

# Supply Chain Integration



## Dell Inc.: Improving the Flexibility of the Desktop PC Supply Chain

It was June 2005, seemingly a good time for Dell Inc. Since the dot-com bubble burst in 2001, the price of the company's stock had roughly doubled. Both the company's revenue and net income were reaching new heights. In spite of the confidence and optimism, however, Dell's desktop PC manufacturing division found that its manufacturing costs had continued to surge. Tom Wilson, one of the division's directors, revealed: "The recent increase in Level 5 manufacturing is alarming to us at Dell. From Dell's perspective, this adds cost to our overall manufacturing process. We are not able to take as much advantage as we should of the lower cost structure of our contract manufacturers. Instead, we have to rely more heavily on the 3rd-party integrators (3PIs). Not only do we get lower-quality products because we currently don't require 3PIs to perform integration unit testing, we also have difficulty forecasting for the 3PIs how much manufacturing capacity they should have available to support Dell's demand."

*Source:* This case study was written based on MIT Leaders for Manufacturing (LFM) Class of 2006 Fellow Johnson Wu's master thesis and co-developed with his thesis advisors Prof. Charles Fine and Prof. David Simchi-Levi and LFM Program Director Dr. Donald Rosenfield. © 2006 Massachusetts Institute of Technology. All rights reserved.

### HISTORY OF THE PC INDUSTRY

In the 1960s, the first so-called personal computers (PCs)—non-mainframe computers—such as the LINC and the PDP-8 became available. They were expensive (around \$50,000) and bulky (many were about the size of a refrigerator). However, they were called "personal computers" because they were small and cheap enough for individual laboratories and research projects. These computers also had their own operating systems so users could interact with them directly.

The first microcomputers hit the market in the mid-1970s. Usually, computer enthusiasts purchased them in order to learn how to program, and used them to run simple office or productivity applications or play games. The emergence of the single-chip microprocessor led to substantially lower computer prices, and, for the first time, a broad spectrum of buyers from the general public. The first widely and successfully sold desktop computer was the Apple II introduced in 1977 by Apple Computer.

In the 1980s, computers became increasingly cheaper and gained great popularity among home and business users. This trend was partly driven by the launch of the IBM PC and its associated software, which enabled the use of a spreadsheet, a word processor, presentation graphics, and a simple database application on a single relatively low-cost machine. In 1982, *Time* magazine named the personal computer its Man of the Year. Laptop computers truly the size of a notebook, also became available in

the 1980s. The first commercially available portable computer was the Osborne 1 in 1981, which used the CP/M operating system. Although it was large and heavy by today's standards, with a tiny CRT monitor, it had a near-revolutionary impact on business, as professionals were able to take their computer and data with them for the first time. However, it was not possible to run the Osborne on batteries; it had to be plugged in.

Personal computers became more powerful and capable of handling more complex tasks in the 1990s. By this time, they were becoming more like multi-user computers or mainframes. During this decade, desktop computers were widely advertised for their ability to support graphics and multimedia, and this power led to increased usage of desktop computers by movie studios, universities, and governments.

By the end of the 1980s, laptop computers, truly the size of a notebook, were becoming popular among business people. By 2005, high-end PCs focused more on greater reliability and more powerful multitasking capability.

#### DELL'S COMPANY BACKGROUND AND ITS DIRECT MODEL

Dell was founded by Michael Dell in his University of Texas–Austin dorm room in 1984 based on a simple business model: eliminating the retailers from the sales channel and selling directly to customers. By using this model to deliver customized systems to customers with lower-than-market-average prices, Dell soon started to enjoy business success, joining the ranks of the top-five computer system makers worldwide in 1993, and became Number 1 in 2001. With three major manufacturing facilities in the United State (Austin, Texas; Nashville, Tennessee; Winston-Salem, North Carolina) and facilities in Brazil, China, Malaysia, and Ireland, Dell's revenue for the last four quarters totaled \$56 billion. Dell employs 65,200 people worldwide.<sup>1</sup>

In addition to personal computers, Dell's current product offerings include a variety of consumer electronics: workstations, servers, storage, monitors, printers, handhelds, LCD TVs, projectors, and so forth. Some of these products are manufactured by Dell factory associates; other products are manufactured by other companies but sold under the Dell brand.

Throughout the company's history, Dell's fundamental business model has not changed: selling

directly to customers has become Dell's key strategy and strength. The direct business model includes no retailers and starts and ends with the customer: a customer orders online or via phone a computer system according to his preferred configuration, Dell manufactures this computer system, and Dell ships directly to the customer. Dell has been able to keep manufacturing costs lower than competitors' costs because it not only saves money by shipping directly to customers, but it also only builds to order, so raw material inventory is low. The direct model also reduces the time from customer order to receipt of the system. Moreover, the direct model provides a single point of accountability so Dell can more easily design its customer service model in order to provide the necessary resources to satisfy its customers.

#### CONTRACT MANUFACTURING

By 2005, most PC makers utilized contract manufacturers to produce high-tech electronic products. The phenomenon of contract manufacturing began in the 1980s. To take advantage of labor cost differences, many original equipment manufacturers (OEMs) initiated business engagements with contract manufacturers (CMs). When the contract manufacturing business model was first implemented, CMs were responsible for producing materials or unassembled components in less expensive regions and shipping them to the OEMs' factories in the United State or Europe for product assembly. By the late 1990s, however, more and more contract manufacturers began to perform some level of manufacturing/assembly for their customers. This helped fuel the growth of contract manufacturing. According to Alameda, California-based Technology Forecasters Inc., in 1998, the contract manufacturing industry was worth \$90 billion. By 2001, this figure almost doubled to \$178 billion.<sup>2</sup> OEMs chose to let contract manufacturers own and manage part of the manufacturing process for the following reasons:<sup>3</sup>

1. Capability: The OEM cannot make the item or easily acquire this capability and must seek a supplier.

<sup>1</sup> Dell Company Web site, Company Facts.

<sup>2</sup> Drew Wilson, "Contract Manufacturing Revs Up for 2000," *The Electronics Industry Yearbook/2000*, p. 88.

<sup>3</sup> Charles H. Fine and Dan Whitney, "Is the Make-Buy Decision Process a Core Competence?" MIT CTPID Working Paper, 1996.

2. Manufacturing competitiveness: The supplier has a lower cost, faster availability, and so forth.
3. Technology: The supplier's version of the item is better.

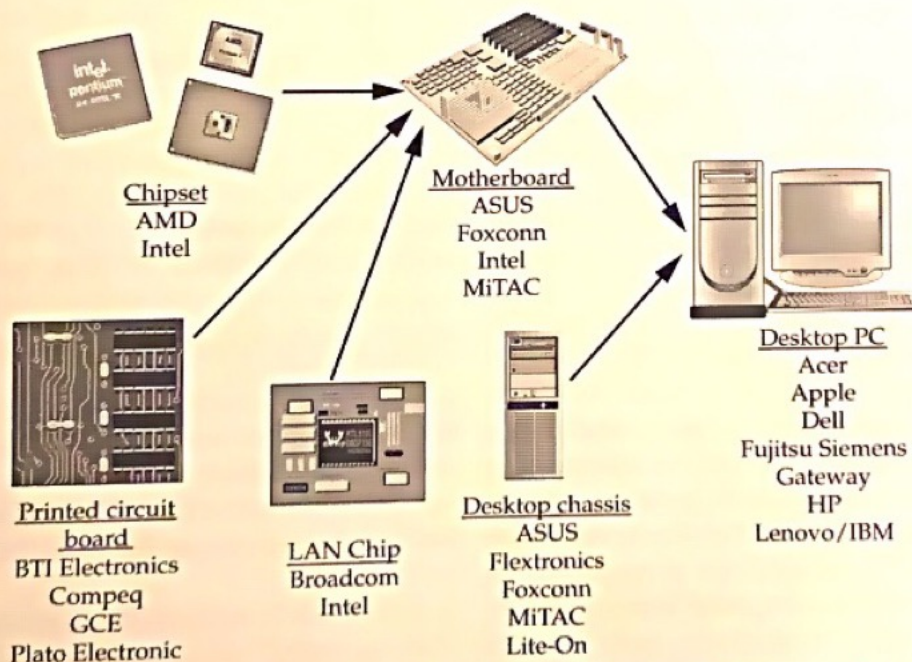
By 2005, almost all the desktop PCs sold in the United States were initially produced by contract manufacturers in China. In a typical contract manufacturing transaction, the OEM approaches the contract manufacturer with a product design. The two negotiate and agree on the price, property of materials, subtier suppliers, and sometimes even the manufacturing process. The contract manufacturer then acts as the OEM's factory. Most contract manufacturers for both desktop and laptop PC products have factories in China or other parts of Asia. Depending on the degree of manufacturing competency and cost, some contract manufacturers do everything from manufacturing all the way to shipping fully assembled products on behalf of the OEM. Therefore, by 2005, most American PC makers had become "fabless," and Dell was one of the few American companies that still retained manufacturing facilities in the United States.

In Dell's case, because customers can customize some components of their PCs when placing an order, manufacturing a fully finished product and shipping it by ocean from the contract manufacturer's facility in China to the customers in the United States would be

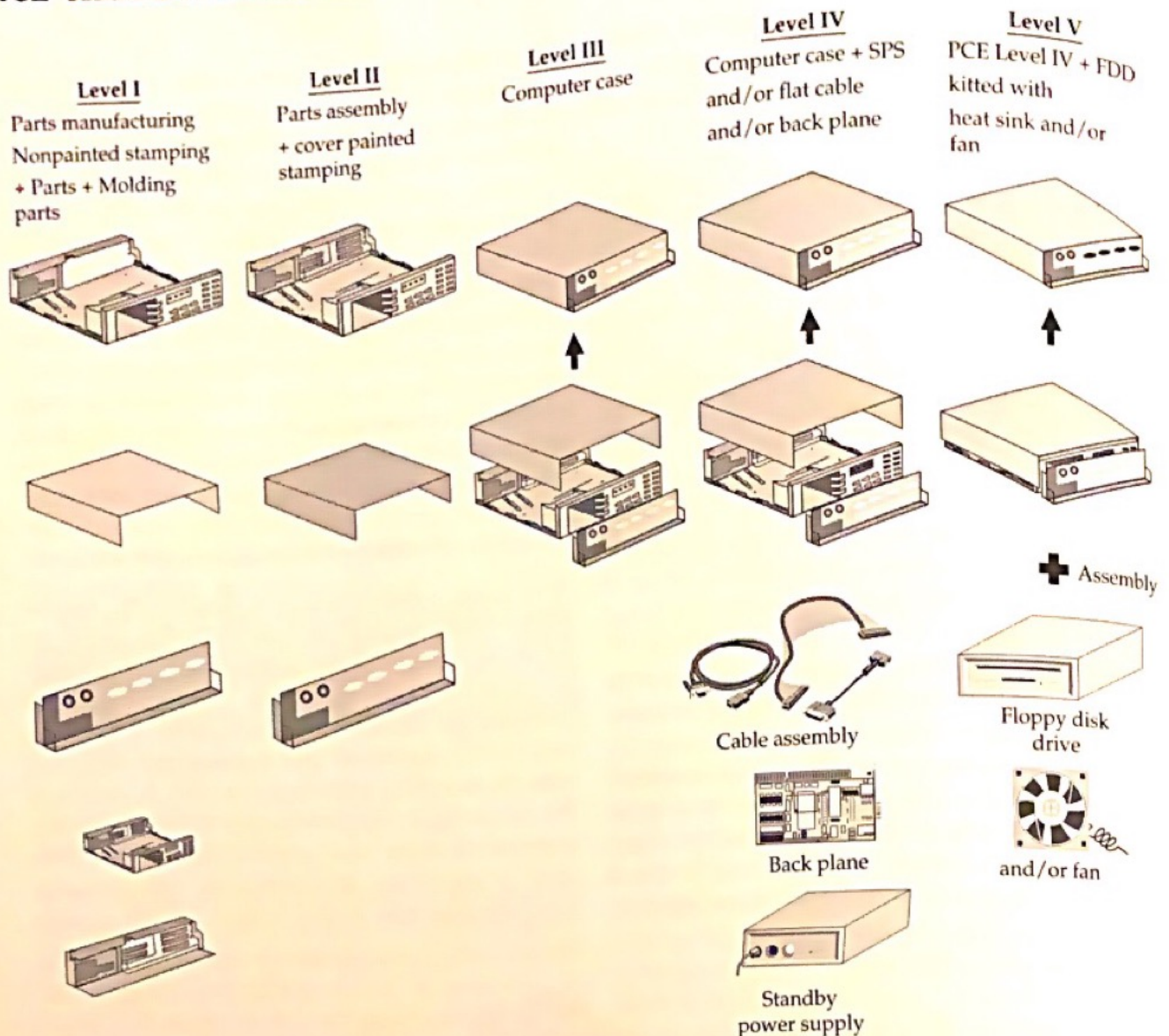
time-prohibitive, and manufacturing a finished product and air-freighting it would be too cost-prohibitive if it is a heavy or bulky desktop product. Therefore, for Dell's desktop products, contract manufacturers in China produce and ship (by ocean) half-assembled products to Dell's factories in the United States. Once the supply arrives and the components preferred by a customer are known, Dell factory associates perform further product fulfillment: building in the customized components (including the processor, memory, hard drive, speaker, etc.), installing the necessary software application, performing final unit testing, and then delivering the fully assembled and functional product to the customer in a timely fashion.

### CRITICAL COMPONENTS OF A DESKTOP PC

Two major components of a desktop PC are the motherboard and the chassis. (See Figure 6-1 for an illustration of these components.) A motherboard is the "nervous system" of a computer: it contains the circuitry for the central processing unit (CPU), keyboard, and monitor and often has slots for accepting additional circuitry. A chassis is the enclosure or framework case that contains and protects all of the vital internal components from dust or moisture. Motherboards are typically screwed manually to the bottom of the chassis



**FIGURE 6-1** Critical components of a desktop PC and major component manufacturers.



**FIGURE 6-2** Levels 1–5 of desktop PC assembly.

case, with the input/output (I/O) ports exposed on the side of the chassis. The chassis also contains the power supply unit.

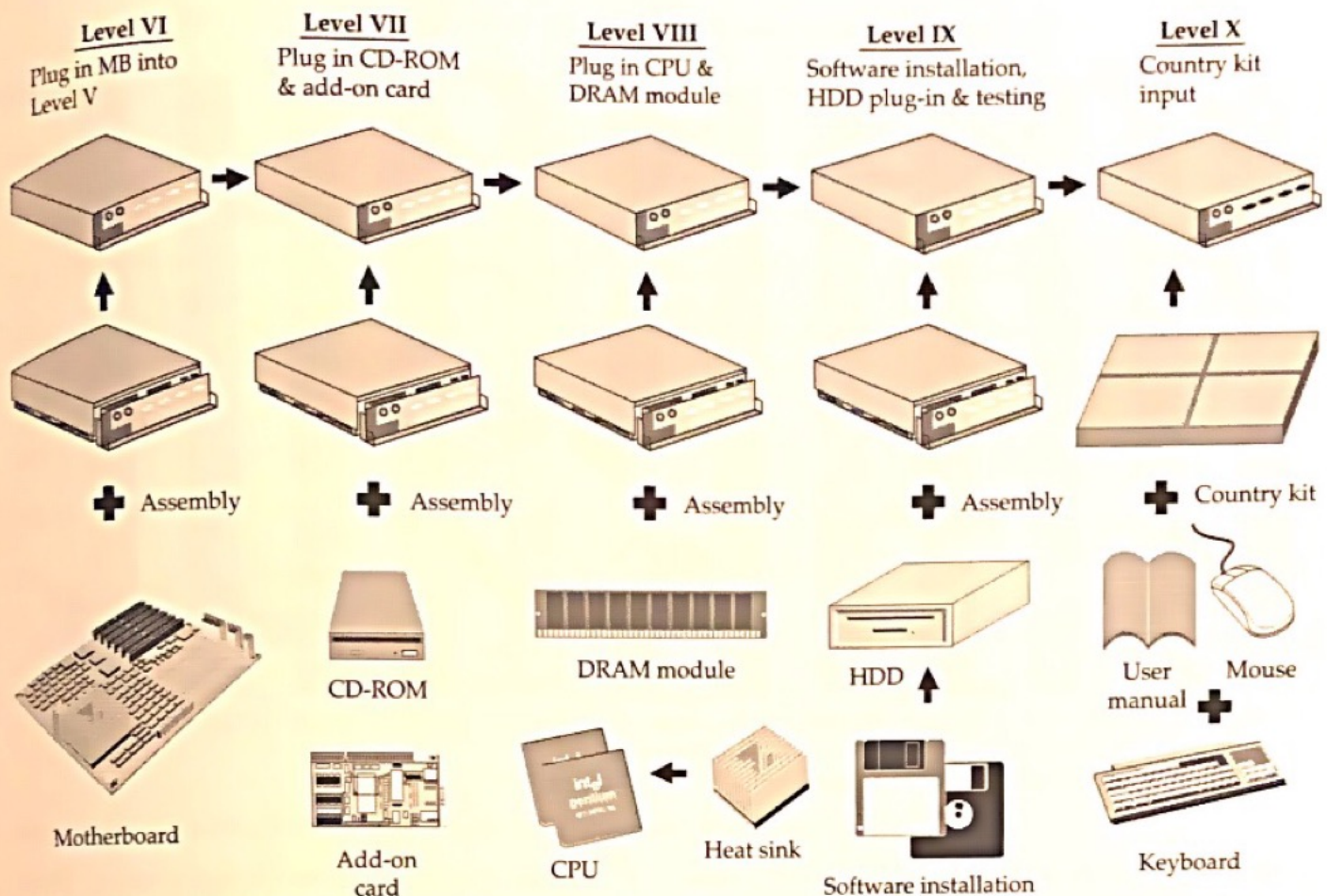
A motherboard contains three critical components: chipset, printed circuit board (PCB), and local area network (LAN) chip. A PCB is the base of a motherboard; it consists of etched conductors attached to a sheet of insulator. Various components are soldered to the circuit board. A chipset is a group of integrated circuits that contains the northbridge and southbridge. The northbridge communicates with the CPU and memory; the southbridge communicates with the slower devices, such as the Peripheral Component Interconnect (PCI) bus, real-time clock, power management, and so forth. A LAN

chip enables a computer to communicate with the Internet via Ethernet or Wi-Fi technology.

#### LEVEL 5 VERSUS LEVEL 6 MANUFACTURING

In desktop PC manufacturing, the degree of assembly can be broken down into 10 levels. The higher the level, the more fully integrated it is. Figures 6-2 and 6-3 depict the 10 levels of desktop PC assembly. This scale also can apply to the manufacturing of servers and storage.

Level 5 (L5) includes the assembly of desktop PC chassis, floppy disk drive, and fan. Depending on the chassis configuration, it also can include the power supply in some cases. In Level 6 (L6), along with



**FIGURE 6-3** Levels 6–10 of desktop PC assembly.  
Source: Foxconn Company presentation.

these components, the motherboard is also installed into the chassis. In other words, when a supplier performs Level 6 manufacturing, the supplier installs the motherboard in the chassis—an activity not performed in Level 5 manufacturing.

When a contract manufacturer in China produces an L6 desktop PC chassis, the chassis is not a functional unit yet and still requires customized parts such as the processor, memory, hard drive, speaker, and so forth. The contract manufacturer ships the L6 chassis from China to Dell's factories in the United States and Ireland, and then Dell factory associates install these customized parts to make the unit "Level 10." A Level 10 product is a fully assembled and functional product that can be shipped to the customer. Figure 6-4 shows the similarities and differences between the L5 and L6 value chains.

Some of Dell's products, such as handhelds and printers, are manufactured to Level 10 by the contract manufacturers. This means that Dell does not have dedicated manufacturing resources or capability

to manufacture these products. Rather, the contract manufacturers produce these products, include the user manuals in the packaging, and ship the products to Dell's merge centers. These products are then "merged" with PCs manufactured by Dell factory associates into the same shipment, so the customer can receive a single shipment with all of the items in the order. Dell uses this shipping strategy to create a more satisfying customer experience.

#### ROOT CAUSES OF INCREASING L5 MANUFACTURING

L5 manufacturing has higher overall manufacturing and logistics cost than L6. Dell's rising manufacturing cost, caused by an increase in the utilization of L5 manufacturing, can be seen in Figure 6-5. Furthermore, as can be seen in Figure 6-6, the level of L5 manufacturing (relative to L6) started to increase quite significantly in March 2005. The L5 percent in June (27 percent) was more than six times the L5 percent in March (4 percent).

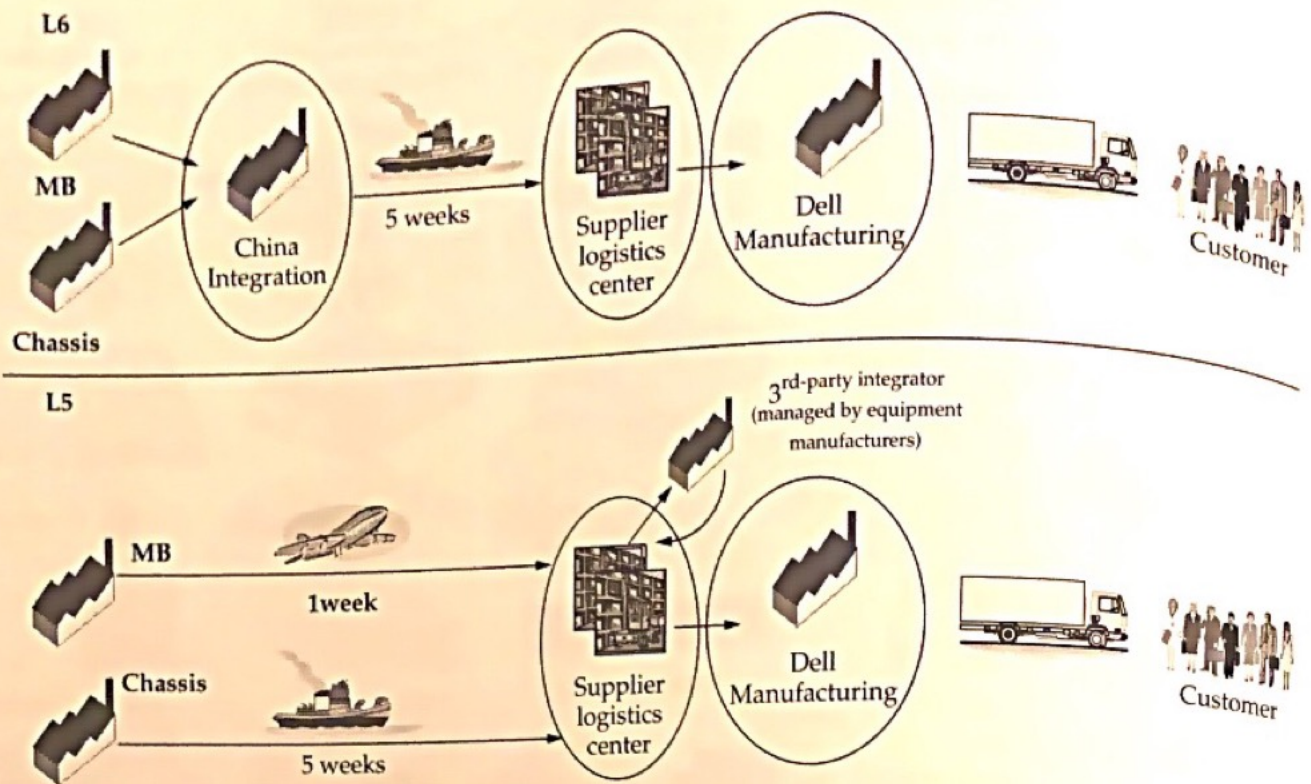


FIGURE 6-4 L6 versus L5 value comparison.

Most of the root causes of the rise of L5 manufacturing have to do with Dell's inability to provide motherboards in a timely fashion to contract manufacturers. These causes can be summarized as follows:

1. *Chipset supplier decommit or supply issues.* When a chipset supplier is unable to deliver the previously agreed quantity of chipsets, it creates a disruption in the desktop PC supply chain. According to the data gathered in the first half of 2005, this accounted

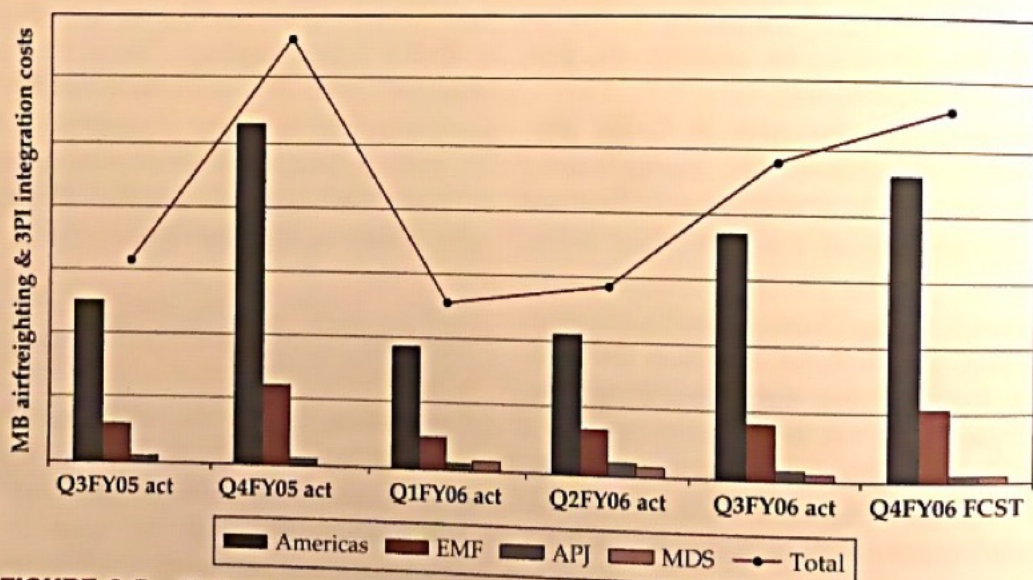
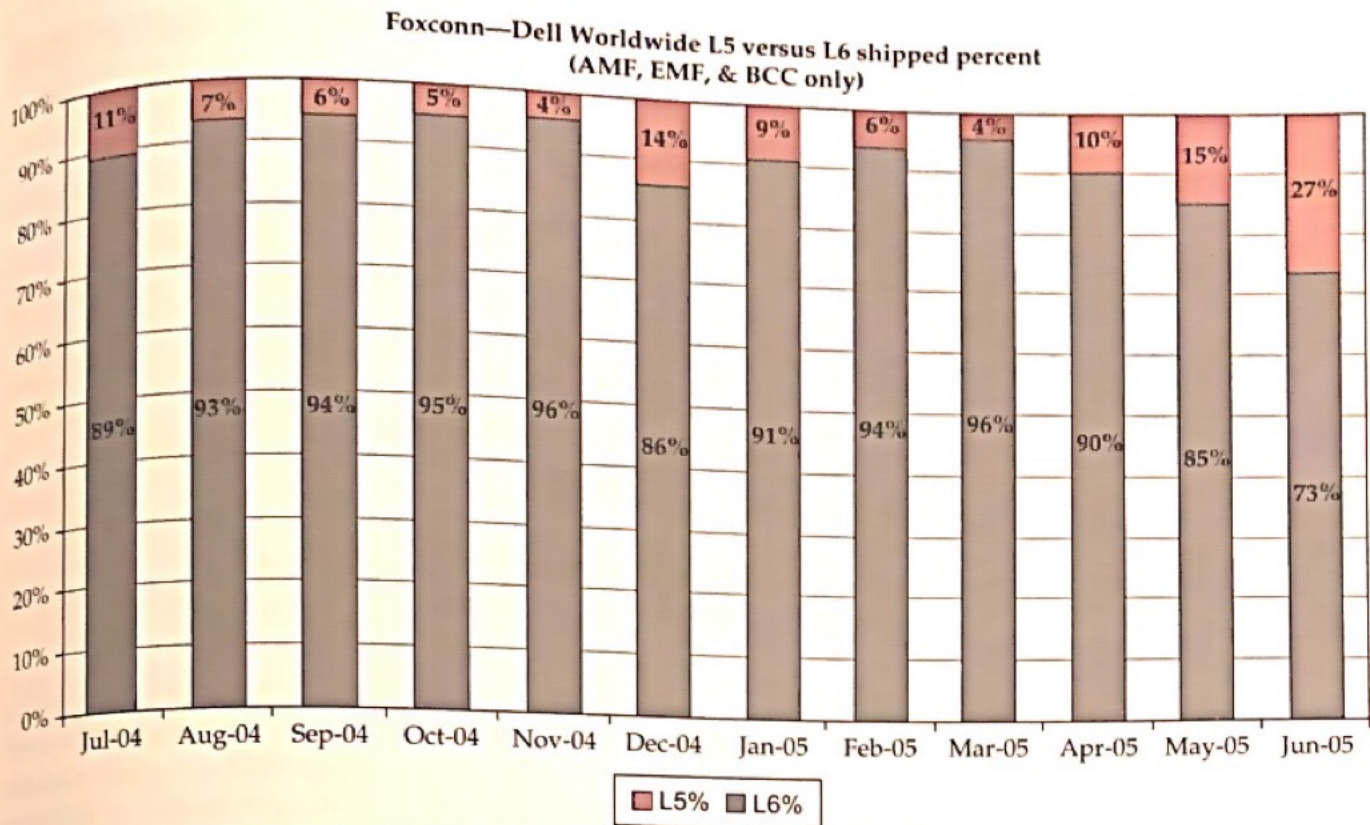


FIGURE 6-5 Motherboard air-freighting and 3PI integration costs (Q3FY05-Q4FY06). Note: Data from Dell's Worldwide Procurement (WWP) organization. AMF includes 3PI integration cost. EMF (European Manufacturing Facility) and APJ (Asia Pacific Japan) don't as integration is done in Dell factory. In Dell's financial year Q1FY05 is February-April 2004; Q4FY06 is November 2005-January 2006.



**FIGURE 6-6** Percentage of L5 versus L6 production from July 2004 to June 2005.

for more than 60 percent of the L5 manufacturing, as motherboards were not available for L6 manufacturing.

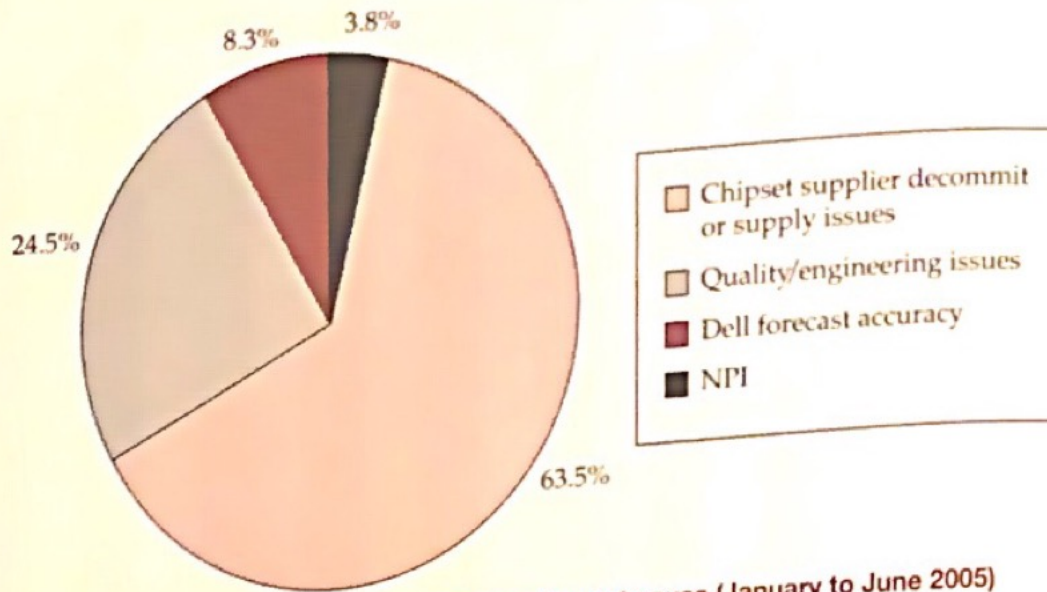
2. *Quality/engineering issues.* These issues lead to dysfunctional or problematic motherboards that need to be repaired or replaced by a new supply, which can subsequently create an additional unexpected demand of motherboards that were not part of the forecast agreed to by Dell's chipset supplier.
3. *Dell forecast accuracy.* When the actual demand surpasses the forecast, Dell needs to source extra chipsets or risk the possibility of not meeting customer demand. Since the lead time for manufacturing, assembling, testing, and delivering a chipset is on average 13 weeks, such a long lead time makes it difficult for the chipset supplier to provide the additional chipsets in order to meet Dell's demand schedule.
4. *New product introduction (NPI).* Since the actual demand of a newly released PC product can be especially volatile, the forecast uncertainty can create a need to air-freight extra motherboards normally not required when the product is in a mature stage with a stable level of demand and a constant level of L6 manufacturing. The volatile

demand can lead to an increase of L5 manufacturing (motherboard-chassis assembly in the United State in order to reduce the time to market for a newly launched product). However, as Figure 6-7 indicates, the amount Dell spends on expediting motherboards under this particular circumstance is rather small—only 3.8 percent.

Figure 6-7 shows the breakdown of motherboard air-freight costs by root cause from Dell AMF (America Manufacturing Facility).

#### DELL BPI TEAM'S METHODOLOGY: FOCUSING ON COMPLEXITY MANAGEMENT

In order to solve the problem of continuously rising manufacturing cost induced by an increasing level of L5, a task force was assembled at Dell. The cross-functional business process improvement (BPI) team consisted of employees from a variety of organizations at Dell: manufacturing/operations, worldwide procurement, regional procurement, production master schedulers, production control, quality, process engineering, supplier quality engineering, cost accounting, inventory control, and logistics. The team, consisting of members from the different organizations affected



**FIGURE 6-7** Dell AMF expedite expenses by root cause (January to June 2005)  
Source: Data from Dell's Worldwide Procurement (WWP) organization.

by the chipset supply shortage, jointly identified six manufacturing options for managing the assembly work in the United State:

1. Keep as current. Motherboard-chassis integration performed by a 3rd party integrator (3PI) managed by the contract manufacturers.
2. Dell America Operations (DAO) cellular integration. Enable the Dell factory work cells to perform L5 to L10 manufacturing work.
3. Offline integration at the supplier logistics center (SLC). Keep the current L6 to L10 manufacturing process unchanged; handle motherboard-chassis integration work at an SLC.
4. Offline integration at a Dell-leased building. Keep the current L6 to L10 manufacturing process unchanged; handle motherboard-chassis integration work at a separate building leased by Dell.
5. 3PI managed directly by Dell.
6. L6 from equipment manufacturers' Mexico plants. Many CMs have manufacturing facilities in which they produce for their other customers. Dell can potentially negotiate with the CMs to dedicate a portion of the CM's manufacturing capacity to support Dell's business.

The BPI team determined that it would survey of the various departments impacted at Dell to quantify the complexity and cost of managing each of the six manufacturing options. The categories of the survey were established by the team based on the attributes or business processes that would be impacted by the change of manufacturing method.

The survey was sent to the content expert within each affected department. These experts were involved in the day-to-day business processes and planning and would be the best source of information regarding the impact on their departments of each manufacturing option. Table 6-1 illustrates the result of the survey.

On the basis of manufacturing complexity, the original option (1) of having the contract manufacturers manage the 3PI had a medium complexity score. Option 3A received the lowest complexity score because overall Dell believed having its own factory associates assemble motherboards into L5 chassis in an SLC would only require Dell to install new equipment at the SLC, so the capital expenditure would be low and not impact the existing manufacturing process in the Dell factory. (Note that the complexity of Option 3A is only a point less than Option 4—Dell-managed 3PI.) At the other end of the complexity spectrum is Option 5. This option was the most complex because it would require Dell's biregional procurement organization (in Austin, Texas, and Shanghai, China) to coordinate and entirely revamp its business processes of managing the L6 chassis from Mexico. (At the time of this case study, all the L6 chassis came from only the Chinese factories of the contract manufacturers.) The lack of a robust transportation and customs infrastructure in Mexico also contributed to the high complexity score.

On the basis of manufacturing cost, the original option (1) of motherboard-chassis assembly in a CM-managed 3PI has the highest manufacturing cost.

**TABLE 6-1**  
**COMPLEXITY AND COST ANALYSIS OF THE SIX POTENTIAL MANUFACTURING OPTIONS**

|                                            | Option 1       | Option 2<br>(original) | Option 2<br>(revised) | Option 3A     | Option 3B     | Option 4      | Option 5      |
|--------------------------------------------|----------------|------------------------|-----------------------|---------------|---------------|---------------|---------------|
| Worldwide procurement                      | 10             | 1                      | 1                     | 1             | 1             | 5             | 10            |
| Regional procurement                       | 8              | 5                      | 5                     | 5             | 5             | 5             | 10            |
| Master scheduler                           | 5              | 5                      | 5                     | 5             | 5             | 5             | 5             |
| Production control                         | 5              | 10                     | 10                    | 7             | 7             | 7             | 5             |
| Operations                                 | 1              | 10                     | 10                    | 5             | 5             | 1             | 1             |
| DAO quality                                | 5              | 10                     | 10                    | 5             | 5             | 1             | 1             |
| Processing engineering                     | 1              | 10                     | 10                    | 5             | 5             | 1             | 1             |
| Supplier quality<br>Engineering (regional) | 10             | 1                      | 1                     | 1             | 1             | 5             | 7             |
| Supplier quality<br>Engineering (global)   | 1              | 1                      | 1                     | 1             | 1             | 1             | 10            |
| Cost accounting                            | 5              | 1                      | 1                     | 10            | 10            | 10            | 1             |
| Inventory control                          | 1              | 5                      | 5                     | 5             | 7             | 10            | 1             |
| Logistics                                  | 5              | 1                      | 1                     | 5             | 5             | 5             | 10            |
| <b>Total:</b>                              | <b>57</b>      | <b>60</b>              | <b>60</b>             | <b>55</b>     | <b>57</b>     | <b>56</b>     | <b>62</b>     |
| <b>Cost per box</b>                        | <b>\$10.07</b> | <b>\$7.00</b>          | <b>\$7.90</b>         | <b>\$7.54</b> | <b>\$7.70</b> | <b>\$7.61</b> | <b>\$7.00</b> |

Notes: The "cost per box" data has been modified to respect Dell's data confidentiality.

Option 1: CM-managed 3PI (original baseline).

Option 3A: Integration at SLC/hub.

Option 4: Dell-managed 3PI.

Option 2: Integration at DAO work cells.

Option 3B: Integration at Dell-leased building.

Option 5: Integrated chassis from CM factories in Mexico.

This high cost is driven by the process complexity involved: there are many changing hands handling the inventory from one part of the process to the next, as evidenced by the following testimony from a Dell quality engineer: "In our current manufacturing option, the motherboards air-freighted from China are first stored in the SLC and then transported to the 3PI site for integration with the chassis. The chassis are then sent back to the SLC before being pulled into our Dell factories. There are many stakeholders that 'touch' the process: CMs, SLC management, 3PI staff, CM staff managing the 3PI production, and Dell factory associates and process engineers. There are just too many cooks in the kitchen trying to accomplish the same thing. We need a cleaner and more straight-forward process. This will not only make it easier to manage the process, but it will also improve our relationships with the CMs and 3PIs since the current process creates many confusing and frustrating situations, as well as last-minute fires related to motherboard quality issues."

With all this information in mind, Tom Wilson and the rest of the BPI team had to select and implement a solution that would deliver advantages to Dell from both a cost angle and an operational complexity perspective. The team pondered the following questions:

1. Why does L5 incur higher manufacturing and logistics costs than L6? What are some of the costs that are incurred in L5 but not in L6? Are there any costs that apply to only L6 but not L5?
2. Which of the six proposed manufacturing solutions should Dell implement, based on the survey result (Table 6-1)? Why? What are the pros and cons of this recommendation?
3. How easily sustainable is your recommendation for the previous question if the chipset supply shortage further deteriorates?
4. How good is the methodology employed by the BPI team to determine the optimal manufacturing option for Dell? Are there more effective approaches?
5. How can Dell effectively address the root causes contributing to the increase of L5 manufacturing?

**B**y the end of this chapter, you should be able to answer the following questions:

- What is a push strategy? A pull strategy? A push–pull strategy? How would you characterize Dell’s supply chain strategy?
- When should the firm use push? pull? or push–pull? What are the key drivers when selecting the appropriate strategy?
- What does it take to implement a push–pull strategy? What is the impact? What would it cost?
- What is the impact of the Internet on the supply chain strategy employed by the traditional retailers and the online stores? In particular, what is the impact on distribution and fulfillment strategies?

## 6.1 INTRODUCTION

In Chapter 1, we observed that supply chain management revolves around *efficient integration of suppliers, manufacturers, warehouses, and stores*. The challenge in supply chain integration, of course, is to coordinate activities across the supply chain so that the enterprise can improve performance: reduce cost, increase service level, reduce the bullwhip effect, better utilize resources, and effectively respond to changes in the marketplace. As many companies have recently realized, these challenges are met not only by coordinating production, transportation, and inventory decisions, but, more generally, by integrating the **front end** of the supply chain, customer demand, to the **back end** of the supply chain, the production and manufacturing portion of the supply chain. The objective of this chapter is to illustrate the opportunities and the challenges associated with supply chain integration. We consider

- Various supply chain strategies, including push, pull, and a relatively new paradigm, the push–pull strategy.
- A framework for matching products and industries with supply chain strategies.
- Demand-driven supply chain strategies.
- The impact of the Internet on supply chain integration.

Obviously, the availability of information plays an important role in supply chain integration. In some cases, the supply chain must be designed to make this information available. In other cases, the supply chain strategy must be designed to *take advantage* of information that is already available. And, in many cases, an expensive network must be designed to compensate for the lack of information.

## 6.2 PUSH, PULL, AND PUSH–PULL SYSTEMS

Traditional supply chain strategies are often categorized as push or pull strategies. Probably, this 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. In this section, we explain each one of the strategies.

### 6.2.1 Push-Based Supply Chain

In a *push-based supply chain*, production and distribution decisions are based on long-term forecasts. Typically, the manufacturer bases demand forecasts on orders received from the retailer’s warehouses. It therefore takes much longer for a push-based supply chain to react to the changing marketplace, which can lead to

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

In addition, we saw in Chapter 5 that the variability of orders received from the retailers and the warehouses is much larger than the variability in customer demand, due to the bullwhip effect. This increase in variability leads to

- Excessive inventories due to the need for large safety stocks (see Chapter 2).
- Larger and more variable production batches.
- Unacceptable service levels.
- Product obsolescence.

Specifically, the bullwhip effect leads to inefficient resource utilization, because planning and managing are much more 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/or high manufacturing costs, due to the need for emergency production changeovers.

### 6.2.2 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 [17]. In a pure pull system, the firm does not hold any inventory and only responds to *specific* orders. This is enabled by fast information flow mechanisms to transfer information about customer demand (e.g., POS data) to the various supply chain participants. Pull systems are intuitively attractive since they lead to

- A decrease in lead times achieved through the ability to better anticipate incoming orders from the retailers.
- A decrease in inventory at the retailers since inventory levels at these facilities increase with lead times (see Chapter 2).
- A decrease in variability in the system and, in particular, variability faced by manufacturers (see the discussion in Section 5.2.3) due to lead-time reduction.
- Decreased inventory at the manufacturer due to the reduction in variability.

#### EXAMPLE 6-1

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, for example, daily or weekly. These data allow the manufacturer to continuously adjust production quantities according to true customer demand.

Thus, in a pull-based supply chain, we typically see a significant reduction in system inventory level, 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 systems are not planned far ahead in time. 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.

### 6.2.3 Push-Pull Supply Chain

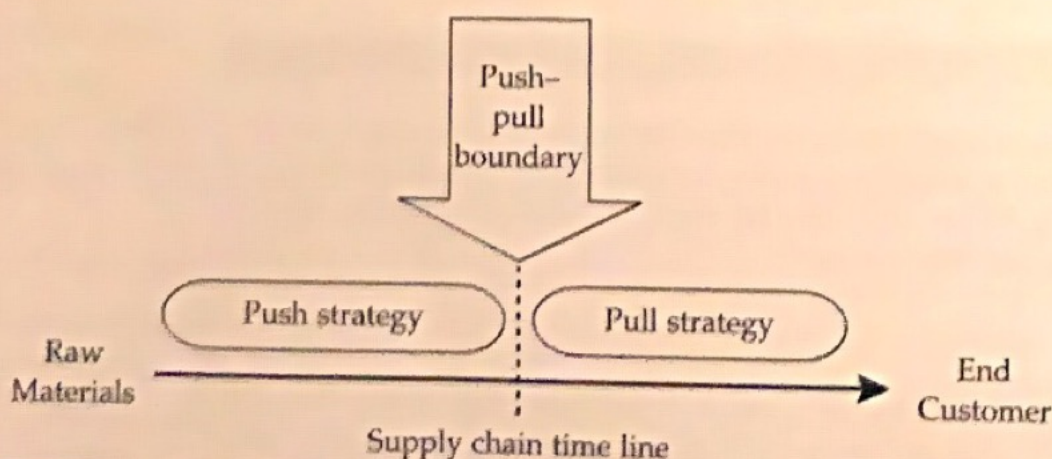
In a *push-pull* strategy, some stages of the supply chain, typically the initial stages are operated in a push-based manner, while the remaining stages employ a pull-based strategy. The interface between the push-based stages and the pull-based stages is known as the **push-pull boundary**.

To better understand this strategy, consider the **supply chain time line** defined as the time that elapses between the procurement of raw material, that is, the beginning of the time line, and the delivery of an order to the customer, that is, the end of the time line. The push-pull boundary is located somewhere along the time line and it 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 6-8.

Consider a PC manufacturer who 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 builds to order. This implies that component inventory is managed based on forecast, but 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 actual customer demand. The push-pull boundary is at the beginning of assembly.

Observe that, in this case, the manufacturer takes advantage of the fact that aggregate forecasts are more accurate (see Chapter 2). Indeed, 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 very effectively and is an excellent example of the impact of the push-pull strategy on supply chain performance.

Postponement, or delayed differentiation in product design (see Chapter 11), 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 is being 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 thus inventory levels are reduced. In contrast, customer demand for a specific end-product typically has a high level of uncertainty and thus 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.

#### 6.2.4 Identifying the Appropriate Supply Chain Strategy

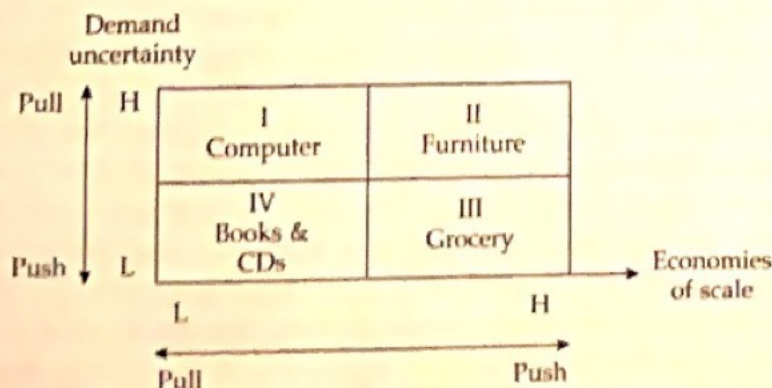
What is the appropriate supply chain strategy for a particular product? Should the firm use a push-based supply chain strategy, a pull-based strategy, or a push-pull strategy? Figure 6-9 provides a framework for matching supply chain strategies with products and industries. The vertical axis provides information on uncertainty in customer demand, while the horizontal axis represents the importance of economies of scale, in either 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.

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, aggregation does not reduce cost, so a pull-based strategy makes more sense.

In Figure 6-9, we partition the region spanned by these two dimensions into four boxes. Box I represents industries (or, more precisely, products) that are characterized by high uncertainty and by situations in which economies of scale in production, assembly, or distribution are not important, such as the computer industry. Our framework suggests that a pull-based supply chain strategy is appropriate for these industries and products. This is exactly the strategy employed by Dell Inc.

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



**FIGURE 6-9** Matching supply chain strategies with products: the impact of demand uncertainty and economies of scale.

soup belong to that category. Demand for these products is quite stable, while reducing transportation cost by shipping full truckloads is critical for controlling supply chain cost. 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. Indeed, 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 the specific costs and uncertainties. We discuss this choice in more detail in Section 6.4.

Finally, box II represents products and industries for which uncertainty in demand is high while economies of scale are important in reducing production and/or delivery costs. The furniture industry is an excellent example of this situation. Indeed, 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 very high. Unfortunately, these are bulky products and hence delivery costs are also high.

Thus, in this case, there is a need to distinguish between the production and the 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. On the other hand, the distribution strategy needs to take advantage of economies of scale in order to reduce transportation cost. This is exactly the strategy employed by many retailers that do not keep any inventory of furniture. When a customer places an order, it is sent to the manufacturer, who orders the fabric and produces to order. Once the product is ready, it is shipped, typically using truckload carriers, together 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 where production is done based on realized demand, a pull strategy, while delivery is according to a fixed schedule, a push strategy.

The automobile industry is another example of the conditions of box II. A typical car manufacturer offers a large number of similar products distinguished by functionality, motor power, shape, color, number of doors, sports wheels, and so forth, and, as a result, demand uncertainty for a particular configuration is very high. Delivery costs are quite high as well. Traditionally, this industry has employed a push-based supply chain strategy, building inventory for the dealer distribution systems. Thus, the automobile industry does not currently follow the model developed in Figure 6-9.

Recently, however, GM announced a dramatic vision for restructuring the way it is designing, building, and selling its products [221]. The goal is to allow customers to

customize and order cars online and have the cars delivered *to the customer's door* in less than 10 days. GM is moving exactly in the direction predicted by our model, toward a build-to-order strategy.

Unfortunately, lead times in the automobile industry are currently long: 50 to 60 days on average. To achieve its vision, GM has to redesign the entire supply chain, including the way it partners with suppliers, the way it manufactures products, and the way it distributes products. Reducing lead times to 10 days or below also may require a significant reduction in the number of options and configurations offered to buyers.

#### 6.2.5 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 6-9. Of course, achieving the design of the pull system depends on many factors, including product complexity, manufacturing lead times, and supplier–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.

#### EXAMPLE 6-2

Consider the automobile industry, known for its long transportation lead times. Prior to its latest effort to implement a make-to-order strategy, there were previous attempts to implement a push–pull strategy. In 1994, GM announced the establishment of a regional distribution center in Orlando, Florida, where an inventory of about 1,500 Cadillacs was maintained. Dealers could order cars they did not have in their lot from the distribution center, and the cars would be delivered within 24 hours. Thus, GM was attempting to employ a push–pull strategy in which inventory at its regional distribution center was managed based on long-term forecasts while delivery to dealers was based on realized demand. This implies that the push–pull boundary was located at the manufacturer's distribution center.

As discussed in Chapter 12, two major issues contributed to the failure of this strategy. First, the regional warehouse shifted inventory costs from the dealers to GM, since it allowed dealers to reduce inventory levels. Second, the regional distribution center equalized small and large dealers. If all dealers have access to the regional warehouse, then there is no difference between small and large dealers. Thus, it is difficult to see why large dealers would be interested in participating in such an arrangement.

The discussion so far suggests that the push strategy is applied to that portion of the supply chain where demand uncertainty is relatively small and, thus, managing this portion based on long-term forecast is appropriate. On the other hand, the pull strategy is applied to the portion of the supply chain time line where uncertainty is high and, hence, it is important to manage this portion based on realized demand. This distinction between the two portions of the supply chain has an important impact on the objectives of the supply chain strategy, as well as on 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 economies of scale in production and/or transportation, but also by long lead times

**TABLE 6-2**  
**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      |

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.

On the other hand, 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. Specifically, high service level is achieved by deploying a **flexible** and **responsive** supply chain, that is, a supply chain that can adapt 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 here to develop an effective strategy for the next few weeks or months. In Chapter 3, we provide a detailed discussion of supply chain planning. Table 6-2 summarizes the characteristics of the push and pull portions of the supply chain.

**EXAMPLE 6-3**

Consider a supplier of fashion skiwear such as Sport Obermeyer [73]. Every year the company introduces many new designs, or products, for which forecast demand is highly uncertain. One strategy used successfully by Sport Obermeyer involves distinguishing between high-risk and low-risk designs. Low-risk products, that is, 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 well in advance of receiving information about market demand, based only on long-term forecasts.

In this case, the manufacturer takes advantage of the same principle applied by Dell Inc.: 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 push strategy. Thus, Sport Obermeyer uses a push–pull strategy for the high-risk products and a push strategy for the 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.

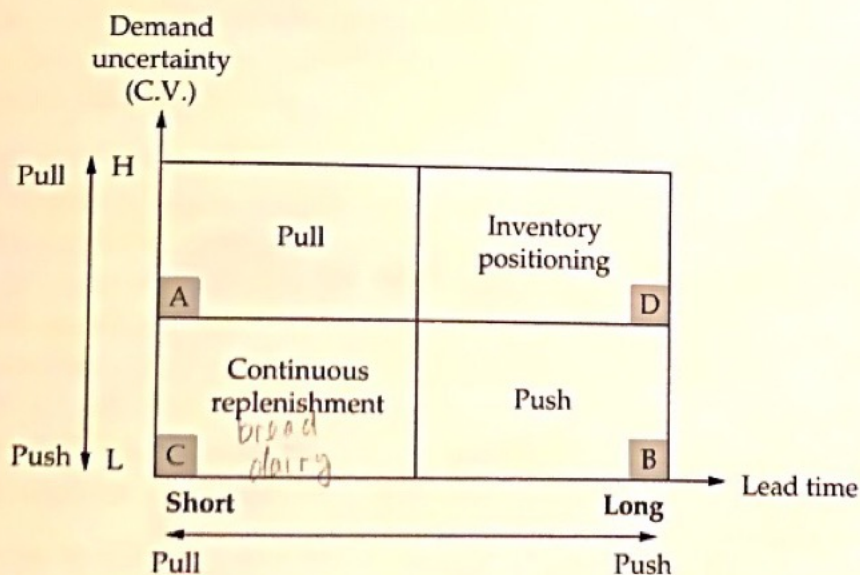
### 6.3 THE IMPACT OF LEAD TIME

The previous discussion motivates a closer look at the impact of lead time on the supply chain strategy. 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 6-10, we consider the impact of lead time and demand uncertainty on supply chain strategy.

Box A represents products with short lead time and high demand uncertainty, suggesting that a pull strategy should be applied as much as possible. Again, the PC industry is a good example of these types of products and the application of a high degree of pull. Box B represents items with 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 having the characteristics of boxes C and D. For instance, box C includes products with short supply lead time and highly predictable demand. Good examples are products in the grocery industry with short life cycle, for example, bread or dairy products. It is interesting to observe how the retail industry takes advantage of the short lead time and low demand uncertainty for these products. Indeed, in these types of situations, retailers and supermarkets use a strategy referred to as *continuous replenishment*. In such a strategy, suppliers receive POS data and use these data to prepare shipments at previously agreed-upon intervals to maintain specific levels of inventory; see Chapter 8 for a detailed discussion. Thus, since customer demand drives production and distribution decisions in this supply



**FIGURE 6-10** Matching supply chain strategies with products: the impact of lead time and demand uncertainty.

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, but this requires positioning inventory strategically in the supply chain (see Chapter 3, Section 3.3). Different stages of the supply chain are managed in different ways, depending, among other things, on economies of scale; those stages that keep inventory are managed based on push and others are managed based on pull. As we will in see in the next example, sometimes the entire supply chain is managed based on push.

EXAMPLE 6-4

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

Recently, the firm 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, because of the tight committed response time to end customers, most inventory was kept close to the customers, at regional and country DCs. Thus, inventory is managed using local optimization: each facility stocks up inventory with little regard to the impact of its decision on supply chain performance. The end result of this strategy is a supply chain with a low inventory turnover ratio of about 3.5.

To overcome these challenges, the manufacturer decided to change the way they position inventory in their supply chain (specifically, the firm applied techniques similar to those described in Section 3.3). The results of this process are described in Figure 6-11, where you can see both the baseline and the supply chain after the change. Each pie represents inventory at a different location, where brown and black colors are associated with cycle stock and safety stock, respectively. As you can see, most of the safety stock in the optimized supply chain is positioned as plant raw material and at the regional DCs. The reason, in both cases, is risk pooling (see Chapter 2). 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 impact of correctly positioning inventory in this supply chain was a significant inventory reduction and an increase to 4.6 turns a year.

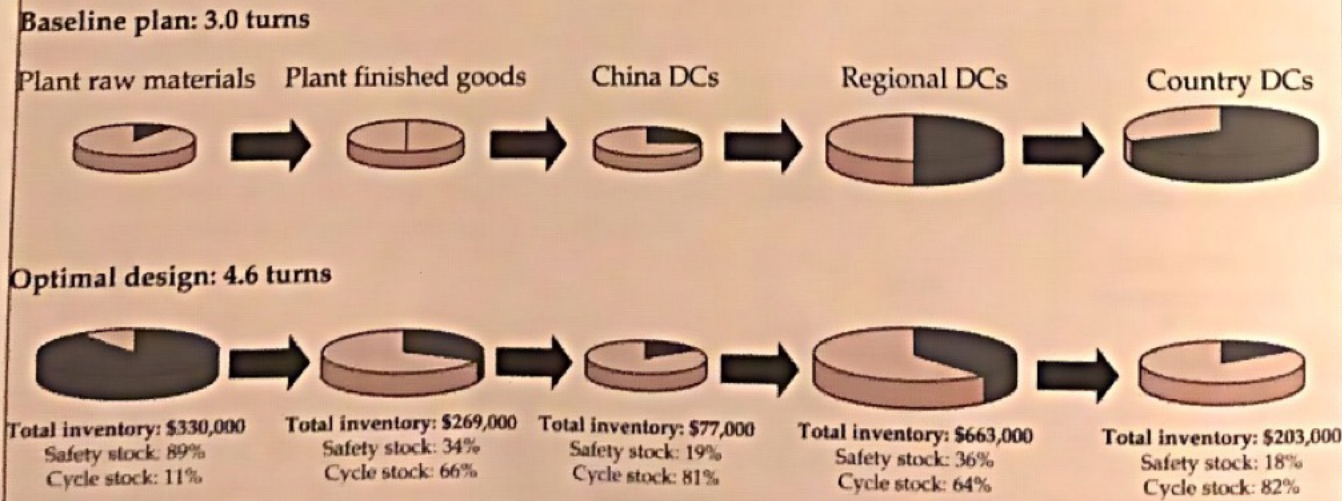


FIGURE 6-11 The impact of positioning inventory strategically.

## 6.4 DEMAND-DRIVEN STRATEGIES

The framework we have developed in this chapter requires integrating demand information into the supply chain planning process. This information is generated by applying two different processes:

- **Demand forecast:** A process in which historical demand data are used to develop long-term estimates of expected demand, that is, forecasts (see Chapter 2 for details).
- **Demand shaping:** A process in which the firm determines the impact of various marketing plans such as promotion, pricing discounts, rebates, new product introduction, and product withdrawal on demand forecasts.

Of course, in either case, the forecast is not completely accurate, and hence an important output from the demand-forecast and demand-shaping processes is an estimate of the **accuracy** of the forecast, the so-called **forecast error**, measured according to its **standard deviation**. This information provides insight into the likelihood that demand will be higher (or lower) than the forecast.

High demand forecast error has a detrimental impact on supply chain performance, resulting in lost sales, obsolete inventory, and inefficient utilization of resources. Can the firm employ supply chain strategies to increase forecast accuracy and thus decrease forecast error? We identify the following approaches:

- Select the push–pull boundary so that demand is aggregated over one or more of the following dimensions:
  - Demand is aggregated across products.
  - Demand is aggregated across geography.
  - Demand is aggregated across time.
 The objective is clear. Since aggregate forecasts are more accurate, the result is improved forecast accuracy.
- Use market analysis and demographic and economic trends to improve forecast accuracy (see Chapter 2 for details).
- Determine the optimal assortment of products by store so as to reduce the number of SKUs competing in the same market. Indeed, we are familiar with a large retailer who used to keep in each store more than 30 different types of garbage cans. It was relatively easy to predict aggregate demand across all SKUs in the garbage can category, but very difficult to predict demand for an individual SKU.
- Incorporate collaborative planning and forecasting processes with your customers so as to achieve a better understanding of market demand, impact of promotions, pricing events, and advertising.

At the end of the demand planning process, the firm has a demand forecast by SKU by location. The next step is to analyze the supply chain and see if it can support these forecasts. This process, called **balancing supply and demand**, involves matching supply and demand by identifying a strategy that minimizes total production, transportation, and inventory costs, or a strategy that maximizes profits. Along the way, the firm also determines the best way to handle volatility and risks in the supply chain. We describe this tactical planning process in Chapter 3.

Of course, demand planning and tactical planning impact each other. Thus, an iterative process must be used to identify

- The best way to allocate marketing budgets and associated supply and distribution resources.
- The impact of deviations from forecast demand.

- The impact of changes in supply chain lead times.
- The impact of competitors' promotional activities on demand and supply chain strategies.

The importance of the iterative process is demonstrated by the following example.

#### EXAMPLE 6-5

A classic example of the perils of not including supply chain analysis in market plans is the story of Campbell's Soup's winter promotion. In one unfortunate season, the marketing department decided to promote chicken noodle soup in the winter. Of course, there is a seasonal spike in the demand for soup in winter anyway. By itself, this seasonal spike requires preparing and storing chicken and ingredients in huge quantities in the spring and fall in order to meet the demand. In addition, due to the promotion, production had to start early and use overtime capacity in order to meet the demand. Unfortunately, the cost of the excess production and inventory requirements far exceeded the revenue from the promotions [47].

### 6.5 THE IMPACT OF THE INTERNET ON SUPPLY CHAIN STRATEGIES

The influence of the Internet and e-commerce on the economy in general, and business practice in particular, has been tremendous. Changes are happening rapidly. For instance, the direct-business model employed by industry giants such as Dell Inc. and Amazon.com enables customers to order products over the Internet and thus allows companies to sell their products without relying on third-party distributors. Similarly, many companies reported that business-to-business e-commerce provides convenience and cost reduction.

In parallel, the Internet and the emerging e-business models have produced expectations that many supply chain problems will be resolved merely by using these new technology and business models. E-business strategies were supposed to reduce cost, increase service level, and increase flexibility and, of course, profits, albeit sometime in the future. In reality, these expectations have frequently gone unmet, as many of the new e-businesses have not been successful. In many cases, the downfall of some of the highest-profile Internet businesses has been attributed to their logistics strategies. Several examples follow.

#### EXAMPLE 6-6

The furniture industry seemed ripe for modernization and e-business when executives from living.com purchased Shaw Furniture Gallery, the 10th largest furniture store in North Carolina, in March of 1999. The purchase was intended to provide living.com with access to top-line furniture manufacturers. After an investment of \$70 million in capital and a spot as the exclusive Amazon.com furniture link, living.com declared bankruptcy on August 29, 2000. Reasons for the failure included the investment in a new information system that did not function correctly and the switch to a carrier that had no experience with furniture delivery, leading to a stunning 30 percent return rate.

#### EXAMPLE 6-7

Furniture.com, launched in January 1999, offered thousands of products from many furniture makers, although only a few brand names. The company had \$22 million in sales in the first nine months of 2000 and one million visitors a month to its Web site. Its downfall in November 2000 was due to logistics details, and, in particular, inefficient delivery processes. Initially, Furniture.com used carriers to ship its products from a central warehouse to the customers. Since transportation costs were too high, the firm formed an alliance with six regional distributors. Unfortunately, these relationships were hard to maintain and left many problems unsolved, including handling of repairs and returns.

**EXAMPLE 6-8**

Founded in 1989, Peapod is based in Skokie, Illinois, and is considered one of America's leading online grocers. As a highly experienced online grocer, the company serves more than 130,000 customers. In 1999, Peapod had sales of \$73 million and generated a loss of \$29 million. Peapod's mounting losses and inability to secure additional funding resulted in a buyout of a majority of its stock in April 2000 by Royal Ahold, the international food company. Peapod thus escaped the fate of Shoplink.com, Streamline.com, and Priceline's WebHouse Club, all of which left the online grocery business at about the same time. These failures are generally attributed to high delivery costs.

Some companies, of course, are extremely successful in developing new business models that allow them to increase profits significantly and capture a sizeable market share. These companies use the Internet as the driver of business change.

**EXAMPLE 6-9**

What started in 1995 as Earth's biggest bookstore is rapidly becoming Earth's biggest store. Amazon.com's main site offers millions of books, CDs, DVDs, videos, toys, tools, and electronics. In addition, Amazon.com conducts auctions for items ranging from art to real estate and provides schedulers, address books, and online greeting cards. Amazon also owns stakes in online sellers of pet supplies, prescription drugs, cars, groceries, and more. Indeed Amazon.com has become a model for Internet companies by placing market share ahead of profits and making acquisitions funded by its meteoric market capitalization. In 1996, the company had \$16M in sales and a \$6M loss; in 1999, it had \$1.6B in sales and a \$720M loss; in 2000, it had \$2.7B in sales and a \$1.4B loss; and in 2005, revenue reached \$8.49B with total profit of \$359M, quite a remarkable transformation..

Despite its downturn in 2001 and the write-off of \$2.25B in excess inventory, Cisco is a good model of a company that makes innovative use of the Internet.

**EXAMPLE 6-10**

According to Peter Solvik, who is CIO of Cisco, "Cisco's Internet-based business model has been instrumental in its ability to quadruple in size from 1994 to 1998 (\$1.3 billion to over \$8 billion), hire approximately 1,000 new employees per quarter while increasing their productivity, and save \$560M annually in business expenses." Over 80 percent of Cisco's customer business is performed over the Internet, and this is only a small part of the entire picture. Indeed, to differentiate itself from the competition in what is essentially a commodity business, Cisco acquires companies that have leading technology and integrates these companies rapidly with its systems. It also sells network solutions, not just components, to its customers. This requires coordination of hardware, software, and service components in many sales. The ability to provide these services and integrate comes from Cisco's single-enterprise system. This system provides the backbone for all activities in the company and not only connects customers and employees but also chip manufacturers, component distributors, contract manufacturers, logistics companies, and systems integrators. These participants can perform like one company because they all rely on the same Web-based data sources. All of Cisco's suppliers see the same demand and do not rely on their own forecasts based on information flowing from multiple points in the supply chain. Cisco also built a dynamic replenishment system to help reduce supplier inventory. Cisco's average turns in 1999 were 10, compared with an average of 4 for competitors. Inventory turns for commodity items are even more impressive: they reach 25–35 turns a year.

The previous examples raise an important question: Why is it that, in some cases, these new business models fail, while, in other cases, they are incredibly successful?

If Amazon, Dell, and Cisco can use the Internet to develop such effective business models, what inhibits other firms from adopting similar techniques?

To answer this question, we require a better understanding of Internet-based supply chain strategies.

#### 6.5.1 What Is E-Business?

To better understand the impact of the Internet on supply chains, we start by introducing our definition of e-business and e-commerce.

**E-business** is a collection of business models and processes motivated by Internet technology and focusing on improvement of extended enterprise performance.

**E-commerce** is the ability to perform major commerce transactions electronically.

These definitions lead to several observations. First, e-commerce is only part of e-business. Second, Internet technology is the force behind the business change. Finally, the focus in e-business is on the extended enterprise, that is, intra-organizational, business-to-consumer (B2C), and business-to-business (B2B) transactions. B2C refers to businesses that are “direct to customer,” especially retail activities over the Internet, and includes products, insurance, banking, and so forth. B2B refers to business conducted over the Internet predominantly between businesses. This includes both electronic sourcing (the so-called eSourcing) and reverse auction as well as collaboration with suppliers and vendors to achieve common goals.

Many companies have recognized that the Internet can have a huge impact on supply chain performance. Indeed, these companies have observed that the Internet can help them move away from the traditional push strategies employed by most supply chains. Initially, the move was toward a pull strategy, but, eventually, many companies ended up with a push-pull supply chain.

#### 6.5.2 The Grocery Industry

Consider the grocery industry. A typical supermarket employs a push-based strategy where inventory at the warehouses and stores is based on a forecast. When Peapod was founded 17 years ago, the idea was to establish a pure pull strategy with no inventory and no facilities. When a customer ordered groceries, Peapod would pick the products at a nearby supermarket. This strategy had significant service problems since stockout rates were very high (about 8 to 10 percent). In 1999, Peapod changed its business model to a push-pull strategy by setting up a number of warehouses; stockout rates are now less than 2 percent. Observe that, in this case, the push part is the portion of the Peapod supply chain prior to satisfying customer demand and the pull part starts from a customer order. Also note that since a Peapod warehouse covers a large geographical area, clearly larger than the one covered by an individual supermarket, demand is aggregated over many customers and locations, resulting in better forecasts and inventory reduction.

Of course, in the online grocery industry, there are other challenges, including reducing transportation costs and responding in a very short period of time, that is, typically within 12 hours in a tight delivery window. Unfortunately, no current online grocers have the density of customers that will allow them to control transportation costs, and therefore compete successfully with traditional supermarkets. This is the reason why most online grocers have failed. Indeed, the framework developed in the previous section suggests that this industry is characterized by a low level of demand

uncertainty for many products and high economies of scale in transportation cost, implying that a push-based strategy is more appropriate.

### 6.5.3 The Book Industry

The book industry is another excellent example of the evolution of supply chain strategies from push to pull and then to push-pull. Until recently, Barnes and Noble had a typical push supply chain. When Amazon.com was established about 10 years ago, their supply chain was a pure pull system with no warehouses and no stock. Indeed, at that time, Ingram Book Group supplied most of Amazon's customer demand.

Ingram Book can aggregate across many customers and suppliers and take advantage of economies of scale. Thus, the pull model employed by Amazon.com was an appropriate strategy when Amazon.com was building its brand name. As volume and demand increased, two issues became clear. First, Amazon.com's service level was affected by Ingram Book's distribution capacity, which was shared by many book-sellers. Indeed, during periods of peak holiday demand, Amazon.com could not meet its service level goals. Second, using Ingram Book in the first few years allowed Amazon.com to avoid inventory costs but significantly reduced profit margins. As demand increased, it became evident that Ingram Book did not provide any advantage for many of the book categories, because Amazon.com's ability to aggregate across large geographical areas allowed the company to reduce uncertainties and hence inventory costs by itself, without using a distributor.

As Amazon.com discovered these issues, the company changed its philosophy, and now Amazon.com has several warehouses around the country where most of the titles are stocked. Thus, inventory at the warehouses is managed based on a push strategy, while demand is satisfied based on individual requests, a pull strategy. In fact, Amazon strategy is a bit more sophisticated; slow-moving, low-volume books and CDs are not stocked at all at Amazon distribution centers; Amazon orders those when demand arrives. Thus, Amazon distinguishes between fast-moving, high-volume and slow-moving, low-volume books. In the latter case, the company is using a pull-based strategy, while in the former, it uses a push-pull strategy (why?).

### 6.5.4 The Retail Industry

The retail industry was, in general, late to respond to competition from virtual stores and to recognize the opportunities provided by the Internet. Recently, however, the landscape has changed, as many so-called brick-and-mortar companies are adding an Internet shopping component to their offering. Enter click-and-mortar giants Wal-Mart, Kmart, Target, and Barnes and Noble, among others. These retailers recognize the advantage they have over pure Internet companies. Indeed, they already have the distribution and warehousing infrastructure in place. Thus, they have established virtual retail stores, serviced by their existing warehousing and distribution structures.

As a result of going online, click-and-mortar firms have changed their approach to stocking inventory. High-volume, fast-moving products, whose demand can be accurately matched with supply based on long-term forecasts, are stocked in stores, while low-volume, slow-moving products are stocked centrally for online purchasing. The low-volume products have highly uncertain demand levels, and thus require high levels of safety stock. Centralized stocking reduces uncertainties by aggregating demand across geographical locations, and thus reduces inventory levels. The analysis implies that these retailers use a push strategy for high-volume, fast-moving products and a push-pull strategy for low-volume, slow-moving products.

Of course, the move from brick-and-mortar to click-and-mortar is not an easy one, and may require skills that the brick-and-mortar companies don't have.

**EXAMPLE 6-11**

Wal-Mart has always prided itself on its distribution operations. Thus, it was a huge surprise when the company announced that it planned to hire an outside firm to handle order fulfillment and warehousing for its online store, Wal-Mart.com, which the retailer launched in the fall of 1999. Fingerhut Business Services filled orders behind the scenes at Wal-Mart's cyberstore. Indeed, with a background in handling individual orders, Fingerhut has emerged as a major provider of third-party distribution services to other retailers and e-tailers interested in home delivery. Fingerhut provided Internet order fulfillment, warehousing, shipment, payment processing, customer service, and merchandise returns for Wal-Mart.com when the service was launched.

**6.5.5 Impact on Transportation and Fulfillment**

This review of the evolution of supply chain strategies in various industries suggests the following insight: The Internet and the associated new supply chain paradigms introduce a shift in fulfillment strategies: from cases and bulk shipments to single items and smaller-size shipments, and from shipping to a small number of stores to serving highly geographically dispersed customers. This shift also has increased the importance and the complexity of reverse logistics.

Table 6-3 summarizes the impact of the Internet on fulfillment strategies. Specifically, the new developments in supply chain strategies are very good news for the parcel and LTL industries. Both pull and push-pull systems rely heavily on individual (e.g., parcel) shipments rather than bulk shipments. This is especially true in the business-to-consumer area, where a new term has been coined: e-fulfillment. Another impact of e-fulfillment on the transportation industry is the significant increase in reverse logistics. Indeed, in the business-to-consumer arena, e-fulfillment typically means that the supplier needs to handle many returns, each of which consists of a small shipment. This is true, since online retailers need to build customer trust through generous return terms. Parcel shipping is already set up to handle these returns, a major issue in B2C and, in many cases, in B2B commerce. This is a challenge for the LTL industry, which traditionally has not been very involved in door-to-door services.

E-fulfillment logistics requires short lead time, the ability to serve globally dispersed customers, and the ability to reverse the flow easily from B2C to C2B. Only parcel shipping can do all that. Indeed, one important advantage of the parcel industry

**TABLE 6-3****TRADITIONAL FULFILLMENT VERSUS E-FULFILLMENT**

|                       | Traditional fulfillment    | E-fulfillment                                      |
|-----------------------|----------------------------|----------------------------------------------------|
| Supply chain strategy | Push                       | Push-pull                                          |
| Shipment              | Bulk                       | Parcel                                             |
| Reverse logistics     | Small part of the business | Important and highly complex                       |
| Delivery destination  | Small number of stores     | Large number of geographically dispersed customers |
| Lead times            | Relatively long            | Relatively short                                   |

is the existence of an excellent information infrastructure that enables real-time tracking. Thus, the future looks promising for the parcel shipping industry and, in particular, for those carriers and consolidators who work to modify their own systems in order to integrate it with their customers' supply chains.

## SUMMARY

In recent years, many companies have improved performance, reducing cost, increasing service levels, reducing the bullwhip effect, and improving responsiveness to changes in the marketplace, by integrating the supply chain. In many cases, this was facilitated by the implementation of push-pull strategies and by a focus on demand-driven strategies. In particular, the Internet has created the opportunity to revolutionize supply chain strategies. Indeed, the success of giants such as Dell Inc. and Cisco and the significant market capitalization of young companies such as Amazon.com can be attributed to sophisticated Internet-based supply chain strategies.

At the same time, the collapse of many Internet companies sends an alarming message that e-business presents not only opportunities but also great challenges. Key to these challenges is the ability to identify the appropriate supply chain strategy for a particular company and individual products. Indeed, the premise on which many of the Internet companies were built—that, in the new economy, there is no need for either physical infrastructure or inventory—has, in many cases, been disastrous. The new supply chain paradigm, push-pull strategy, advocates holding inventory, although it pushes the inventory upstream in the supply chain.

## DISCUSSION QUESTIONS

1. Discuss the advantages of a push-based supply chain. What about a pull-based supply chain?
2. What is an example of a product with a primarily push-based supply chain? A product with a primarily pull-based supply chain?
3. What are the advantages of moving the push-pull boundary earlier in a supply chain? What about later?
4. Amazon.com, Peapod, Dell, and many furniture manufacturers use push-pull supply chain strategies. Describe how each of these companies takes advantage of the risk-pooling concept.
5. Explain Amazon's strategy for slow-moving, low-volume products and fast-moving, high-volume items.
6. Discuss some additional examples of each of the four categories in Figure 6-9.
7. Is it possible for the appropriate supply chain (push, pull, or push-pull) to change during a product's life cycle? If not, explain why? If it is possible, what are some specific examples of products for which the appropriate supply chain changed?
8. Is e-fulfillment a new concept? What is the difference between online and catalog selling? Consider, for instance, Land's End, a company that has both channels.
9. Explain how demand for a product like televisions can be shaped? How does this compare to the ways in which demand for a product like canned soup can be shaped?
10. Other than the examples listed in Section 6.5, what are some more examples of failed Internet supply chain strategies? Successful Internet supply chain strategies?
11. Answer the questions at the end of the case study "Dell Inc.: Improving the Flexibility of the Desktop PC Supply Chain."

Simchi-Levi, David.

Designing and managing the supply chain : concepts, strategies,

Simchi-Levi, Philip Kaminsky, Edith Simchi-Levi.—3rd ed.

p. cm—(McGraw-Hill/Irwin series in operations and decision

Cover title: Designing & managing the supply chain

Includes index.

ISBN-13: 978-0-07-298239-8 (alk. paper)

ISBN-10: 0-07-298239-X (alk. paper)

1. Physical distribution of goods—Management. 2. Market  
3. Business logistics. 4. Industrial procurement. I. Kaminsky,  
III. Title. IV. Title: Designing & managing the supply chain.

HF5415.7.S425 2008

658.5—dc22