cost operations strategy, typically increases time to serve customers and does not emphasize a high level of service. Alternatively, a highly responsive strategy increases cost but reduces customer response time.

Taken together, the three challenges impose enormous barriers for managers looking for strategies that differentiate them from the competition and create a sustainable competitive advantage. Addressing these challenges requires a shift from best practice to a more systematic and scientific approach that links customer value, product characteristics, and market channels directly with operations strategy.

The term *best practice* refers to the achievement of a specific outcome—higher level of service, lower cost, shorter response time, or any other performance measure—by following accepted management principles. For example, best practice led a major supplier in the automotive industry to invest in demand forecasting technology and associated processes to reduce inventory levels. The intuition is clear: accurate forecasts reduce safety stock and hence overall inventory. But as appealing as it was, the forecast improvement had no significant impact on this supplier's inventory levels. At the heart of the inventory crisis the company was facing was not poor forecast accuracy—as suggested by accepted management principles—but rather a poor choice of where inventory was positioned in the supply chain. Repositioning stock led to a 30 percent reduction in inventory levels while maintaining the same level of service and response time.

This story suggests that there is a need for deeper understanding of what drives operations strategy. For this purpose, the book converts ideas, observations, and research into a set of rules that management can follow to achieve a quantum leap in operations performance. These rules, which I refer to as the *engineering of operations and supply chains,* are at the heart of powerful frameworks that allow executives to *match strategies with customer value propositions, channels, and product characteristics*.

Ignore these rules, and you will find yourself heading toward failure. Follow them, and you will steer yourself away from predictable problems and toward an operations strategy that drives real business value.

1.4 Trade-offs and Rules

When establishing a business strategy, the firm takes a market position on the customer value proposition: price, experience and relationships, product innovation, branding, or choice. Since it is impossible to excel in all dimensions of customer value, firms need to choose. For example, Wal-Mart dominates in price but not necessarily in a large variety of

products, while Amazon dominates in choice and product availability but not necessarily in price.

A business strategy thus characterizes a company's unique position in the market and distinguishes the firm's value proposition from that of its competitors. Such a unique market position drives and depends on operations and supply chain strategies. Unfortunately, no company can be both highly efficient (delivering low cost) and extremely responsive (delivering short response times and dazzling customer satisfaction). This is where the need to make trade-offs emerges.

Of course, trade-offs need to be made not only between efficiency and responsiveness but also between flexibility and cost, cost and exposure to risk, inventory and service levels, and between quality and price. Each of these trade-offs entails a diagram similar to figure 1.3.

Operations and supply chain innovation is about improving performance despite these trade-offs. Consider figure 1.3, and assume that your current strategy corresponds to point A on the solid efficient frontier curve. This strategy invests in a deliberate trade-off between efficiency and responsiveness.

Imagine now that you devise a new strategy that somehow pushes the efficient frontier downward. If this is possible, then for the same level of efficiency, you can improve response time (point B). Alternatively, for the same level of responsiveness, you can improve operations efficiency and hence reduce costs (point C). More importantly, there is a range of strategies between B and C where the firm improves both efficiency and responsiveness.

This insight is the motivation behind many of the rules and associated concepts featured in this book. Indeed, they enable this shift in the trade-off curve. Examples include the concept of push-pull (chapter 3), risk sharing contracts (chapter 4), process and technology integration (chapter 6), and flexibility (chapters 7, 8, and 9).

This is the essence of PBG's newly established operations strategy. Prior to collaborating with MIT, PBG focused on supply chain efficiency. But faced with shifts in consumer preference, PBG needed a new approach that eliminated the stockout crises the firm faced during periods of peak demand but that did not increase and in fact even decreased supply chain costs. Thus, PBG was not trying to move along its existing efficient frontier but rather push its efficient frontier downward and thereby eliminate stockouts and decrease costs.

Other rules are designed to help companies match operations strategy with product characteristics, channels, and customer value. Examples

include rules regarding channels, price, product characteristics, and value-added services (chapter 2), procurement-strategy rules (chapter 4), and rules associated with IT strategy (chapter 6).

The origin of all the rules in this book is scientific. They are all based on either mathematical or empirical approaches. By *mathematical*, I refer to rules derived from detailed mathematical models. These rules are universal laws that are always true, independent of geography, culture, or products. Examples include principles that govern the relationships between variability and supply chain performance, between inventory, capacity, and response time, between redundancy and supply chain cost, and between information, lead time, and variability.

The empirical approach devises rules based on carefully conducted research that observes the strategies and performance of various companies. Such rules are also universal, but like any empirical research, and unlike mathematical models, they need to be considered within the context of the origin of the data. Examples include principles that explain the relationships between operations strategies and channel characteristics, product attributes, customer value, and IT capability.

Together, the two approaches complement each other and generate a set of principles that transform operations and supply chain management from a discipline that is based on gut feelings, anecdotes, and best practice to a true engineering discipline.

1.5 The Journey Ahead

The book includes three interrelated parts. Part I (chapters 2–6) presents an analytical framework for understanding operations strategy. Part II (chapters 7–9) outlines an implementation framework for a key supply chain enabler, flexibility, the single most important capability that enables the firm to innovate its operations and supply chain strategies. Finally, Part III (chapters 10 and 11) discusses emerging trends that are likely to stir profound changes in operations and supply chain strategies. The book concludes with a chapter on the barriers to success in operations (chapter 12).

Operations Strategy

Operations strategy is an important enabler of the business strategy. To characterize the link between the two, the firm's customer value proposition—the unique market position that the firm defines in its business

3

Matching Products, Markets, and Strategies

In the previous chapter, *customer value* is defined as the way that customers view the company's offerings—from product innovation through price all the way to experience and relationships. I argued that different customer value propositions require different operations and supply chain strategies.

This chapter focuses on the effects of customer value, product characteristics, and the sales channel on operations and supply chain strategies. I consider various supply chain strategies including push, pull, and a relatively new paradigm, the push-pull strategy, and develop a framework for matching products and industries with supply chain strategies. Importantly, these concepts and framework provide a deep insight into the appropriate manufacturing strategy that the firm should apply, and this strategy is directly related to the degree of operational flexibility and the sales channel.

Beyond specific frameworks and strategies, two important themes run throughout the chapter. First, customer value, product and channel characteristics significantly affect operations and supply chain strategies. Thus, when the same product is offered through multiple channels (say, retail and online), different supply chain strategies may apply. Second, different portions of the supply chain may require different strategies, and identifying the appropriate one requires a holistic, global view of the entire chain.

3.1 Push, Pull, and Push-Pull Strategies

Traditional supply chain strategies are often categorized as either push or pull strategies. This distinction probably stems from the manufacturing revolution of the 1980s, in which manufacturing systems were divided into these categories. Interestingly, in the last few years, a number

of companies have employed a hybrid approach—the push-pull supply chain paradigm.

The Push-Based Supply Chain

In a *push-based supply chain*, production and distribution decisions are based on long-term forecasts. Typically, the manufacturer bases its demand forecasts on orders received from the retailer's warehouses. A push-based supply chain therefore is slow to react to the changing marketplace, which can lead to

- An inability to meet changing demand patterns, and
- The obsolescence of supply chain inventory as demand for certain products disappears.

In addition, variability of orders received from retailers is typically much higher than variability in customer demand, and this increase in variability propagates upstream in the supply chain. This is the so-called bullwhip effect (see appendix A). This increase in variability leads to

- Excessive inventories due to the need for large safety stocks,
- Larger and more variable production batches,
- Unacceptable service levels, and
- Product obsolescence.

Specifically, the bullwhip effect leads to inefficient resource utilization because planning and managing are difficult. For instance, it is not clear how a manufacturer should determine production capacity. Should it be based on peak demand, which implies that most of the time the manufacturer has expensive resources sitting idle, or should it be based on average demand, which requires extra—and expensive—capacity during periods of peak demand? Similarly, it is not clear how to plan transportation capacity—based on peak demand or average demand. Thus, in a push-based supply chain, we often find increased transportation costs, high inventory levels, and high manufacturing costs, due to the need for emergency production changeovers.

The Pull-Based Supply Chain

In a *pull-based supply chain*, production and distribution are demand driven so that they are coordinated with true customer demand rather than forecast demand. In a pure pull system, the firm does not hold any inventory and responds only to specific orders. This is enabled by fast information-flow mechanisms that transfer information about customer

demand, e.g., point-of-sale (POS) data, to the various supply chain participants. Pull systems are intuitively attractive since they lead to

- Decreased lead times, which are achieved by better anticipating incoming orders from the retailers,
- Decreased inventory at retailers' warehouses since inventory levels at these facilities increase with lead times,
- Decreased variability in the system and, in particular, variability faced by manufacturers due to lead time reduction, and
- Decreased inventory at the manufacturer due to the reduction in variability.

The following example illustrates the impact of a pull-based supply chain strategy:

Example 3.1

A major apparel manufacturer recently changed its supply chain strategy to a pull-based system. Retailers order from this manufacturer about once a month but transfer POS data much more frequently, usually daily or weekly, which allows the manufacturer to adjust production quantities continuously according to true customer demand.

Thus, in a pull-based supply chain, we typically see a significant reduction in system inventory level, an enhanced ability to manage resources, and a reduction in system costs when compared with the equivalent push-based system.

On the other hand, pull-based systems are often difficult to implement when lead times are so long that it is impractical to react to demand information. Also, in pull-based systems, it is frequently more difficult to take advantage of economies of scale in manufacturing and transportation since planning is not done far ahead to take advantage of this capability.

These advantages and disadvantages of push and pull supply chains have led companies to look for a new supply chain strategy that takes advantage of the best of both. Frequently, this is a push-pull supply chain strategy.

The Push-Pull Supply Chain

In a *push-pull strategy*, some stages of the supply chain, typically the initial stages, are operated in a push-based manner while the remaining stages employ a pull-based strategy. The interface between the

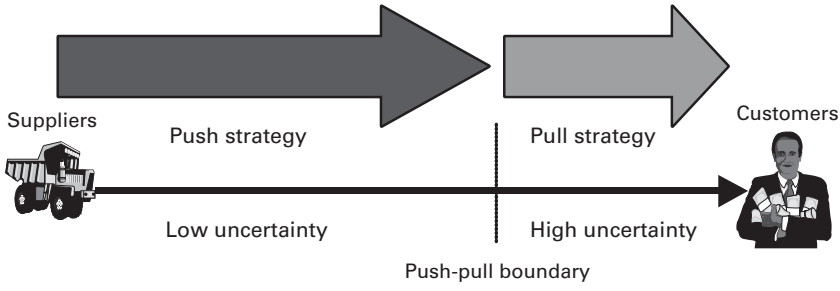

Figure 3.1
The push-pull supply chain time line

push-based stages and the pull-based stages is known as the *push-pull boundary*.

Consider the *supply chain time line*—the time that elapses between procurement of raw material (the beginning of the time line) and the delivery of an order to the customer (the end of the time line). The push-pull boundary is located somewhere along the time line and indicates the point in time when the firm switches from managing the supply chain using one strategy (typically a push strategy) to managing it using a different strategy (typically a pull strategy). This is illustrated in figure 3.1.

Consider a PC manufacturer that builds to stock and thus makes all production and distribution decisions based on forecast. This is a typical push system. By contrast, an example of a push-pull strategy is one in which the manufacturer assembles-to-order. This implies that components inventory are managed based on forecast but that final assembly is in response to a specific customer request. Thus, the push portion of the manufacturer's supply chain is that portion prior to assembly, while the pull part of the supply chain starts with assembly and is performed based on realized customer demand. The push-pull boundary is at the beginning of assembly.

Observe that in this case, the manufacturer takes advantage of *risk pooling*, a strategy driven by following statistical principle:

Rule 3.1 *Aggregate forecasts are always more accurate than individual forecasts.*

Indeed, predicting demand for an individual product is much more difficult than predicting total demand for all products within one product

family. Similarly, sales-region forecasts are typically more accurate than sales forecast from an individual store in that region.

By the same token, demand for a component is an aggregation of demand for all finished products that use this component. Since aggregate forecasts are more accurate, uncertainty in component demand is much smaller than uncertainty in finished goods demand, and this leads to safety stock reduction. Dell Computers has used this strategy effectively in its direct-business model and is an excellent example of the impact of the push-pull strategy on supply chain performance.

Postponement or delayed differentiation in product design is also an excellent example of a push-pull strategy. In postponement, the firm designs the product and the manufacturing process so that decisions about which specific product should be manufactured can be delayed as long as possible. The manufacturing process starts by producing a generic or family product, which is differentiated to a specific end product when demand is revealed. The portion of the supply chain prior to product differentiation is typically operated using a push-based strategy. In other words, the generic product is built and transported based on a long-term (aggregate) forecast. Since demand for the generic product is an aggregation of demand for all its corresponding end products, forecasts are more accurate, and inventory levels are reduced. In contrast, customer demand for a specific end product typically has a high level of uncertainty, and product differentiation occurs only in response to individual demand. Thus, the portion of the supply chain starting from the time of differentiation is pull-based.

3.2 Identifying the Appropriate Supply Chain Strategy

What is the appropriate supply chain strategy for a particular product? Should the firm use a push-based supply chain strategy, a pull-based strategy, or a push-pull strategy? Figure 3.2 provides a framework for matching supply chain strategies with products and industries. The vertical axis provides information on uncertainty in customer demand, while the horizontal axis represents the importance of economies of scale, either in production or distribution.

Everything else being equal, higher demand uncertainty leads to a preference for managing the supply chain based on realized demand—a pull strategy. Alternatively, smaller demand uncertainty leads to an interest in managing the supply chain based on a long-term forecast—a push strategy.

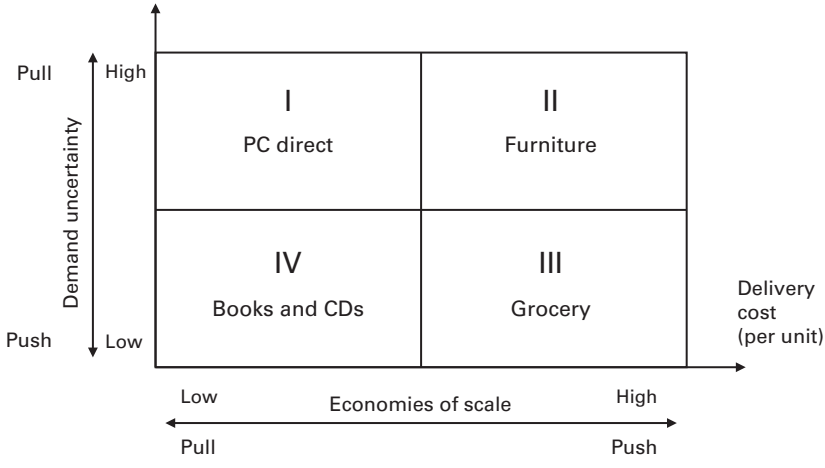

Figure 3.2
Matching supply chain strategies with products: The effect of demand uncertainty and economies of scale

Similarly, everything else being equal, the higher the importance of economies of scale in reducing cost, the greater the value of aggregating demand and thus the greater the importance of managing the supply chain based on long-term forecast—a push-based strategy. If economies of scale are not important, then aggregation does not reduce cost, so a pull-based strategy makes more sense.

In figure 3.2, the area spanned by these two dimensions is divided into four boxes. Box I represents products that are characterized by high uncertainty and by situations in which economies of scale in production, assembly, or distribution are not important. Our framework suggests that a pull-based supply chain strategy is appropriate for these industries and products. This is exactly the direct business strategy that Dell Inc. employs when it allows customers to configure their PCs online and then assembles the product based on individual orders. Because the number of configurations that a customer can choose from is high and since there are no economies of scale in assembly, a high degree of pull is appropriate, which is precisely Dell's strategy.

Box III represents products that are characterized by low demand uncertainty and high economies of scale. Products in the grocery industry such as beer, pasta, and soup belong to that category. Demand for these products is quite predictable, and reducing transportation costs by ship-

ping full truckloads is critical for controlling supply chain costs. In this case, a pull strategy is not appropriate. Indeed, a traditional, push-based retail strategy is appropriate because managing inventory based on long-term forecasts does not increase inventory holding costs while delivery costs are reduced by leveraging economies of scale.

Boxes I and III represent situations in which it is relatively easy to identify an efficient supply chain strategy. In the remaining two cases, there is a mismatch between the strategies suggested by the two attributes—uncertainty and the importance of economies of scale. In these boxes, uncertainty "pulls" the supply chain toward one strategy, while economies of scale "push" the supply chain in a different direction.

For instance, box IV represents products characterized by low demand uncertainty, indicating a push-based supply chain, and low economies of scale, suggesting a pull-based supply chain strategy. Many high-volume, fast-moving books and CDs fall in this category. In this case, a more careful analysis is required, since both traditional retail push strategies and more innovative push-pull strategies may be appropriate, depending on specific costs and uncertainties.

Finally, box II represents products and industries for which uncertainty in demand is high while economies of scale are important in reducing production and delivery costs. The furniture industry is an excellent example of this situation. A typical furniture retailer offers a large number of similar products distinguished by shape, color, fabric, and so forth, and as a result demand uncertainty is high. Because these are bulky products, delivery costs are also high.

In this case, there is a need to distinguish between production and distribution strategies. The production strategy has to follow a pull-based strategy since it is impossible to make production decisions based on long-term forecasts. By contrast, the distribution strategy needs to take advantage of economies of scale to reduce transportation costs. This is exactly the strategy employed by many retailers that do not keep any inventory of furniture. When a customer places an order, the retailer sends it to the manufacturer, which orders the fabric and produces to the customer's specifications. After the product is ready, it is shipped (typically by truck) with many other products to the retail store and from there to the customer. For this purpose, the manufacturer typically has a fixed delivery schedule, and this is used to aggregate all products that are delivered to stores in the same region, thus reducing transportation costs due to economies of scale. Hence, the supply chain strategy

followed by furniture manufacturers is, in some sense, a pull-push strategy—production is done based on realized demand, a pull strategy, and delivery is according to a fixed schedule, a push strategy.

Rule 3.2 *The appropriate supply chain strategy—push, pull, or push-pull—is driven by demand uncertainty and economies of scale.*

This powerful rule has been applied by many firms to match product characteristics and supply chain strategies. The same rule is applicable when considering the sales channel. Consider products such as personal computers that can be sold either online or retail. Demand uncertainty and forecast accuracy are quite different in the two channels (see table 2.2). This is true since a typical manufacturer of PCs offers a large variety of configurations online and consequently demand uncertainty is high. By contrast, the same manufacturer typically offers a limited number of configurations through retail store so forecast accuracy is higher. Similarly, because of the volume committed by retailers before the selling season, the retail channel can take advantage of economies of scale, a dimension that is difficult to exploit online. Thus, the retail channel is typically associated with box III and hence a push strategy while the online channel is associated with box I and therefore a high degree of pull.

3.3 Implementing a Push-Pull Strategy

The framework developed in the previous section attempts to characterize the appropriate level of pull and push for different products. For instance, a high degree of pull is appropriate for products that belong to box I in figure 3.2. But achieving the design of the pull system depends on many factors, including product complexity, manufacturing lead times, and supplier and manufacturer relationships. Similarly, there are many ways to implement a push-pull strategy, depending on the location of the push-pull boundary. For instance, Dell locates the push-pull boundary at the assembly point, while furniture manufacturers locate the boundary at the production point.

The discussion so far suggests that the push strategy is applied to the portion of the supply chain where demand uncertainty is relatively small, which makes managing this portion based on long-term forecast appropriate. The pull strategy is applied to the portion of the supply chain time line where uncertainty is high, which makes managing this portion based on realized demand appropriate. This distinction between the two

Table 3.1
Characteristics of the push and pull portions of the supply chain

Portion	Push	Pull
Objective	Minimize cost.	Maximize service level.
Complexity	High	Low
Focus	Resource allocation	Responsiveness
Lead time	Long	Short
Processes	Supply chain planning	Order fulfillment

portions of the supply chain has an important effect on the objectives of the supply chain strategy and on the organizational skills required to manage the system effectively.

Since uncertainty in the push portion of the supply chain is relatively small, service level is not an issue, so the focus can be on *cost minimization*. In addition, this portion of the supply chain is characterized not only by low demand uncertainty and high economies of scale in production and transportation, but and also by long lead times and complex supply chain structures, including product assembly at various levels. Thus, cost minimization is achieved by better utilizing resources such as production and distribution capacities while minimizing inventory, transportation, and production costs.

The pull portion of the supply chain is characterized by high uncertainty, simple supply chain structure, and a short cycle time. Hence, the focus here is on service level which is achieved by deploying a *flexible* and *responsive* supply chain, that is a supply chain that can adapt and respond quickly to changes in customer demand.

This implies that different processes need to be used in different portions of the supply chain. Since the focus in the pull part of the supply chain is on service level, *order-fulfillment processes* are typically applied. Similarly, since the focus of the push part of the supply chain is on cost and resource utilization, supply chain *planning processes* are used to develop an effective strategy for the next few weeks or months. Table 3.1 summarizes the characteristics of the push and pull portions of the supply chain.

Example 3.2

Consider a supplier of fashion skiwear such as Sport Obermeyer.[1] *Every year, the company introduces many new designs or products for which forecast demand is highly uncertain. One strategy used successfully by*

Example 3.2
(continued)

Sport Obermeyer involves distinguishing between high-risk and low-risk designs. Low-risk products (those for which uncertainty and price are low) are produced in advance using long-term forecasts and focusing on cost minimization—a push-based strategy. But decisions on production quantities for high-risk products are delayed until there is a clear market signal on customer demand for each style—a pull strategy. Since fabric lead times are long, the manufacturer typically orders fabric for high-risk products based only on long-term forecasts, well in advance of receiving information about market demand. In this case, the manufacturer takes advantage of the same principle, Rule 3.1, that Dell applies—that aggregate forecasts are more accurate. Since demand for fabrics is an aggregation of demand for all products that use that fabric, demand uncertainty is low, and thus fabric inventory is managed based on a push strategy. So Sport Obermayer uses a push-pull strategy for its high-risk products and a push strategy for its low-risk products.

Notice that the push portion and the pull portion of the supply chain interact only at the push-pull boundary. This is the point along the supply chain time line where there is a need to coordinate the two supply chain strategies, typically through *buffer inventory*. However, this inventory plays a different role in each portion. In the push portion, buffer inventory at the boundary is part of the output generated by the tactical planning process, while in the pull part it represents the input to the fulfillment process.

Thus, the interface between the push portion of the supply chain and the pull portion of the supply chain is forecast demand. This forecast, which is based on historical data obtained from the pull portion, is used to drive the supply chain planning process and determines the buffer inventory.

3.4 The Effect of Lead Time

Undoubtedly, shortening lead time will improve supply chain performance. Indeed, shortening lead times improves the ability to forecast, decreases variability, and hence reduces inventory. So this is an important priority for any organization.

Assuming that lead times cannot be further shortened, the next step is to make sure that the supply chain strategy matches with lead time

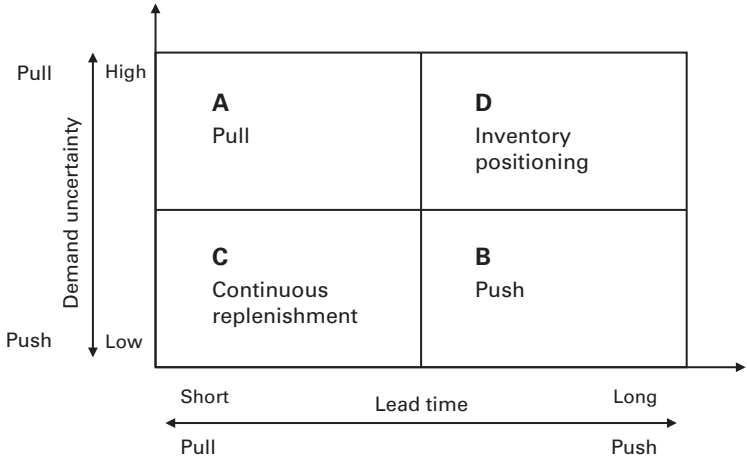

Figure 3.3
Matching supply chain strategies with products: The effect of lead time and demand uncertainty

characteristics. Intuitively, the longer the lead time, the more important it is to implement a push-based strategy. Indeed, it is typically difficult to implement a pull strategy when lead times are so long that it is hard to react to demand information.

In figure 3.3, the effect of lead time and demand uncertainty on supply chain strategy is diagrammed. Box A represents products with short lead times and high demand uncertainty, suggesting that a pull strategy should be applied as much as possible. Again, the PC direct business model is a good example of these types of products and the application of a high degree of pull. Box B represents items with a long supply lead time and low demand uncertainty. Examples include many items in the grocery industry. Again, in this case, the appropriate supply chain strategy is push.

The situation is more challenging for products with the characteristics of boxes C and D. For instance, box C includes products with short supply lead times and highly predictable demand. Good examples are products in the grocery industry with a short life cycle such as bread and dairy products. The retail industry takes advantage of short lead times and low demand uncertainty for these products by using a strategy referred to as *continuous replenishment*. In this strategy, suppliers receive point-of-sale (POS) data and use these data to prepare shipments at previously agreed-on intervals to maintain specific levels of inventory.

Thus, since customer demand drives production and distribution decisions in this supply chain, this strategy is a pull strategy at the production and distribution stages and push at the retail outlets.

Finally, the most difficult supply chains to manage are those associated with box D, where lead times are long and demand is not predictable. Inventory is critical in this type of environment, which requires positioning inventory strategically in the supply chain. Different stages of the supply chain are managed in different ways, depending, among other things, on economies of scale. The stages that keep inventory are managed based on push, and others are managed based on pull. As is shown in the next example, sometimes the entire supply chain is managed based on push.

Example 3.3

A large manufacturer of metal components has a manufacturing facility in China, a central distribution center in China, and many regional and country warehouses serving different markets. Customers include automotive manufacturing companies such as GM, Ford, Toyota, and others. The commitment the manufacturer makes to the original equipment manufacturer (OEM) is that any order will be released from the closest warehouse in less than eight days. Important characteristics of this supply chain include the following:

- *The same component is used across multiple assemblies, and*
- *Lead times for raw material and finished goods (from the China distribution center to the regional and country warehouses) are long.*

Recently, the firm has realized that its supply chain is not effective, with too much inventory and at the same time low service levels. A careful examination of the current supply chain strategy used by the firm suggests that inventory is managed using local optimization. Each facility stocks up inventory with little regard for the effect of its decision on supply chain performance. The result of this strategy is a supply chain with a low inventory turnover ratio of about 3.0.

To overcome these challenges, the manufacturer decided to change the way that it positions inventory in the supply chain. The results of this process are described in figure 3.4, which shows both the baseline and the supply chain after the change. Each pie represents inventory at a different location, where light gray is associated with cycle stock and dark gray with safety stock. Most of the safety stock in the optimized supply chain is positioned as plant raw material and at the regional

Example 3.3
(continued)

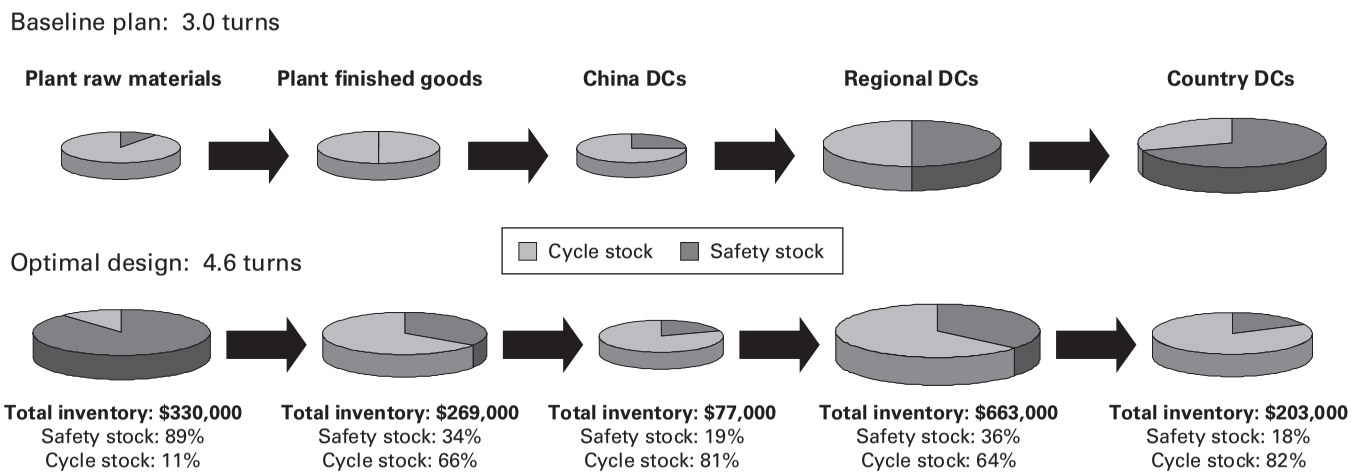

Figure 3.4
The effect of positioning inventory strategically

Example 3.3
(continued)

distribution centers (DCs). In both cases, the reason is risk pooling. Indeed, raw material inventory takes advantage of the risk pooling concepts by aggregating demand across all finished products that use the same component. The regional DCs take advantage of the risk pooling concept by aggregating demand across many country DCs. The net effect of correctly positioning inventory in this supply chain was a significant inventory reduction and an increase to 4.6 turns a year.

Rule 3.3 *Lead times are drivers of the appropriate supply chain strategy.*

3.5 Strategies for Innovative and Functional Products

We now have all the ingredients required to identify the appropriate supply chain strategy for functional and innovative products. Consider again table 2.1 in the previous chapter, where functional products are associated with slow product innovation speed, predictable demand, and low profit margins. Examples include diapers, soup, milk, and tires. On the other hand, innovative products—such as fashion items, cosmetics, or high-tech products—are associated with fast product-innovation speed, unpredictable demand, and high profit margins.

The different characteristics of innovative and functional products imply that the supply chain strategies for innovative products and functional products are very different. It is clear that the appropriate supply chain strategy for functional products is push, where the focus is on efficiency, cost reduction, and supply chain planning. By contrast, the appropriate supply chain strategy for innovative products is pull because of high profit margins, fast technology clock speed, and unpredictable demand. Indeed, here the focus is on responsiveness—time, service level, and order fulfillment. These insights are summarized in figure 3.5.[2]

3.6 Sales Channels, Flexibility, and Manufacturing Strategies

The concepts and framework introduced so far can be used to characterize the appropriate manufacturing strategy that a firm should apply. This strategy depends on the sales channel, the response time that the business

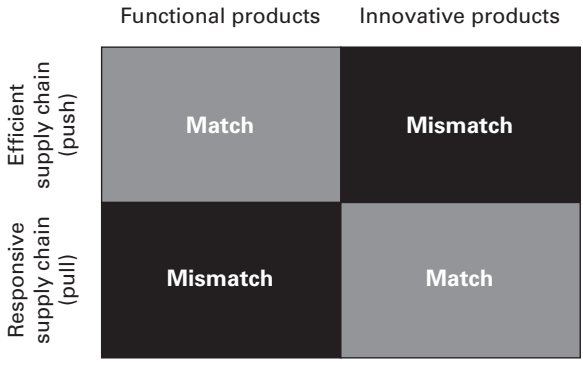

Figure 3.5
Matching product characteristics with strategies. From M. L. Fisher, "What Is the Right Supply Chain for Your Product?," *Harvard Business Review* (March–April 1997): 105–117.

commits to with its customers, and the degree of operational flexibility.

Three manufacturing strategies need to be considered:

- In a build-to-stock strategy, inventory is built based on forecast—a push strategy,
- In an assemble-to-order strategy, individual products are assembled based on customer configuration—a pull strategy, and
- In a build-to-order strategy, lot sizes are produced after receiving a customer order—a pull strategy.

Thus, in a build-to-stock strategy, production is completed typically before customer orders are realized, and in assemble-to-order and build-to-order strategies, production happens after the customer order is received. One way to distinguish between the two is that an assemble-to-order is similar to a build-to-order strategy except that it has a lot size of one and so does not benefit from economies of scale. Build-to-order, on the other hand, takes advantage of economies of scale by "building" lot sizes.

One industry that illustrates this difference between assemble-to-order and build-to-order strategies is the PC industry. Dell sells PCs direct, and its traditional business model is designed around an assemble-to-order strategy where an individual customer order is configured by the assembly line after the order is received. HP's strategy of selling through retailers such as Best Buy implies that the retailer and the manufacturer

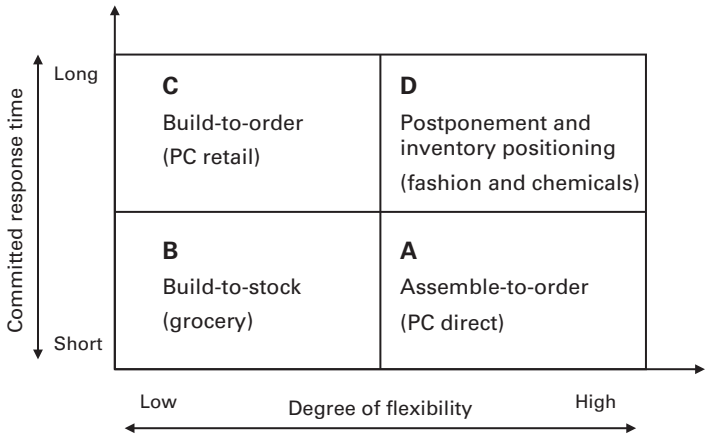

Figure 3.6
Flexibility and the manufacturing strategy

agree on order specifics (such as lot size and configuration) well in advance of the sales period, which allows the manufacturer to produce a large lot based on the retailer requirement—a build-to-order strategy.

Figure 3.6 characterizes the relationships between the committed response time to the customers, the manufacturing strategy, and the firm's degree of flexibility. For example, when the degree of flexibility is high and the committed response time is short (box A), an assemble-to-order strategy is appropriate. This is consistent with the view that in industries where the business sells direct (like the PC industry), a high degree of responsiveness and flexibility is important.

On the other hand, when the degree of flexibility is low and committed response time is short (box B), a build-to-stock strategy—a push strategy—is appropriate. Unlike in PC direct, here the focus is on cost reduction and effective forecast, perhaps using point-of-sales data, much like in the retail business for grocery, soap, diapers, or soft drinks.

For the same degree of flexibility but when committed response time is long—for example, selling high-tech products such as PCs, cell phones, or printers through retailers—a build-to-order strategy is effective (box C). Here, the manufacturer focuses on efficiency or cost reduction, which is achieved through economies of scale in manufacturing and distribution.

Observe an important implication of this framework:

Rule 3.4 *The sales channel determines the manufacturing and distribution strategies.*

To illustrate this rule, recall the analysis in chapter 2, particularly section 2.2, which discusses the challenges and opportunities of selling either online or in traditional retail stores (see table 2.2). The analysis in the current section supports the observation made in that section: selling online implies a large number of possible product configurations (Dell direct) and hence assemble-to-order. By contrast, selling through brick-and-mortar outlets limits the set of choices offered to consumers and hence build-to-order strategies are effective when lead times are long (HP), and build-to-stock strategies are effective when lead times are short (grocery products).

Finally, box D represents industries such as fashion or chemicals that are characterized by a high degree of uncertainty. In the fashion industry, uncertainty is due to the short product life cycle and the fierce market competition. In the chemicals and pharmaceutical industries, this is due to competition and new product introduction.

Two forces affect these industries. On the one hand, manufacturing time is long. In the chemical industry, manufacturing can take more than six months. On the other hand, commitments to customers are long but typically not enough to allow production to start after receiving customer orders. Thus, positioning work-in-process inventory in some manufacturing stages is common in the chemical and pharmaceutical industries. In fashion, postponement and standard parts—such as zippers or fabrics—are typically applied.

3.7 Summary

Many companies have improved their performance by reducing costs, increasing service levels, reducing the bullwhip effect, and improving responsiveness to changes in the marketplace. In many cases, these improvements were facilitated by the implementation of a push, pull, or hybrid push-pull strategy, depending on product characteristics such as product and technology-innovation speed, economies of scale, lead time, and demand uncertainty.

Some of these characteristics are directly related to the value proposition provided by the firm. For example, when selling PCs direct, Dell focuses on customer experience and allows a large variety of product

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The Triple-A Supply Chain

by Hau L. Lee

From the Magazine (October 2004)

Summary. Reprint: R0410F Building a strong supply chain is essential for business success. But when it comes to improving their supply chains, few companies take the right approach. Many businesses work to make their chains faster or more cost-effective, assuming that... **more**

During the past decade and a half, I've studied from the inside more than 60 leading companies that focused on building and rebuilding supply chains to deliver goods and services to consumers as quickly and inexpensively as possible. Those firms invested in state-of-the-art technologies, and when that proved to be inadequate, they hired top-notch talent to boost supply chain performance. Many companies also teamed up to streamline processes, lay down technical standards, and invest in infrastructure they could share. For instance, in the early 1990s, American apparel companies started a Quick Response initiative, grocery companies in Europe and the United States touted a program called Efficient Consumer Response, and the U.S. food service industry embarked on an Efficient Foodservice Response program.

All those companies and initiatives persistently aimed at greater speed and cost-effectiveness—the popular grails of supply chain management. Of course, companies' quests changed with the industrial cycle: When business was booming, executives concentrated on maximizing speed, and when the economy headed south, firms desperately tried to minimize supply costs.

As time went by, however, I observed one fundamental problem that most companies and experts seemed to ignore: Ceteris paribus, companies whose supply chains became more efficient and cost-

effective didn't gain a sustainable advantage over their rivals. In fact, the performance of those supply chains steadily deteriorated. For instance, despite the increased efficiency of many companies' supply chains, the percentage of products that were marked down in the United States rose from less than 10% in 1980 to more than 30% in 2000, and surveys show that consumer satisfaction with product availability fell sharply during the same period.

Evidently, it isn't by becoming more efficient that the supply chains of Wal-Mart, Dell, and Amazon have given those companies an edge over their competitors. According to my research, top-performing supply chains possess three very different qualities. First, great supply chains are agile. They react speedily to sudden changes in demand or supply. Second, they adapt over time as market structures and strategies evolve. Third, they align the interests of all the firms in the supply network so that companies optimize the chain's performance when they maximize their interests. Only supply chains that are agile, adaptable, and aligned provide companies with sustainable competitive advantage.

The Perils of Efficiency

Why haven't efficient supply chains been able to deliver the goods? For several reasons. High-speed, low-cost supply chains are unable to respond to unexpected changes in demand or supply. Many companies have centralized manufacturing and distribution facilities to generate scale economies, and they deliver only container loads of products to customers to minimize transportation time, freight costs, and the number of deliveries. When demand for a particular brand, pack size, or assortment rises without warning, these organizations are unable to react even if they have the items in stock. According to two studies I helped conduct in the 1990s, the required merchandise was often already in factory stockyards, packed and ready to ship, but it couldn't be moved until each container was full. That "best" practice delayed shipments by a week or more, forcing stocked-out stores to turn away consumers. No wonder then that, according to another recent research report, when companies announce product promotions, stock outs rise to 15%, on average, even when executives have primed supply chains to handle demand fluctuations.

When manufacturers eventually deliver additional merchandise, it results in excess inventory because most distributors don't need a container load to satisfy the increased demand. To get rid of the stockpile, companies mark down those products sooner than they had

planned to. That's partly why department stores sell as much as a third of their merchandise at discounted prices. Those markdowns not only reduce companies' profits but also erode brand equity and anger loyal customers who bought the items at full price in the recent past (sound familiar?).

Companies' obsession with speed and costs also causes supply chains to break down during the launch of new products. Some years ago, I studied a well-known consumer electronics firm that decided not to create a buffer stock before launching an innovative new product. It wanted to keep inventory costs low, particularly since it hadn't been able to generate an accurate demand forecast. When demand rose soon after the gizmo's launch and fell sharply thereafter, the company pressured vendors to boost production and then to slash output. When demand shot up again a few weeks later, executives enthusiastically told vendors to step up production once more. Five days later, supplies of the new product dried up as if someone had turned off a tap.

The shocked electronics giant discovered that vendors had been so busy ramping production up and down that they hadn't found time to fix bugs in both the components' manufacturing and the product's assembly processes. When the suppliers tried to boost output a second time, product defects rose to unacceptable levels, and some vendors, including the main assembler, had to shut down production lines for more than a week. By the time the suppliers could fix the glitches and restart production, the innovation was all but dead. If the electronics company had given suppliers a steady, higher-than-needed manufacturing schedule until both the line and demand had stabilized, it would have initially had higher inventory costs, but the product would still be around.

Efficient supply chains often become uncompetitive because they don't adapt to changes in the structures of markets. Consider Lucent's Electronic Switching Systems division, which set up a fast and cost-effective supply chain in the late 1980s by centralizing component procurement, assembly and testing, and order fulfillment in Oklahoma City. The supply chain worked brilliantly as long as most of the demand for digital switches emanated from the Americas and as long as Lucent's vendors were mostly in the United States. However, in the 1990s, when Asia became the world's fastest-growing market, Lucent's response times increased because it hadn't set up a plant in

the Far East. Furthermore, the company couldn't customize switches or carry out modifications because of the amount of time and money it took the supply chain to do those things across continents.

Lucent's troubles deepened when vendors shifted manufacturing facilities from the United States to Asia to take advantage of the lower labor costs there. "We had to fly components from Asia to Oklahoma City and fly them back again to Asia as finished products. That was costly and time consuming," Lucent's then head of manufacturing told me. With tongue firmly in cheek, he added, "Neither components nor products earned frequent-flyer miles." When Lucent redesigned its supply chain in 1996 by setting up joint ventures in Taiwan and China to manufacture digital switches, it did manage to gain ground in Asia.

In this and many other cases, the conclusion would be the same: Supply chain efficiency is necessary, but it isn't enough to ensure that firms will do better than their rivals. Only those companies that build agile, adaptable, and aligned supply chains get ahead of the competition, as I pointed out earlier. In this article, I'll expand on each of those qualities and explain how companies can build them into supply chains without having to make trade-offs. In fact, I'll show that any two of these dimensions alone aren't enough. Only companies that build all three into supply chains become better faster than their rivals. I'll conclude by describing how Seven-Eleven Japan has become one of the world's most profitable retailers by building a truly "triple-A" supply chain.

Building the Triple-A Supply Chain

Agility

Objectives:

Respond to short-term changes in demand or supply quickly; handle external disruptions smoothly.

Methods:

- Promote flow of information with suppliers and customers.
- Develop collaborative relationships with suppliers.
- Design for postponement.

- Build inventory buffers by maintaining a stockpile of inexpensive but key components.
- Have a dependable logistics system or partner.
- Draw up contingency plans and develop crisis management teams.

Adaptability

Objectives:

Adjust supply chain's design to meet structural shifts in markets; modify supply network to strategies, products, and technologies.

Methods:

- Monitor economies all over the world to spot new supply bases and markets.
- Use intermediaries to develop fresh suppliers and logistics infrastructure.
- Evaluate needs of ultimate consumers—not just immediate customers.
- Create flexible product designs.
- Determine where companies' products stand in terms of technology cycles and product life cycles.

Alignment

Objective:

Create incentives for better performance.

Methods:

- Exchange information and knowledge freely with vendors and customers.
- Lay down roles, tasks, and responsibilities clearly for suppliers and customers.

- Equitably share risks, costs, and gains of improvement initiatives.

Fostering Agility

Great companies create supply chains that respond to sudden and unexpected changes in markets. Agility is critical, because in most industries, both demand and supply fluctuate more rapidly and widely than they used to. Most supply chains cope by playing speed against costs, but agile ones respond both quickly and cost-efficiently.

Most companies continue to focus on the speed and costs of their supply chains without realizing that they pay a big price for disregarding agility. (See the sidebar "The Importance of Being Agile.") In the 1990s, whenever Intel unveiled new microprocessors, Compaq took more time than its rivals to launch the next generation of PCs because of a long design cycle. The company lost mind share because it could never count early adopters, who create the buzz around high-tech products, among its consumers. Worse, it was unable to compete on price. Because its products stayed in the pipeline for a long time, the company had a large inventory of raw materials. That meant Compaq didn't reap much benefit when component prices fell, and it couldn't cut PC prices as much as its rivals were able to. When vendors announced changes in engineering specifications, Compaq incurred more reworking costs than other manufacturers because of its larger work-in-progress inventory. The lack of an agile supply chain caused Compaq to lose PC market share throughout the decade.

The Importance of Being Agile

Most companies overlook the idea that supply chains should be agile. That's understandable; adaptability and alignment are more novel concepts than agility is. However, even if your supply chain is both adaptable and aligned, it's dangerous to disregard agility.

In 1995, Hewlett-Packard teamed up with Canon to design and launch ink-jet printers. At the outset, the American company aligned its interests with those of its Japanese partner. While HP took on the responsibility of producing printed circuit boards (or "formaters"), Canon

agreed to manufacture engines for the LaserJet series. That was an equitable division of responsibilities, and the two R&D teams learned to work together closely. After launching the LaserJet, HP and Canon quickly adapted the supply network to the product's markets. HP used its manufacturing facilities in Idaho and Italy to support the LaserJet, and Canon used plants in West Virginia and Tokyo.

But HP and Canon failed to anticipate one problem. To keep costs down, Canon agreed to alter the number of engines it produced, but only if HP communicated changes well in advance—say, six or more months before printers entered the market. However, HP could estimate demand accurately only three or fewer months before printers hit the market. At that stage, Canon could modify its manufacturing schedule by just a few percentage points. As a result, the supply chain couldn't cope with sudden fluctuations in demand. So when there was an unexpected drop in demand for the LaserJet III toward the end of its life cycle, HP was stuck with a huge and expensive surplus of printer engines: the infamous LaserJet mountain. Having an adaptable and aligned supply chain didn't help HP overcome its lack of agility.

By contrast, smart companies use agile supply chains to differentiate themselves from rivals. For instance, H&M, Mango, and Zara have become Europe's most profitable apparel brands by building agility into every link of their supply chains. At one end of their product pipelines, the three companies have created agile design processes. As soon as designers spot possible trends, they create sketches and order fabrics. That gives them a head start over competitors because fabric suppliers require the longest lead times. However, the companies finalize designs and manufacture garments only after they get reliable data from stores. That allows them to make products that meet consumer tastes and reduces the number of items they must sell at a discount. At the other end of the pipeline, all three companies have superefficient distribution centers. They use state-of-the-art sorting and material-handling technologies to ensure that distribution doesn't become a bottleneck when they must respond to demand

fluctuations. H&M, Mango, and Zara have all grown at more than 20% annually since 1990, and their double-digit net profit margins are the envy of the industry.

Agility has become more critical in the past few years because sudden shocks to supply chains have become frequent. The terrorist attack in New York in 2001, the dockworkers' strike in California in 2002, and the SARS epidemic in Asia in 2003, for instance, disrupted many companies' supply chains. While the threat from natural disasters, terrorism, wars, epidemics, and computer viruses has intensified in recent years, partly because supply lines now traverse the globe, my research shows that most supply chains are incapable of coping with emergencies. Only three years have passed since 9/11, but U.S. companies have all but forgotten the importance of drawing up contingency plans for times of crisis.

Without a doubt, agile supply chains recover quickly from sudden setbacks. In September 1999, an earthquake in Taiwan delayed shipments of computer components to the United States by weeks and, in some cases, by months. Most PC manufacturers, such as Compaq, Apple, and Gateway, couldn't deliver products to customers on time and incurred their wrath. One exception was Dell, which changed the prices of PC configurations overnight. That allowed the company to steer consumer demand away from hardware built with components that weren't available toward machines that didn't use those parts. Dell could do that because it got data on the earthquake damage early, sized up the extent of vendors' problems quickly, and implemented the plans it had drawn up to cope with such eventualities immediately. Not surprisingly, Dell gained market share in the earthquake's aftermath.

Nokia and Ericsson provided a study in contrasts when in March 2000, a Philips facility in Albuquerque, New Mexico, went up in flames. The plant made radio frequency (RF) chips, key components for mobile telephones, for both Scandinavian companies. When the fire damaged the plant, Nokia's managers quickly carried out design changes so that other companies could manufacture similar RF chips and contacted backup sources. Two suppliers, one in Japan and another in the United States, asked for just five days' lead time to respond to Nokia. Ericsson, meanwhile, had been weeding out backup suppliers because it wanted to trim costs. It didn't have a plan B in place and was unable to find new chip suppliers. Not only did Ericsson have to scale back production for months after the fire, but it

also had to delay the launch of a major new product. The bottom line: Nokia stole market share from Ericsson because it had a more agile supply chain.

Companies can build agility into supply chains by adhering to six rules of thumb:

- Provide data on changes in supply and demand to partners continuously so they can respond quickly. For instance, Cisco recently created an e-hub, which connects suppliers and the company via the Internet. This allows all the firms to have the same demand and supply data at the same time, to spot changes in demand or supply problems immediately, and to respond in a concerted fashion. Ensuring that there are no information delays is the first step in creating an agile supply chain.

- Develop collaborative relationships with suppliers and customers so that companies work together to design or redesign processes, components, and products as well as to prepare backup plans. For instance, Taiwan Semiconductor Manufacturing Company (TSMC), the world's largest semiconductor foundry, gives suppliers and customers proprietary tools, data, and models so they can execute design and engineering changes quickly and accurately.

- Design products so that they share common parts and processes initially and differ substantially only by the end of the production process. I call this strategy "postponement." (See the 1997 HBR article I coauthored with Edward Feitzinger, "Mass Customization at Hewlett-Packard: The Power of Postponement.") This is often the best way to respond quickly to demand fluctuations because it allows firms to finish products only when they have accurate information on consumer preferences. Xilinx, the world's largest maker of programmable logic chips, has perfected the art of postponement. Customers can program the company's integrated circuits via the Internet for different applications after purchasing the basic product. Xilinx rarely runs into inventory problems as a result.

- Keep a small inventory of inexpensive, nonbulky components that are often the cause of bottlenecks. For example, apparel manufacturers H&M, Mango, and Zara maintain supplies of accessories such as decorative buttons, zippers, hooks, and snaps so that they can finish clothes even if supply chains break down.

- Build a dependable logistics system that can enable your company to regroup quickly in response to unexpected needs. Companies don't need to invest in logistics systems themselves to reap this benefit; they can strike alliances with third-party logistics providers.

- Put together a team that knows how to invoke backup plans. Of course, that's only possible only if companies have trained managers and prepared contingency plans to tackle crises, as Dell and Nokia demonstrated.

Adapting Your Supply Chain

Great companies don't stick to the same supply networks when markets or strategies change. Rather, such organizations keep adapting their supply chains so they can adjust to changing needs. Adaptation can be tough, but it's critical in developing a supply chain that delivers a sustainable advantage.

Most companies don't realize that in addition to unexpected changes in supply and demand, supply chains also face near-permanent changes in markets. Those structural shifts usually occur because of economic progress, political and social change, demographic trends, and technological advances. Unless companies adapt their supply chains, they won't stay competitive for very long. Lucent twice woke up late to industry shifts, first to the rise of the Asian market and later to the advantages of outsourced manufacturing. (See the sidebar "Adaptation of the Fittest.") Lucent recovered the first time, but the second time around, the company lost its leadership of the global telecommunications market because it didn't adapt quickly enough.

Adaptation of the Fittest

Many executives ask me, with a twinkle in their eye, if companies must really keep adapting supply chains. Companies may find it tough to accept the idea that they have to keep changing, but they really have no choice.

Just ask Lucent. In the mid-1990s, when the American telecommunications giant realized that it could make inroads in Asia only if had local manufacturing facilities, it overhauled its supply chain. Lucent set up plants in Taiwan and China, which allowed the company to customize switches as inexpensively and quickly as rivals

Siemens and Alcatel could. To align the interests of parent and subsidiaries, Lucent executives stopped charging the Asian ventures inflated prices for modules that the company shipped from the United States. By the late 1990s, Lucent had recaptured market share in China, Taiwan, India, and Indonesia.

Unhappily, the story doesn't end there, because Lucent stopped adapting its supply chain. The company didn't realize that many medium-sized manufacturers had developed the technology and expertise to produce components and subassemblies for digital switches and that because of economies of scale, they could do so at a fraction of the integrated manufacturers' costs. Realizing where the future lay, competitors aggressively outsourced the manufacture of switching systems. Because of the resulting cost savings, they were able to quote lower prices than Lucent. Meanwhile, Lucent was reluctant to outsource its manufacturing because it had invested in its own factories. Ultimately, however, Lucent had no option but to shut down its Taiwan factory in 2002 and create an outsourced supply chain. The company's adaptation came too late for Lucent to regain control of the global market, even though the supply chain was agile and aligned.

The best supply chains identify structural shifts, sometimes before they occur, by capturing the latest data, filtering out noise, and tracking key patterns. They then relocate facilities, change sources of supplies, and, if possible, outsource manufacturing. For instance, when Hewlett-Packard started making ink-jet printers in the 1980s, it set up both its R&D and manufacturing divisions in Vancouver, Washington. HP wanted the product development and production teams to work together because ink-jet technology was in its infancy, and the biggest printer market was in the United States. When demand grew in other parts of the world, HP set up manufacturing facilities in Spain and Singapore to cater to Europe and Asia. Although Vancouver remained the site where HP developed new printers, Singapore became the largest production facility because the company needed economies of scale to survive. By the mid-1990s, HP realized that printer-manufacturing technologies had matured and

that it could outsource production to vendors completely. By doing so, HP was able to reduce costs and remain the leader in a highly competitive market.

> **The best supply chains identify structural shifts, sometimes before they occur, by capturing the latest data, ï¬ltering out noise, and tracking key patterns.**

Adaptation needn't be just a defensive tactic. Companies that adapt supply chains when they modify strategies often succeed in launching new products or breaking into new markets. Three years ago, when Microsoft decided to enter the video game market, it chose to outsource hardware production to Singapore-based Flextronics. In early 2001, the vendor learned that the Xbox had to be in stores before December because Microsoft wanted to target Christmas shoppers. Flextronics reckoned that speed to market and technical support would be crucial for ensuring the product's successful launch. So it decided to make the Xbox at facilities in Mexico and Hungary. The sites were relatively expensive, but they boasted engineers who could help Microsoft make design changes and modify engineering specs quickly. Mexico and Hungary were also close to the Xbox's biggest target markets, the United States and Europe. Microsoft was able to launch the product in record time and mounted a stiff challenge to market leader Sony's PlayStation 2. Sony fought back by offering deep discounts on the product. Realizing that speed would not be as critical for medium-term survival as costs would be, Flextronics shifted the Xbox's supply chain to China. The resulting cost savings allowed Microsoft to match Sony's discounts and gave it a fighting chance. By 2003, the Xbox had wrested a 20% share of the video game market from PlayStation 2.

Smart companies tailor supply chains to the nature of markets for products. They usually end up with more than one supply chain, which can be expensive, but they also get the best manufacturing and distribution capabilities for each offering. For instance, Cisco caters to the demand for standard, high-volume networking products by commissioning contract manufacturers in low-cost countries such as China. For its wide variety of mid-value items, Cisco uses vendors in low-cost countries to build core products but customizes those products itself in major markets such as the United States and

Europe. For highly customized, low-volume products, Cisco uses vendors close to main markets, such as Mexico for the United States and Eastern European countries for Europe. Despite the fact that it uses three different supply chains at the same time, the company is careful not to become less agile. Because it uses flexible designs and standardized processes, Cisco can switch the manufacture of products from one supply network to another when necessary.

Gap, too, uses a three-pronged strategy. It aims the Old Navy brand at cost-conscious consumers, the Gap line at trendy buyers, and the Banana Republic collection at consumers who want clothing of higher quality. Rather than using the same supply chain for all three brands, Gap set up Old Navy's manufacturing and sourcing in China to ensure cost efficiency, Gap's chain in Central America to guarantee speed and flexibility, and Banana Republic's supply network in Italy to maintain quality. The company consequently incurs higher overheads, lower scale economies in purchasing and manufacturing, and larger transportation costs than it would if it used just one supply chain. However, since its brands cater to different consumer segments, Gap uses different kinds of supply networks to maintain distinctive positions. The adaptation has worked. Many consumers don't realize that Gap owns all three brands, and the three chains serve as backups in case of emergency.

Sometimes it's difficult for companies to define the appropriate markets, especially when they are launching innovative new products. The trick is to remember that products embody different levels of technology. For instance, after records came cassettes and then CDs. Videotapes were followed by DVDs, and almost anything analog is now or will soon become digital. Also, every product is at a certain stage of its life cycle, whether it's at the infant, ramp-up, mature, or end-of-life stage. By mapping either or both of those characteristics to supply chain partners, manufacturing network, and distribution system, companies can develop optimal supply chains for every product or service they offer.

For example, Toyota was convinced that the market for the Prius, the hybrid car it launched in the United States in 2000, would be different from that of other models because it embodied new technologies and was in its infancy. The Japanese automobile maker had expertise in tracking U.S. trends and geographical preferences, but it felt that it would be difficult to predict consumer response to a hybrid car. Besides, the Prius might appeal to particular consumer

segments, such as technophiles and conservationists, which Toyota didn't know much about. Convinced that the uncertainties were too great to allocate the Prius to dealers based on past trends, Toyota decided to keep inventory in central stockyards. Dealers took orders from consumers and communicated them via the Internet. Toyota shipped cars from stockyards, and dealers delivered them to buyers.

Although Toyota's transportation costs rose, it customized products to demand and managed inventory flawlessly. In 2002, for example, the number of Toyotas on the road in Northern California and the Southeast were 7% and 20%, respectively. However, Toyota sold 25% of its Prius output in Northern California and only 6% in the Southeast. Had Toyota not adapted its distribution system to the product, it would have faced stock outs in Northern California and been saddled with excess inventory in the Southeast, which may well have resulted in the product's failure.

Building an adaptable supply chain requires two key components: the ability to spot trends and the capability to change supply networks. To identify future patterns, it's necessary to follow some guidelines:

- Track economic changes, especially in developing countries, because as nations open up their economies to global competition, the costs, skills, and risks of global supply chain operations change. This liberalization results in the rise of specialized firms, and companies must periodically check to see if they can outsource more stages of operation. Before doing so, however, they must make sure that the infrastructure to link them with vendors and customers is in place. Global electronics vendors, such as Flextronics, Solectron, and Foxcom, have become adept at gathering data and adapting supply networks.

- Decipher the needs of your ultimate consumers—not just your immediate customers. Otherwise, you may fall victim to the "bullwhip effect," which amplifies and distorts demand fluctuations. For years, semiconductor manufacturers responded to customer forecasts and created gluts in markets. But when they started tracking demand for chip-based products, the manufacturers overcame the problem. For instance, in 2003, there were neither big inventory buildups nor shortages of semiconductors.

At the same time, companies must retain the option to alter supply chains. To do that, they must do two things:

- They must develop new suppliers that complement existing ones. When smart firms work in relatively unknown parts of the world, they use intermediaries like Li & Fung, the Hong Kong–based supply chain architects, to find reliable vendors.

- They must ensure that product design teams are aware of the supply chain implications of their designs. Designers must also be familiar with the three design-for-supply principles: commonality, which ensures that products share components; postponement, which delays the step at which products become different; and standardization, which ensures that components and processes for different products are the same. These principles allow firms to execute engineering changes whenever they adapt supply chains.

Creating the Right Alignment

Great companies take care to align the interests of all the firms in their supply chain with their own. That's critical, because every firm —be it a supplier, an assembler, a distributor, or a retailer—tries to maximize only its own interests. (See the sidebar "The Confinement of Nonalignment.") If any company's interests differ from those of the other organizations in the supply chain, its actions will not maximize the chain's performance.

The Conï¬nement of Nonalignment

It's not easy for executives to accept that different firms in the same supply chain can have different interests, or that interest nonalignment can lead to inventory problems as dire as those that may arise through a lack of agility or a lack of adaptability. But the story of Cisco's supply chain clinches the argument.

All through the 1990s, everyone regarded Cisco's supply chain as almost infallible. The company was among the first to make use of the Internet to communicate with suppliers and customers, automate work flows among trading partners, and use solutions such as remote product testing, which allowed suppliers to deliver quality results with a minimum of manual input. Cisco outsourced the manufacturing of most of its networking

products and worked closely with contract manufacturers to select the right locations to support its needs. If ever there were a supply chain that was agile and adaptable, Cisco's was it.

Why then did Cisco have to write off $2.25 billion of inventory in 2001? There were several factors at play, but the main culprit was the misalignment of Cisco's interests with those of its contract manufacturers. The contractors accumulated a large amount of inventory for months without factoring in the demand for Cisco's products. Even when the growth of the U.S. economy slowed down, the contractors continued to produce and store inventory at the same pace. Finally, Cisco found it couldn't use most of the inventory of raw materials because demand had fallen sharply. The company had to sell the raw materials off as scrap.

Misaligned interests can cause havoc even if supply chain partners are divisions of the same company, as HP discovered. In the late 1980s, HP's integrated circuit (IC) division tried to carry as little inventory as possible, partly because that was one of its key success factors. Those low inventory levels often resulted in long lead times in the supply of ICs to HP's ink-jet printer division. Since the division couldn't afford to keep customers waiting, it created a large inventory of printers to cope with the lead times in supplies. Both divisions were content, but from HP's viewpoint, it would have been far less expensive to have a greater inventory of lower-cost ICs and fewer stocks of expensive printers. That didn't happen, simply because HP's supply chain didn't align the interests of the divisions with those of the company.

Lack of alignment causes the failure of many supply chain practices. For example, several high-tech companies, including Flextronics, Solectron, Cisco, and 3Com, have set up supplier hubs close to their assembly plants. Vendors maintain just enough stock at the hubs to support manufacturers' needs, and they replenish the hubs without waiting for orders. Such vendor-managed inventory (VMI) systems allow suppliers to track the consumption of components, reduce transportation costs, and, since vendors can use the same hub to support several manufacturers, derive scale benefits. When VMI offers so many advantages, why hasn't it always reduced costs?

The problem starts with the fact that suppliers own components until they physically enter the manufacturers' assembly plants and therefore bear the costs of inventories for longer periods than they used to. Many suppliers are small and medium-sized companies that must borrow money to finance inventories at higher interest rates than large manufacturers pay. Thus, manufacturers have reduced costs by shifting the ownership of inventories to vendors, but supply chains bear higher costs because vendors' costs have risen. In fact, some VMI systems have generated friction because manufacturers have refused to share costs with vendors.

One way companies align their partners' interests with their own is by redefining the terms of their relationships so that firms share risks, costs, and rewards equitably. For instance, the world's largest printer, RR Donnelley (which prints this magazine) recognized in the late 1990s that its supply chain performance relied heavily on paper-and-ink suppliers. If the quality and reliability of supplies improved, the company could reduce waste and make deliveries to customers on time. Like many other firms, RR Donnelley encouraged suppliers to come up with suggestions for improving processes and products. To align their interests with its own, however, the company also offered to split any resulting savings with suppliers. Not surprisingly, supplier-initiated improvements have helped enhance RR Donnelley's supply chain ever since.

Sometimes the process of alignment involves the use of intermediaries. In the case of VMI, for instance, some financial institutions now buy components from suppliers at hubs and sell them to manufacturers. Everyone benefits because the intermediaries' financing costs are lower than the vendors' costs. Although such an arrangement requires trust and commitment on the part of suppliers, financial intermediaries, and manufacturers, it is a powerful way to align the interests of companies in supply chains.

Automaker Saturn's service parts supply chain, one of the best in the industry, is a great example of incentive alignment that has led to outstanding results. Instead of causing heartburn, the system works well because Saturn aligned the interests of everyone in the chain—especially consumers.

Saturn has relieved car dealers of the burden of managing service parts inventories. The company uses a central system to make stocking and replenishment decisions for dealers, who have the right to accept, reject, or modify the company's suggestions. Saturn doesn't

just monitor its performance in delivering service parts to dealers, even though that is the company's only responsibility. Instead, Saturn holds its managers and the dealers jointly accountable for the quality of service the vehicle owners experience. For example, the company tracks the off-the-shelf availability of parts at the dealers as the relevant metric. Saturn also measures its Service Parts Operation (SPO) division on the profits that dealers make from service parts as well as on the number of emergency orders that dealers place. That's because when a dealer doesn't have a part, Saturn transfers it from another dealer and bears the shipping costs. The SPO division can't overstock dealers because Saturn shares the costs of excess inventory with them. If no one buys a particular part from a dealer for nine months, Saturn will buy it back as obsolete inventory.

That kind of alignment produces two results. First, everyone in the chain has the same objective: to deliver the best service to consumers. While the off-the-shelf availability of service parts in the automobile industry ranges from 70% to 80%, service part availability at Saturn's dealers is 92.5%. After taking transfers from other retailers into account, the same-day availability of spare parts is actually 94%. Second, the right to decide about inventory replenishment rests with Saturn, which is in the best position to make those decisions. The company shares the risks of stock outs or overstocks with dealers, so it has an interest in making the best possible decisions. Fittingly, the inventory turnover (a measure of how efficient inventory management is, calculated by dividing the annual cost of inventory sold by the average inventory) of spare parts at Saturn's dealers is seven times a year while it is only between one and five times a year for other automobile companies' dealers.

Like Saturn, clever companies create alignment in supply chains in several ways. They start with the alignment of information, so that all the companies in a supply chain have equal access to forecasts, sales data, and plans. Next they align identities; in other words, the manufacturer must define the roles and responsibilities of each partner so that there is no scope for conflict. Then companies must align incentives, so that when companies try to maximize returns, they also maximize the supply chain's performance. To ensure that happens, companies must try to predict the possible behavior of supply chain partners in the light of their current incentives. Companies often perform such analyses to predict what competitors would do if they raised prices or entered a new segment; they need to

do the same with their supply chain partners. Then they must redesign incentives so partners act in ways that are closer to what's best for the entire supply chain.

Seven-Eleven Japan's Three Aces

Seven-Eleven Japan (SEJ) is an example of how a company that builds its supply chain on agility, adaptability, and alignment stays ahead of its rivals. The $21 billion convenience store chain has remarkably low stock out rates and in 2004 had an inventory turnover of 55. With gross profit margins of 30%, SEJ is also one of the most profitable retailers in the world. Just how has the 9,000-store retailer managed to sustain performance for more than a decade?

The company has designed its supply chain to respond to quick changes in demand—not to focus on fast or cheap deliveries. It has invested in real-time systems to detect changes in customer preference and tracks data on sales and consumers (gender and age) at every store. Well before the Internet era began, SEJ used satellite connections and ISDN lines to link all its stores with distribution centers, suppliers, and logistics providers. The data allow the supply chain to detect fluctuations in demand between stores, to alert suppliers to potential shifts in requirements, to help reallocate inventory among stores, and to ensure that the company restocks at the right time. SEJ schedules deliveries to each store within a ten-minute margin. If a truck is late by more than 30 minutes, the carrier has to pay a penalty equal to the gross margin of the products carried to the store. Employees reconfigure store shelves at least three times daily so that storefronts cater to different consumer segments and demands at different hours.

SEJ has adapted its supply chain to its strategy over time. Some years ago, the company decided to concentrate stores in key locations instead of building outlets all over the country. But doing so increased the possibility of traffic congestion every time the company replenished stores. The problem became more acute when SEJ decided to resupply stores three or more times a day. To minimize delays due to traffic snarls, the company adapted its distribution system. It asked its suppliers from the same region to consolidate shipments in a single truck instead of using several of them. That minimized the number of trucks going to its distribution centers, which is where SEJ cross-docks products for delivery to stores. The company has also expanded the kinds of vehicles it uses from trucks to motorcycles, boats, and even helicopters. The effectiveness of the

company's logistics system is legendary. Less than six hours after the Kobe earthquake on January 17, 1995, when relief trucks were crawling at two miles per hour on the highways, SEJ used seven helicopters and 125 motorcycles to deliver 64,000 rice balls to the city.

Fundamental to the supply chain's operation is the close alignment between Seven-Eleven Japan's interests and those of its partners. The incentives and disincentives are clear: Make Seven-Eleven Japan successful, and share the rewards. Fail to deliver on time, and pay a penalty. That may seem harsh, but the company balances the equation by trusting its partners. For instance, when carriers deliver products to stores, no one verifies the truck's contents. That allows carriers to save time and money, since drivers don't have to wait after dropping off merchandise.

> **The message to Seven-Eleven Japan's partners is clear: Make the company successful, and share the rewards. Fail to deliver on time, and pay a penalty.**

When Seven-Eleven Japan spots business opportunities, it works with suppliers to develop products and shares revenues with them. For instance, two years ago, SEJ created an e-commerce company, 7dream.com, with six partners. The new organization allows consumers to order products online or through kiosks at SEJ stores and pick up the merchandise at any Seven-Eleven. The partners benefit from SEJ's logistics network, which delivers products to stores efficiently, as well as from the convenient location of stores. By encouraging partners to set up multimedia kiosks to produce games, tickets, or CDs in its shops, Seven-Eleven Japan has become a manufacturing outlet for partners. The company could not have aligned the interests of its partners more closely with those of its own.• • •

When I describe the triple-A supply chain to companies, most of them immediately assume it will require more technology and investment. Nothing could be further from the truth. Most firms already have the infrastructure in place to create triple-A supply chains. What they need is a fresh attitude and a new culture to get their supply chains to deliver triple-A performance. Companies must

give up the efficiency mind-set, which is counterproductive; be prepared to keep changing networks; and, instead of looking out for their interests alone, take responsibility for the entire chain. This can be challenging for companies because there are no technologies that can do those things; only managers can make them happen.

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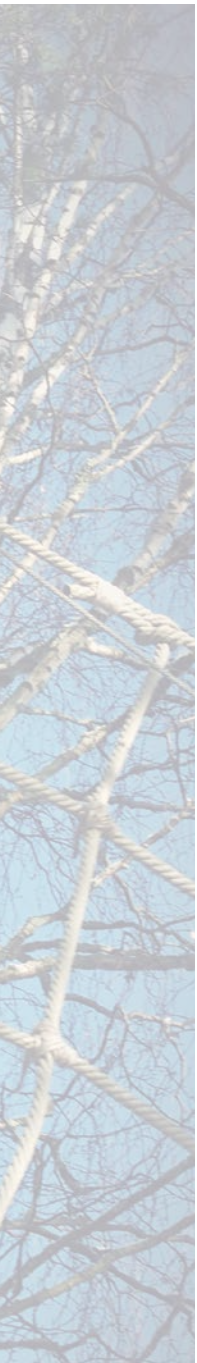


Low cost, high stakes: Five strategies for generic supply chains

Andrew Gonce, Xin Huang, Jordan Levine, Martin Lösch

The supply chain performance of generic drug (Gx) companies stands out compared with that of its Big Pharma, non-Gx peers. Despite their much more complex product portfolio, Gx companies' costs and inventory are much lower. Challenges, however, continue to arise in this critical sector that provides the majority of medicine to patients in need. Not only do customers often expect 99 plus percent service levels within 24 to 48 hours, but supply reliability is also becoming more tenuous as once local supply chains now extend around the world. To achieve high service standards across a global footprint, leading Gx companies have found that agility and integration along the supply chain are essential to improvement programs. We highlight the choices of leading Gx companies as well as those of fast-moving consumer goods (FMCG) companies (a sector that provides a model for continued improvement) to demonstrate the importance of agility and integration. Other hallmark features include responsiveness and stability, as well as excellence around tenders, complexity management, and long-term planning.

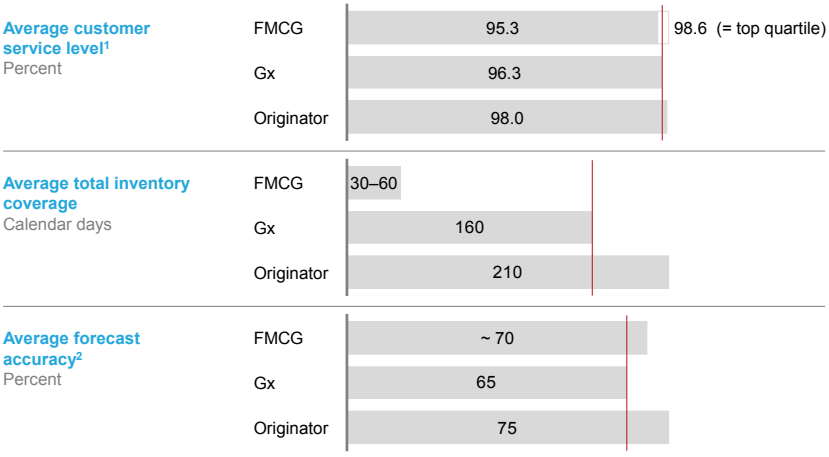
Supply chain leaders of generics (Gx) pharmacos deserve credit for their effectiveness in meeting the needs of the rapidly growing Gx market. Generics market share in prescription drugs has grown from 23 percent in 2007 to 27 percent in 2012, and is expected to reach 38 percent by 2020. Compared with some big originator (Rx) peers, Gx manufacturers can have ten times the number of SKUs in a market-place and still maintain inventory levels some 25 percent lower. Our POBOS benchmarking shows that a median Gx manufacturer has 160 days of inventory on hand, compared with 210 days for non-Gx manufacturers. This is partially because Gx companies have a higher

outsourcing share of API and also because Gx companies have a more responsive supply chain. Additionally, the Gx manufacturers are able to produce at a conversion cost that is 40 percent lower than big pharma sites.

That is not to say, however, that there's no room for improvement, particularly in areas of stability and service. As a comparison, we can look at fast-moving consumer goods (FMCG) companies. These companies—food, beverage, apparel, personal electronics, and personal care—struggle with the same factors of intense competition, changing product mixes and presentations, multiple market demands, and an extremely diversified portfolio. However, the average consumer goods company operates with one-third to one-fifth of the inventory of Gx companies, and forecast accuracy is ten percentage points higher. With respect to service levels, FMCGs are comparable to the Gx average, but top-quartile FMCG companies still perform at 98.6 percent service level. To put it simply, the FMCG supply chain appears to be efficiently firing on all cylinders.

Exhibit 1

Performance of generics, originator, and consumer goods companies on key metrics



1 OTIF vs. confirmed on orderline level for pharma
2 Based on MAPE, 3 months out for pharma; scaled for product families for FMCG

SOURCE: POBOS SCM database; McKinsey analysis

In this chapter, we will look at what leading Gx and FMCG companies are doing to drive holistic improvements across their complex supply chains.

How to improve Gx supply chain: five key lessons

Given the nature of the market and its challenging environment, Gx companies are often in firefighting mode when managing their supply chains. Even though this might temporarily deliver what the company wants, the supply chain is not stable and cannot deliver sustainable results when it is facing large challenges. Therefore, Gx companies should focus on building the structural capabilities that can help them succeed over the long term. Below, we discuss five fundamental challenges that Gx companies are facing in their supply chain and how leaders in Gx companies and other industries are addressing them.

Making the supply chain more responsive

Gx companies need to handle volatile demands and supplies driven by internal and external factors. While patient demand is often stable for on-market products, competitor stockouts, distributor order patterns, tenders, and erratic buying and rebate patterns create volatility that manufacturers must manage. New-product launches create their own source of volatility for manufacturers that encounter uncertainty in timing, markets, and order sizes. From the supply side, Gx companies struggle with more complex manufacturing and quality issues driven by rushed development, greater on-site complexity, and often tighter resource constraints than those of innovators.

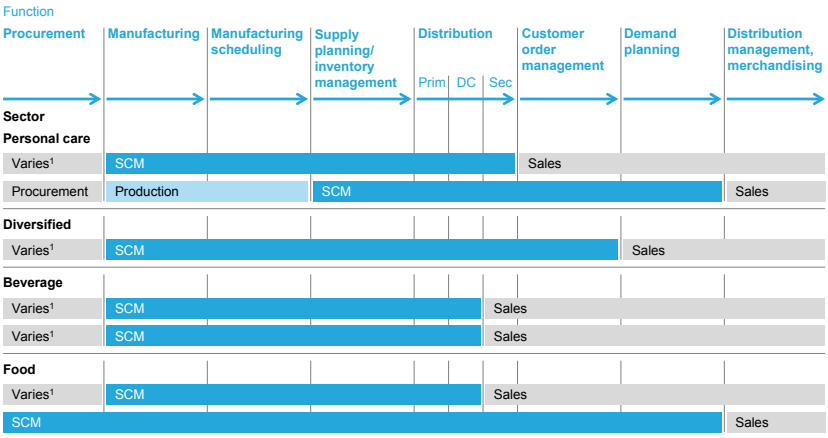
To be more responsive, supply chain leaders must do the following:

- **Ensure end-to-end visibility enabled by IT system:** Many of the FMCG companies not only have visibility of demand-and-supply information but also have real-time information on what has been changed (for example, large demand changes, large new confirmed orders, and manufacturing delays and misses). This information is understood and seen by all parties: markets, supply chain, and sites. Establishing such visibility does not mean relying on a full enterprise resource planning (ERP) integration, which can easily take more than three years and tens of millions of dollars. Some leaders choose user-friendly interface tools that bring transparency to performance and enable routine decisions without the burden of ERP implementation.

- **Establish a responsive and proactive cross-functional planning process to react to demand-and-supply changes:** In order to be responsive and proactive, the supply chain first needs to understand and validate forecast and demand changes and their impact to operations. (This is enabled by the end-to-end visibility discussed above.) The supply chain then needs to have a rigorous planning process that enables cross-functional team members to make quick decisions based on a common business objective. Finally, the team always needs to set aside time to understand the root causes of service failures and supply disruption, and develop corrective actions to reduce the occurrence of these exceptions. A large Gx manufacturer used the "control tower" approach to establish a well-defined daily and weekly planning process that addresses the three areas mentioned above. Within four months of implementation, the company had increased the service level from the high 80s to mid 90s. Exhibit 2 shows how some FMCG companies have taken cross-functional planning across the business, under a central supply chain management (SCM) approach.

Exhibit 2

End-to-end integration is becoming an industry standard for FMCG supply chain



1 "Varies" indicates that procurement connection to planning process varies by product type and product family

- **Invest in postponement strategies:** Gx companies need to actively leverage postponement to manage the complexity and volatility of their market. Regional supply hubs that at minimum do the packaging (or, potentially serve as regional hubs for third-party suppliers and retesting) can help simultaneously create short order lead times for the given region or market as well as decouple bulk production from market demand, thereby enabling production to focus on formulation. A significant majority of EU pharmaceutical manufacturers have adopted postponement strategies. This practice pushes the complexity as close to the end of production as practical—reducing the complexity associated with small-batch formulation in favor of small-batch packaging. A recent study of more than two dozen pharma supply chain leaders showed that about 23 percent of volume was routed through a postponement strategy. In 82 percent of cases, the manufacturers decoupled bulk and late-stage packaging, and in 68 percent they postponed labeling in order to facilitate subsequent country-specific labeling. By pushing the complexity close to customers, the upstream processes are vastly simplified.

- **Work with customers to proactively shape demand and jointly manage demand shocks:** For most of the pharma industry's on-market products, end customer consumption is very stable. Much of the volatility is introduced by the different channel tiers. Therefore, to effectively manage external volatility, leading Gx companies are working with large distributors, wholesalers, and retailers to jointly manage and shape demand as well as manage for demand shocks. One large Gx manufacturer has visibility of inventory position at its large distributors and retailers in the United States. The company works with these large customers on a weekly basis to mitigate demand shocks and supply risk. For example, when current inventory cannot cover next month's forecast, the company will automatically trigger an allocation process with predefined rules based on factors such as profitability, strategic relationship, importance of the customers, and impact to end patients. Customer service teams will actively communicate (for example, expected restocking dates) and manage stock level with customers when the allocation process starts. In addition to the mitigation process, the company also proactively shapes the demand with its key customers. For example, when it sees an unusually large order from the customer that has sufficient inventory, the company will reach out to the customers to understand the drivers of the orders and discuss how to smooth out the orders without impacting the supply to end customers. Monthly collaboration planning meetings also are held with key customers to share and compare forecast information. If there is a large gap between

the forecasts, the company will work with the customers to understand the drivers of the gap and also determine the actions to close or reduce the gaps. By actively mitigating and shaping the demand with customers, the company can significantly reduce the "bullwhip" before it hits the manufacturing sites.

Creating stable and reliable manufacturing in a highly volatile environment

Many Gx companies are facing a vicious cycle in their supply chain: the commercial organization makes frequent forecast changes right up to the last minute in order to react to market changes. This in turn creates corresponding last-minute changes to the production schedule. As a consequence, manufacturing is often caught in a bind. On the one hand, it must manage frequent manufacturing and quality issues to sustain internal product and process robustness; while on the other hand, it needs to handle frequent schedule changes. As a result, manufacturing struggles to provide reliable supply to the markets. Market forecasters then lose confidence in supply and will make further changes to forecasts to try to protect the supply (for example, "If I ask for 50, I will get 40; therefore, in order to get 50, I will ask for 60"). Manufacturing will start to second-guess the forecast since they also do not trust it. Thus, the cycle continues. To break this vicious cycle, supply chain needs to work with commercial, manufacturing, and other stakeholders to provide stabilized plans to manufacturing and reliable supply to commercial organizations.

To facilitate stability, supply chain leaders must do the following:

- **Find the right balance between stability and agility in the supply chain:** To achieve the right balance, leaders must have clear segmentation of products and tailor the planning strategy accordingly. For example, a large pharmaco has four product segments: large-volume products, small-volume products that can be championed with the large-volume products, other small-volume but stable products, and very small-volume and volatile products. For large-volume products, the company establishes a stable, cyclic planning approach with fixed production frequency and frozen lead time. It then "piggybacks" the second group of products with large-volume products through champions (although these products have lower production frequency and are not necessarily produced each time the large-volume products are produced). For other small but stable products, it slots in flexibility based on the order or inventory situations. Finally, for very small-volume and volatile products, it reviews the needs of every production period and triggers a production if

inventory falls below a certain ratio. When the company produces, it makes sufficient quantity based on economic order quantity (EOQ) model and batch size requirements. By doing so, the company achieves stability for the large-volume products and agility for the small and volatile products.

Leading FMCG supply chains have taken key actions to improve flexibility and reliability within their operations. Many FMCG companies have frozen production windows of one to two weeks and are thus able to run through most of their SKUs within a given month. Leaders have reduced setup times from hours to minutes, management processes have been established to quickly resolve the tough cross-functional issues that regularly arise, and many products are built from common platforms.

- **Drive out sources of supply volatility and manage supply reliability issues:** The number of rejected batches for Gx manufacturers is 1.4 percent,[1] more than three times the rate of Rx manufacturers (0.4 percent). Supply chain plays the key role of bringing the visibility of root causes across the value chain even though it might not be the owner of the process where the root causes occur. Specifically, this means systematic tracking and investigation of non-worked time or lost shifts, overall equipment effectiveness (OEE) losses, and schedule changes. An example of effectively responding to supply volatility comes from a Gx manufacturer that was experiencing an increase in long-term stockouts and service issues for ten SKUs. The root cause of this unreliability was an API supplier's loss of GMP status following a very poor inspection. Comparable issues were also occurring in other countries. The supply chain had managed similar challenges for the Japanese market with a separate API supplier. Learning from these experiences, the supply chain team escalated the issue, and is now partnering with global operations and quality to address such supply risks holistically by seeking alternate sources of supply and by strengthening the supplier risk assessment program.

1 POBOS: Benchmarking of solid finished dosage sites, globally.

- **Drive out sources of demand volatility:** One Gx manufacturer was experiencing excessive inventory, multiple manufacturing disruptions, rush orders, and stockouts because of persistently over-forecasting actual demand. The company took on a focused forecast accuracy improvement program to address these gaps. One of the first changes was that the commercial and operations executives created clear, companywide guidance on promotions. Another change was to use clearer product segmentation to shift focus to those SKUs that drive near-term volatility, leveraging simple models for the stable on-market SKUs. These and other changes drove an improvement in forecast accuracy of over 10 percent within three months.

- **Use trust-based working relationships to reduce the endless e-mails and time-consuming negotiations.** Lack of accurate and timely information often leads to a lack of stability—late changes and rash decisions drive instability—that in turn drives last-minute e-mails and urgent requests. Establishing routine weekly exception management processes with cross-functional decision makers is one approach that has been adopted in both consumer packaged goods (CPG) and Gx pharma environments to improve communications. One Gx company put a regional exception management process in place to align on large forecast changes, supply projection and changes, inventory situation, and other tactical issues such as artwork changes. The process is supported by a tool that brings all critical information from different systems. The impact was rapid: within six months, service levels increased by more than 6 percent, inventories decreased by 16 percent, and stockouts fell by 55 percent. Further, the relationships between site, supply chain, and commercials, as well as between executives, improved significantly.

Effectively supporting the tender business model

There are two main challenges for supply chain in the tender business model. First, in order to bid on the tender, the Gx company needs to ensure that there is reliable supply if it wins the tender. Second, winning and losing the tender can significantly change the demand profile. Even so, the volume of the business from tender is increasing for many markets, and winning tenders is critical to the supply chain and the business.

To better support the tender business model, supply chain leaders must be able to do the following:

- **Understand the true end-to-end costs:** Leaders can readily provide cost information for commercial in the bidding, and have transparency into the total cost as well as the variable cost for each product. They also are able to understand the components of cost to inform pricing choices—learning when to account for a fully loaded cost and when to price closer to variable cost.

- **Conduct quick scenario analysis to estimate the impact to capacity and manufacturing:** Leaders have a clear understanding of their capability at asset level with modeling tools that allow the supply chain organization to conduct rapid scenario analysis on the impact and risk of tenders. Based on this information, commercial, supply chain, and manufacturing can have a fact-based discussion and alignment on how to position in the tenders.

- **Improve tender forecasting:** While many uncertainties are inherent in tenders, leaders invest to improve tender-forecasting accuracy by tracking tender history, using statistical analyses, and establishing a rigorous demand-planning process. For example, one Gx company established a three-step tender-forecasting process: tender master planning, tender baseline forecasting, and tender fine-tuning. Tender master planning is a quarterly process owned by key account management. The main focuses are to collect information of upcoming tenders from health insurance and estimate the volume. Three to six months before the tender starts, the marketing and forecasting team begins the tender baseline forecasting process to generate the baseline forecast without markups or markdowns. After the tender starts, product managers and forecasting fine-tune the forecast to include markup and markdown information. The company also reviews tender-forecasting performance such as forecast accuracy and bias. It focuses on the top offenders to make the performance review tangible and actionable.

Setting up the best operating model and accountability in a highly complex and fast-paced environment

Gx companies need to manage a large amount of SKUs and a complex manufacturing network. Further, they need to manage allocation among markets when there is limited manufacturing capacity.

To manage complexity, supply chain leaders must do the following:

- **Manage by exceptions:** Set up the system and planning parameters to handle the majority of SKUs while the supply chain focuses on handling the exceptions. Industry leaders further differentiate themselves by focusing not only on addressing the exceptions but also on bringing the exceptions down through continuous improvement.

- **Create regional supply hubs with full accountability:** FMCG companies are moving toward regional hubs, in part to simplify the interactions between operating parties and to be more responsive to changes. One Gx company, for example, had a supply chain design where each market made contact with each site to manage supply chain decisions and allocation choices. This led to suboptimal outcomes: too many e-mails, unclear priorities, preferences accorded the market most local to the site, and poor performance. In response, the company established a single point of contact for the markets. It also created a commercial position to work with supply chain and manufacturing to make trade-offs when supply is limited but demanded by multiple customers and markets. The change has resulted in far easier and more streamlined decision making as well as reduced stockouts and inventory levels.

- **Understand the upstream and downstream effects:** By seeing end-to-end supply chain challenges, leaders can manage the complexity of global supply chains. Many FMCG companies have long taken a brand view that extends across functions. Some leading innovative pharmacos are also transitioning to a value stream view for their hugely important brands. Leading Gx companies also are beginning to shift from a solely functional view to one that enables better end-to-end planning for therapeutic areas or product families (such as ceph/pen/penem, controlled substances, oncology). Understanding the whole picture enables faster and better decision making.

Developing long-term capacity planning to support growth

The generics market is continuing to grow. For example, in Germany, the Gx prescription volume doubled between 2004 and 2012. If supply chain does not correctly plan long-term capability, they will soon run into problems. Biologics production has already experienced a capacity bubble, with excess capacity across the industry as great as 40 percent. Similar risks await other segments of the Gx value chain if long-term supply chain planning is not matched to an understanding of the business.

To manage long-term planning, supply chain leaders must do the following:

- **Create strong linkages with product development and commercial to understand the sources of both growth and future supply:** One common problem in Gx is that there are strong silos within product development, commercial, and supply chain functions on new product introduction. Gathering demand forecast for new products is often hard and manual. The demand information is shared with the supply chain only at the late stage of the new product introduction process, preventing the supply chain from effectively planning its long-term capacity. Leaders in FMCG and innovative pharma have extensive integrated launch-planning efforts and a clear process for information sharing.

- **Use sales and operations planning (S&OP) with scenario analysis to align all stakeholders on a long-term capability plan:** An additional practice that leaders have put in place is to have clear linkage between new product-planning processes and S&OP processes for all stages of new product introduction. Long-term planning of new production introduction is a key input to the strategic quarterly and long-term S&OP process. Shorter-term launch planning is integrated with the monthly mid-term S&OP process. The cross-functional team reviews, discusses, and aligns the actions to be taken in response to changes in market assumptions and supply situation for new product (for example, reduced new product launches uncertainty as launch time grows nearer), along with on-market products. As a result, all stakeholders have clear roles and responsibilities on new production planning and can effectively plan long-term capability.

□ □ □

Gx supply chain leaders deserve to feel proud of their progress, particularly relative to the performance of their branded peers. That said, however, the key question for these companies is how to build on their strengths to ensure cost effectiveness through stable manufacturing, high reliability, fast reaction times, and sufficient capacity in a highly challenging environment. They must continue to leverage integration, agility, and continuous improvement not only to drive a higher performance level but also to avoid a constant state of firefighting. The task ahead is admittedly daunting, but their considerable progress thus far should give supply chain leaders the confidence to persevere.

MAY 17, 2020

The Boeing 787 Dreamliner: A tale of TERRIBLE supply chain management

#industry-focus/outsourcing/boeing-787-dreamliner-tale-terrib

FREDDIE PIERCE 4 MIN

Boeings production of the 787 Dreamliner is almost laughable. It has become such a mess, such a supply chain disaster, that it almost makes you think B...

production meeting where the Boeing execs decided that outsourcing nearly every aspect of the Dreamliner's production was a savvy business move.

This is the same aircraft that Boeing said was one of the most important in its history. It's the same one that will deploy the latest technology and most revolutionary design in the history of passenger air travel. This is the aircraft that will supposedly set the standard for all aircraft manufacturers to follow in the future. The Boeing 787 Dreamliner is the first of its kind use carbon-composites in its structure. Considerably lighter than its aluminum counterparts, the 787 Dreamliner will operate on 20 percent less fuel, which can mean millions upon millions in savings each year for the major airliners.

Naturally, Boeing also thought this was also an ideal time to say, "**F*ck it**. Let's throw out everything we've ever known or used in airplane production and use this new, unproven method."

Pretty smart play, right?

How did that conversation even start? If it was about costs, it didn't work. Boeing will tell you that Dreamliner production has been about as cost effective as driving a Hummer. They are paying late-delivery fees out of their butts. More than likely the reason for the outsourcing move came simply because Boeing execs just got cocky. They thought they could use over 50 suppliers from multiple countries across the world and get away with it. They thought they had a tight enough grip on their supply chain that it wouldn't matter. They thought that outsourcing things like engineering and manufacturing would be as seamless as outsourcing a call center.

But there's a tricky thing about outsourcing. It's supposed to be used for a company's non-core areas of business. It's supposed to be for things like IT, graphic design and website building. I didn't think it was ever about your core areas of business. So when Boeing outsourced things like engineering and manufacturing, one had to wonder, "If they are outsourcing that, then what are Boeing's core areas of business?" You just don't outsource your the areas where you are most competent. If you do, you run the risk of becoming fully reliant on your suppliers. That's what Boeing did, and now they are paying for it dearly.

Boeing even touted the fact by openly saying it was getting a "world of help" (pun intended) on the 787 Dreamliner. It's not that big of a shock to receive parts from global vendors, but Boeing was using so many that you had to wonder if they were still part of Team America. Sources from South Korea, Italy, Japan, Australia, China, Sweden, France and Canada all have significant roles in the production of the 787 Dreamliner. The cogs in receiving supplies from such a vast network of global vendors have taken its toll on Boeing.

Boeing was supposed to debut the 787 Dreamliner in a test flight in August 2007 and then achieve first delivery in May 2008. Boeing, however, has been pushing the date back ever since, much to the chagrin of Dreamliner buyers. They finally got the Dreamliner in the air for a test flight in November 2010, but it had to do an emergency landing after an unexpected fire on board. (Go figure) Boeing recently said that they hope to have the plane operational by the 3Q of 2011, but really they should have just said, "It will be ready, when it's ready."

Boeing has cited everything from a shortage of bolts (seriously) to inadequacies in flight control software for delayed production. What did they expect with their expansive vendor list? Boeing effectively outran the ability to effectively manage the supply chain and in doing so they lost control of the 787 Dreamliner. In fact, I'm not sure Boeing ever had control of it in the first place. The company's fate with regards to the Dreamliner was always in the hands of its suppliers.

management; that they could slip by using a new, cost-effective approach that had never been seen before in Boeing's 90-plus year history.

And we are all seeing how that's working out. Good work, guys.

Want more? Of course you do. You made it this far, so check out how Apple manages it's Supply Chain or Caterpillar Logistics Supply Chain Rule of Thumb.

As always, don't forget to check us out on Facebook, and if you want to get in touch with me personally, hit me up with a message on my personal page: Brett Supply Chain