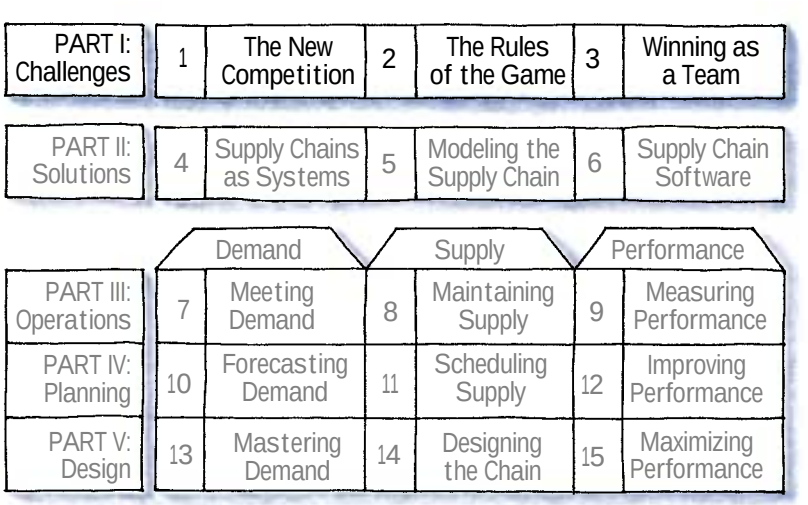
PART I

Challenges



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The New Competition

The way you manage the supply chain can make or break your company. Some of the most spectacular business successes over the past 20 years have come from finding more effective ways to deliver products to consumers, but there have been some major wrecks along this same road. It's a high-stakes game, and you don't have a lot of choice about playing; if your company touches a physical product, it's part of a supply chain and your success hangs on the weakest link of that chain. Why? Because the nature of competition is shifting away from the classic struggle between companies. The new competition is supply chain vs. supply chain.

The Thrill of Victory

Siemens CT reinvented its supply chain

Siemens CT of Forchheim, Germany, makes computed tomography X-ray machines for hospitals and diagnostic labs all over the world. The machines cost about half a million dollars apiece and they are custom-built for each customer. Four years ago, Siemens CT found itself faced with rising costs and price erosion that threatened its position in this lucrative market. The group's response was to completely reinvent the way they provision, assemble, and deliver their products. They cut out two layers of middle management, switched the entire company to team structures, aligned incentives with supply chain success, and let creativity run rampant. Among other changes, the teams tightened the links with suppliers, eliminated all interim warehousing, adopted just-in-time production techniques, and switched to airfreight deliveries for customers outside of Europe.

Lead time went from six months to two weeks

Today, Siemens CT has an award-winning supply chain that sets a new standard for best practices in its industry. Lead time for their custom-built machines is down from 22 weeks to just 2 weeks. The

rate of on-time deliveries has gone from 60% to 99.3%, and *on time* now means that deliveries occur within a two-hour window—an impressive feat for a delivery that requires closing off a street and hauling in a crane. The cost of achieving these stellar results? Zero: These gains in performance were accompanied by a 40% reduction in inventory, a 50% reduction in factory workspace, a 76% reduction in assembly time, and a 30% reduction in total costs. The company also managed to double its output to 1,250 machines a year without increasing its head count.

Gillette slashed $400 million of inventory

Siemens' stunning success would be hard to match, but the company is not alone it its willingness to reinvent the supply chain. At the end of the 1990s, the Gillette Company, a $9 billion supplier of consumer goods, found itself losing market share because of escalating costs. In January 2000 it created a new kind of operating group, combining purchasing, packaging, logistics, and materials management in a single organization with the authority to completely rework its supply chain. Over the course of the next 18 months, the group reduced the total inventory in the chain by 30%, eliminating 40 days' worth of materials costing $400 million. The supply chain organization believes that it is just now getting up to speed, but it has already saved the company $90 million.

Chrysler reinvented its chain in 1990

Supply chain victories like these make for exciting news, but there is nothing new in the techniques these companies applied. At the end of the 1980s, Chrysler Corporation was on the ropes, ending the decade with a fourth-quarter loss of $664 million. Desperate for a way out of its financial morass, the company decided to experiment with some of the techniques being used by Japanese carmakers. Just as Siemens CT and Gillette would do a decade later, Chrysler formed cross-functional teams bringing together design, engineering, manufacturing, procurement, marketing, and finance, and it gave those teams the authority they needed to reinvent the supply chain. The teams cut the supplier base in half, brought the

remaining suppliers in on the design of a new generation of cars, and developed long-term relationships based on trust rather than coercion. Instead of hammering suppliers on price as it had in the past, Chrysler asked for suppliers' help in finding ways to save the carmaker money. More surprisingly, the company offered to split the savings with the suppliers rather than asking them to pass all the savings on to Chrysler.

SCORE saved Chrysler $1.7B a year

Chrysler called its sharing program the supplier cost reduction effort, or SCORE. The company announced SCORE in 1990 to a highly skeptical supply base. But once suppliers realized that this wasn't a trick—that Chrysler was serious about partnering with its suppliers and sharing the winnings—the ideas came flooding in. By 1995, the company had implemented 5,300 ideas suggested by suppliers, for a net annual savings of $1.7 billion. The cost of developing a new vehicle dropped by as much as 40%, and the time required for the development process fell from 234 weeks to 160 weeks. At the same time, Chrysler's profit per vehicle leapt from an average of $250 in the mid-1980s to $2,110 in the mid-1990s, an increase of 844%.

Apple reduced inventory by 94%

Chrysler isn't the only company that staved off disaster by revamping its supply chain. In 1997 Apple Computer was losing $1 billion a year and was on the verge of bankruptcy. The most visible change the company made was to bring back Steve Jobs, but it was radical surgery on its supply chain that actually saved the company. Among other changes, Apple killed off 15 of its 19 products, adopted just-in-time production techniques for those that remained, overhauled its sales forecasting system, and began a relentless effort to minimize inventory. Within two years, the company went from holding a month's worth of inventory, with a value of $437 million, to a few days' worth, valued at just $25 million. Inventory went down by 94%, gross margins went up by 40%, and Apple is still in business today.

The supply chain made Amazon profitable

Speaking of still being in business, Amazon.com Inc., one of the few surviving dot-coms, announced its first-ever profit as of the fourth quarter of 2001. This profit was not so much a vindication of the e-commerce model as it was the result of an intensive, year-long effort to fix the company's sloppy supply chain. The problems had been so bad that 12% of incoming inventory was routed to the wrong storage location, resulting in a great deal of wasted time and energy as the company scrambled to track down its own goods. A year later, after installing better inventory controls, the company had that figure down to 4%—far from perfect, but no longer crippling. Amazon also started combining its shipments to gain economies of scale, sending 40% of those shipments out in full truckloads and driving them directly to destination cities. The results: an 18% reduction in inventory, removing $31 million worth of idle merchandise from Amazon's books, and a 17% reduction in fulfillment expenses, for a further savings of $22 million. These savings may be small compared to the preceding examples, but Amazon's $5 million net profit clearly wouldn't have been possible without them.

Cost reductions are only part of the story

The victories achieved by Siemens, Gillette, Chrysler, Apple, and Amazon illustrate the tremendous impact of supply chain performance on the cost of doing business. These savings are vitally important, and managers know this well: Cost reduction is the number-one reason that companies initiate supply chain improvements. But there's an even bigger opportunity here: Supply chain improvements are good for the bottom line, but they can be even better for the top line. Getting the supply chain right can give a company a tremendous competitive advantage, and sometimes that advantage is enough to overturn an entire industry structure.

Dell transformed the computer industry

The shining example of this kind of victory is the way Dell Computer systematically dismantled the rest of the personal computer industry. Prior to Dell, personal computers were manufactured in volume, shipped to retail stores, and sold individually to customers—pretty

much like washing machines, televisions, and other appliances. It worked, but it required massive amounts of inventory, and customers were limited to a relatively small set of configurations. Dell changed all that by adopting a direct sales strategy, building every PC to order, and shipping it directly to the customer (Figure 1.1). Initially a mail-order house, Dell was one of the first to recognize the potential of the Internet, selling its first computers on line in 1996. Four years later it was doing $50 million a day from its Web site alone. In 2001, Dell became the largest producer of personal computers in the world, a position it surrendered only briefly after the merger of the former market leaders, HP and Compaq.

Dell's success rests on its supply chain

It's common knowledge that Dell's success was built on a combination of direct sales with build-to-order production, but Dell wasn't the first PC company to try this strategy. What really makes the company so successful is the way it executes the strategy. Dell is absolutely relentless about pulling time and cost out of its supply chain. Suppliers are located right next to Dell's assembly plants, and they deliver a constant stream of components on a just-in-time basis. Monitors are shipped directly from the companies that make them and merged in transit with Dell's own shipments, arriving in matching Dell boxes in

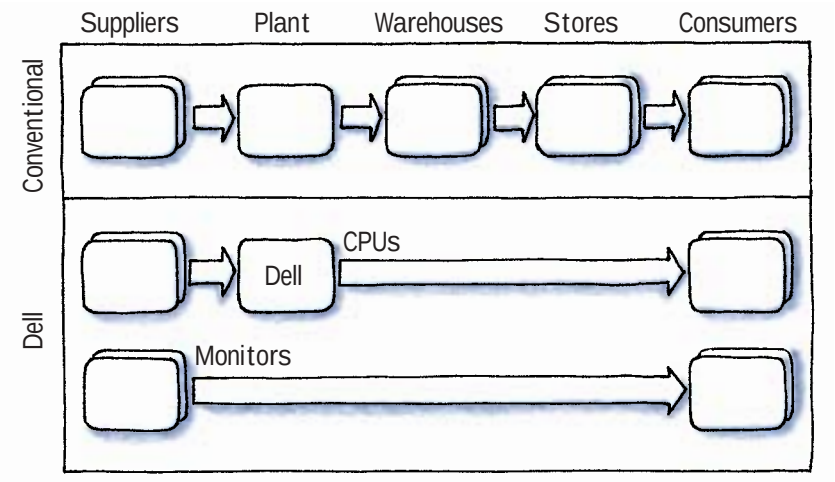


Figure 1.1
Dell's Supply Chain Strategy

a single customer delivery (as shown in Figure 1.1). The company has forecasting and planning down to a science, and it enjoys the financial advantage of a negative cash-to-cash time—it actually gets paid for its products before it buys the components. The perfection of techniques such as these gives the company a full five percentage points of profit advantage over its competitors, a virtually unassailable advantage in what is now almost a commodity market.

Supply chains are the last untapped vein

Supply chains are as old as commerce, but the opportunities they now present are without precedent. Modern manufacturing has driven so much time and cost out of the production process that there is only one place left to turn for competitive advantage. As business-engineering guru Michael Hammer recently put it in his new book *The Agenda*, the supply chain is the last untapped vein of business gold. The examples in this section make it clear that this vein runs deep, but no one knows just how much gold is in there because the real potential of supply chains is just now being discovered. Today, supply chain management is far more important than manufacturing as a core competence; so much so that it's possible, as Nike and Cisco Systems have amply demonstrated, to dominate the market for a product without owning so much as a single factory. The future of supply chains looks bright indeed.

The Agony of Defeat

Supply chains are double-edged swords

Cutting-edge supply chains are double-edged swords. Wielded with skill, they can slice open new markets. Improperly handled, they lead to deep, self-inflicted wounds. For all the advantages that can come from getting the supply chain right, getting it wrong can be catastrophic.

Kmart launched a $1.4 billion overhaul

By the end of the 1990s, Kmart Corporation's supply chain was crippling its ability to match the prices offered by Wal-Mart and Target, and in the discount retail business price is everything. Worse,

when the company did manage to lure back customers with its Blue Light specials, the products weren't in the stores when people came in to buy them; the supply chain couldn't deliver them in time for the sale, even with plenty of advance warning. Kmart was floundering, and it decided that it needed new technology to solve its problems. In May of 2000, the company announced an unprecedented $1.4 billion investment in software and services to overhaul its supply chain, including warehouse management software from EXE Technologies and planning systems from i2 Technologies.

The company is now in bankruptcy

A year and a half later, before the systems ever went live, Kmart announced that it was abandoning most of the software it had purchased and taking a $130 million write-off. What went wrong? Nearly everything, it seems, but the company did admit to a lack of clarity about its strategy, saying it needed to rethink its supply chain strategy first before implementing its systems. This was the right idea, but it seems to have arrived late and left early. Not long after the write-off, Kmart announced that it was buying $600 million worth of warehouse management software from Manhattan Associates, and that this purchase would solve its problems. Perhaps in a further effort to take some pressure off its supply chain, Kmart also announced that it was closing 250 stores. The company is now in bankruptcy.

Chrysler failed to keep SCORE

Even companies that once got it right can still to get it wrong. After years of success with its SCORE program, Chrysler completed the famous "merger of equals" that led to DaimlerChrysler. Like the merger itself, the SCORE program quickly degenerated, and relationships with suppliers soured. The company has now resorted to demanding unilateral price reductions from suppliers in order to stave off mounting losses. Chrysler's moment in the sun has passed.

Nike threw the switch and lost $100 million

Nike, the virtual enterprise that became the world's largest shoe company, has also managed to get itself into trouble with its supply chain. In February of 2001, the company announced that it had lost

$100 million in sales the previous quarter because of snafus in its supply chain. The debacle came right after the company went live with i2 Technologies' planning system. After a year of installation work, Nike decided it was time to throw the switch, and the new system immediately created havoc across the chain. Nike blamed i2, with the chairman complaining to analysts, "This is what we get for our $400 million?" (quoted in *Computerworld*; see the Notes on Sources). The vendor, in turn, complained that Nike had pushed the system into service too quickly and had required too many customizations. Whoever is to blame, both companies lost big. Nike's stock dropped 20% the day it made the announcement, and i2's fell 22% that same day.

Cisco blew $2 billion on excess inventory

Even Cisco Systems, the paragon of supply chain management, is capable of the occasional misstep. In May of 2001, the company reported that it had to write off some inventory as unusable—to the tune of $2.2 billion, the largest inventory write-down in the history of business. The problem stemmed from a breakdown in communication up the supply chain (Figure 1.2). Cisco was competing for large contracts in a booming market for Internet hardware. Having no production capacity of its own, Cisco passed all its anticipated demand directly on to its contract manufacturers. Those contractors added this to the demand they saw coming from Cisco's competitors, some of which were bidding on the same business, and each contractor looked at the demand independently, leading to double and triple counting of the same demand. The result: Component suppliers worked overtime to fill orders that were never placed, and Cisco wound up holding the bag.

Broken chains beat down stock prices

As these examples illustrate, supply chain failures can be devastatingly expensive. But there is an even bigger price to be paid than the immediate impact on cash flow. Nike and i2 both lost a fifth of their market value the day Nike went public with its problems. The size of these drops is exceptional, but their occurrence is not. A

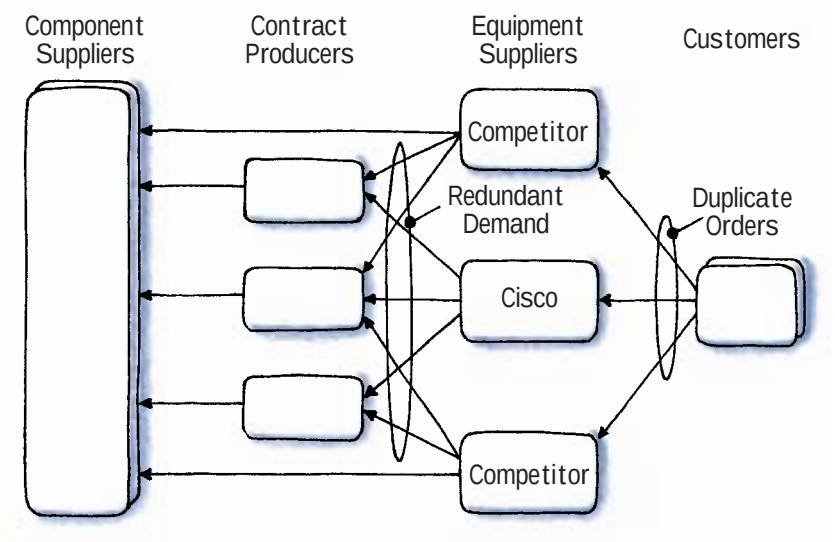


Figure 1.2
Cisco's $2 Billion Blunder

recent study conducted at Georgia Tech examined more than a thousand news reports of supply chain problems between 1989 and 1999, looking to see whether these reports had an impact on stock prices. The answer they got was a resounding yes: Companies reporting problems suffered an average drop in their stock price of 7.5% the day of the announcement. When the researchers examined the prices six months before and after the announcement, they discovered that the prices actually began to fall well before the announcement, suggesting that the bad news had a tendency to leak, and the prices showed no signs of recovering after the fact (Figure 1.3). The total drop over 12 months was 18.5%.

The average loss of value is $350 million

These percentage drops are obviously large, but the full impact is better conveyed by actual valuations. On the day of the announcement, the average drop in shareholder value for the company making the announcement was $143 million. Over the course of a year, the average loss was more than $350 million. But even this figure underestimates the total loss because prices were rising at 15% per year during that period, so the real impact may be nearly twice the

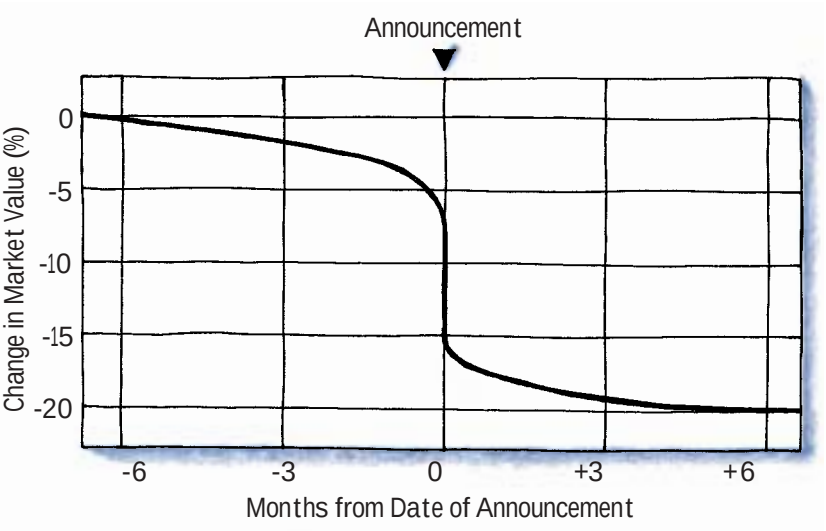


Figure 1.3
The Market Reaction to Supply Problems

calculated amount. But even at the most conservative calculations and considering only the one-day loss, the researchers conclude that the 1,131 supply chain problems they examined in their study caused a loss of more than $160 billion in shareholder value. Clearly, the market doesn't react well to supply chain failures.

Investors punish all kinds of failures

The study also revealed that investors don't really care who caused the problem. When the reporting company accepted the blame for the incident, its stock dropped 7.1%. When it blamed its suppliers, its stock dropped 8.3%. And when it blamed its customers—usually for changing their requirements during the lead time—the company's stock dropped 10.9%. The message is clear: If a company reports a problem with its supply chain, it's going to get hammered in the stock market, regardless of who's at fault. If anything, pointing the finger at a trading partner only increases the punishment.

A High Stakes Game

U.S. supply chains cost 10% of GDP

Why does getting the supply chain right have such a big impact on success? Because the stakes are so high: Holding and moving merchandise is a very expensive proposition. Collectively, U.S. companies spend a trillion dollars a year on their supply chains, just under 10% of the nation's GDP. About a third of this cost is for holding inventory and the rest is for moving it around, with a bit of change left over for administration. As large as these figures may seem, they used to be substantially higher, totaling about 15% of GDP at the beginning of the 1980s. Deregulation of the transportation industry coupled with inventory reductions brought the total down to 10% by the early 1990s, and it has remained stable at that level ever since.

Some companies enjoy a huge advantage

The same percentage holds good for individual companies, which spend an average of just under 10% of their gross income on supply chain functions. What is striking about the figures for individual companies is the tremendous advantage that some companies have over others in this regard. A recent survey of supply chain costs across a variety of industries yielded an average of 9.8% of revenue devoted to supply chains, a perfect match to the overall value. But the survey also revealed that the top quartile—the 25% best performers—had an average cost of just 4.2% of revenue. These companies spend less than half as much on their supply chains as the competition, giving them a full five-point advantage in profits. Continuing surveys reveal that the gap is not closing, but widening. The message is clear: If your company is on the wrong side of the supply chain gap, the sooner it makes the leap the better.

A penny saved is a nickel earned

Actually, the advantage is more dramatic than these figures might suggest, because in business a penny saved isn't really a penny earned. Depending on profit margins, it is usually closer to a nickel or a dime. Suppose you're running a company with $100 million in

sales, 10% supply chain costs, and a 10% gross profit, as shown in the first panel of Figure 1.4. How could you increase your overall profit by 50%? One way is to increase sales by 50%, as shown in middle panel of the figure. The other way is to imitate the best-in-class companies and bring your supply chain costs down to 5%, as shown in the last panel. At the level of gross margins, this $5 million savings is the equivalent of $50 million in additional sales. This is not to suggest that you wouldn't prefer to get the profit from growth rather than cost reductions. But the fact that a 5% reduction in costs can produce the same increase in profits as a 50% increase in sales is certainly a valuable insight.

Small savings can lead to big profits

Here is a real-world, albeit anonymous, illustration of how supply chain savings translate into profits. A major electronics company found that it had $500 million in excess inventory. Its carrying costs were 50% of the purchase price, so it was paying $250 million a year to hold the extra material. Given the company's profit margin of 10%, it would need $2.5 billion in additional earnings to equal the bottom-line benefit of eliminating that excess inventory. In the retail sector, where profit margins of 2% are common, the impact

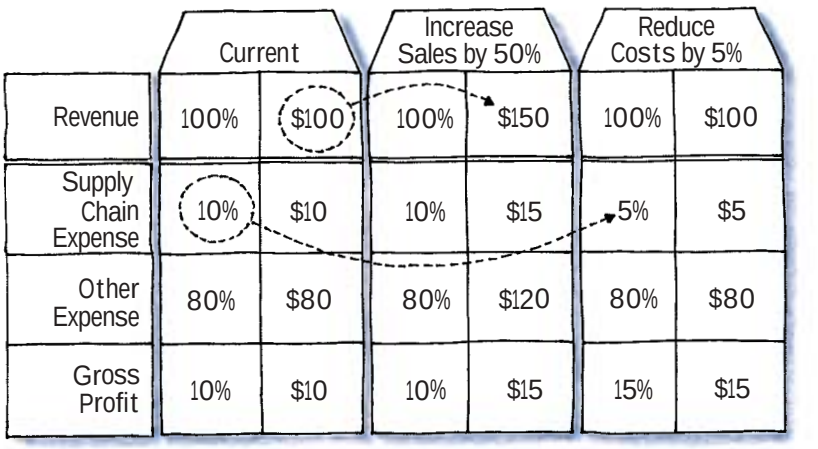


Figure 1.4
Supply Chain Costs and Profit

of savings in the supply chain can be even more dramatic. With margins that thin, reducing supply chain costs from 10% to 8%—still nowhere near best-in-class performance—can increase profits as much as doubling sales.

You can't avoid the game

Given the enormous stakes involved, the pressure to pull time and cost out of the supply chain is becoming relentless, and the demands are only going to increase as everyone gets better at the game. In addition to the financial drivers, several other factors are combining to put pressure on supply chains, including shorter product life spans, faster product development, rising globalization of sourcing, increasing demand for customization, and intensive quality initiatives such as the Six Sigma program. Given the challenges involved in getting the supply chain right, this may not be a game you are eager to play, but nobody gets to pass on this one. Every company that touches a product is part of a supply chain, and every company that is part of a supply chain has to deal with these problems sooner or later. The only choice you have is whether to tackle the problem now or wait until it tackles you.

The New Competition

Few companies know how to fix their chains

Very few companies are prepared to handle the new pressures being placed on their supply chains. A recent survey of executives in manufacturing companies found that 91% of them ranked supply chain management as either "very important" or "critical" to the success of their companies. Yet most acknowledged that they had problems with their chains, and only 2% regarded their chains as excellent. When asked about their strategies to improve their chains, 59% reported that their company had no strategy at all. Think about this for a moment: By their own reports, these managers realize that getting the supply chain right is essential, and they know they haven't done it yet, but most haven't even formulated a strategy for attacking the problem.

No one group is responsible for success

It would be nice to say that these results are unusual, but the same pattern shows up in survey after survey: Companies realize that they are in trouble with their supply chains, but they don't really understand the problems, much less know how to fix them. Why so helpless? There are lots of reasons, but the root cause seems to be this: No one in the company is responsible for running the supply chain. Engineering designs the product, marketing sets prices and runs promotions, sales cuts deals with customers, purchasing negotiates with suppliers, manufacturing controls the inventories, logistics arranges transportation, accounting handles the cash flow, and so on. All the key activities take place in different groups with different agendas and conflicting goals. Worse yet, most of these groups go all the way up to the CEO before they come under common management. And the CEO is not the right person to be planning and operating the supply chain.

Teamwork is required to gain control

Given this level of disorganization, it's hardly surprising that supply chains are out of control. The amazing thing is that these chains function at all. Clearly, the first step toward regaining control is to assemble the key decision makers from each group and get them working together to find solutions. Did you notice that all the supply chain successes described in the first section of the chapter started out by forming a team to take responsibility for the chain? That's no coincidence: Cross-functional teams are a recurring theme in companies that run good supply chains. The most successful companies usually go further by designating a single top-level executive who has full responsibility for the chain.

The problem is bigger than any one company

Even if a company gets its act together and forms a crack supply chain team, it's still not ahead of the game. Today, the very nature of competition is changing, and it's not an easy change to absorb. Ever since the Industrial Revolution, the battles have been company against company, and the weapons have been the techniques of production. Today, that game is largely played out. Good design,

efficient production, and quality construction, while not yet universal, have become the basic qualifications for making it into the top ranks. Among the serious players, it's now the supply chain that makes the difference between winning and losing.

Consumers only care about results

Think about it this way. From the consumer's point of view, supply chains are irrelevant. All the hardball negotiations about price and terms, all the careful synchronization of deliveries, all the delays and the scrambling to keep products moving down the chain—none of these things matter to consumers. Most of them don't even know what a supply chain is, much less appreciate the problems of running one. In the ordinary course of events, the only member of the chain consumers ever see is the retailer, and their only sense of what lies upstream is summarized in the notion of a brand. For them, it all boils down to who can sell them the best product at the best price.

The fates of companies are now joined

From an individual company's point of view, this is hardly fair. Should a manufacturer be punished because a distributor runs out of stock? Should a retailer lose sales because a producer has a quality problem? But this isn't about fairness; it's about winning a new kind of competition. Like it or not, the fates of all the members of a supply chain are becoming increasingly joined. The new competition is no longer company vs. company; it's supply chain vs. supply chain. If the members of a chain can work together to put the most quality in the consumer's hands at the lowest price, they win. If not, they lose. Figure 1.5 illustrates this point by showing how a supply chain that is consistently cost-effective across the chain can outperform chains that are superior to it in any one link.

A higher level of teamwork is required

Cast in this light, the conflicting agendas and political infighting among functional departments seem like minor problems. The real challenge isn't getting your own people to work as a team; it's getting all the companies in your supply chain to form a larger team

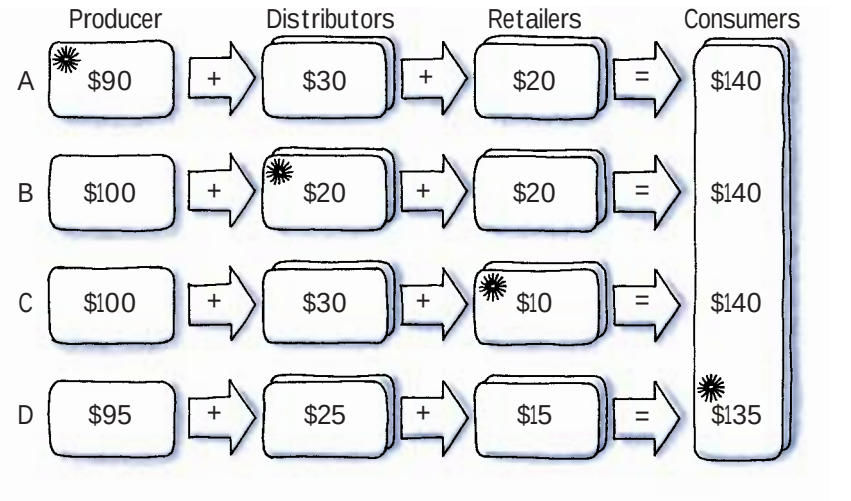


Figure 1.5
Competing Supply Chains

that can play and win the new competition. But how do you even approach a problem of this scale? Is vertical integration the answer? Will the techniques of supply chain collaboration do the trick? Is buying more software the solution? This book is here to answer these questions, but I'll give you a quick preview: Probably not, not likely, and no way.

This is a major shift in business

The new competition is a major upheaval that is affecting every aspect of how companies organize and operate. The required shift in thinking is so great—and the danger of not making the transition is so serious—that the National Research Council commissioned a study to articulate the problem and help prepare American manufacturers to meet the challenge. Their conclusion was that we are in the midst of a fundamental revolution in the nature of business, one that, in their words, "has the potential to alter the manufacturing landscape as dramatically as the Industrial Revolution." If you want to thrive in this new landscape, you have to understand how supply chains work—and how you can make them work better.

The challenge of mastering your supply chain may be daunting, but it's not insurmountable. Dell, Wal-Mart, and other supply chain leaders didn't succeed because they found a magic formula or were managed by business geniuses. They succeeded because they understood the core problems of supply chains, committed themselves to long-term solutions rather than quick fixes, and had the stamina to stick with those solutions until they worked. I can't help you with the stamina part, but I can explain the problems and show you how to find the best solutions. The next chapter kicks off that process by explaining how supply chains work and why they can be so difficult to manage.

2

The Rules of the Game

Supply chain management is a difficult game to master. It requires you to move a great many pieces in very specific ways, and you have to choreograph those moves to make each piece arrive in the right place at the right time. It's also a game that plays out on a grand scale, with a playing field that spans the entire planet. Fortunately, the rules of the game—the descriptions of the pieces and the ways they move—are simple enough to be summarized in a few pages. In a nutshell, supply chains consist of production and storage facilities connected by transportation lanes, and they exist to support the flow of demand, supply, and cash. The difficulty of managing supply chains comes primarily from the complexity that creeps into their structure and the variability that characterizes their flows. It's this complexity and variability that make an easy game hard to master.

Facilities and Links

A supply chain is a network of facilities

A **supply chain** is basically a set of facilities connected by transportation lanes. Figure 2.1 illustrates one slice of the supply chain that brought you this book. **Facilities**, shown as rounded rectangles in the illustration, generally fall into one of two categories, depending on their primary function: **production facilities** and **storage facilities**. **Transportation lanes**, shown as arrows, are categorized by their **mode of transportation**; they include roadways, railways, waterways, sea lanes, air lanes, and pipelines. Viewed in the largest context, supply chains extend from the original **extractors** of raw materials, such as mines and farms, to the ultimate **consumers** of finished goods, the people who actually put those goods to their intended purpose.

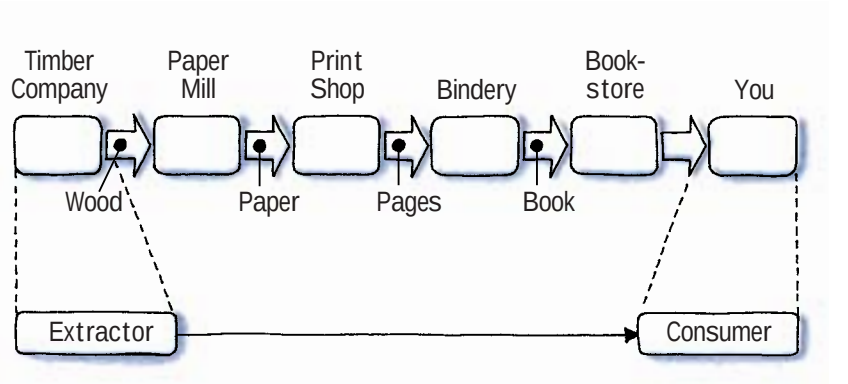


Figure 2.1
From Tree to Book

Facilities contain inventories

Facilities contain controlled quantities of materials called **inventories** (Figure 2.2). Production facilities hold inventory in three different forms: **Raw materials inventory** consists of materials ready for use in production; **work-in-process (WIP) inventory** includes all the materials currently being worked on; and **finished goods inventory** holds completed products ready for shipment. Storage facilities vary: **Warehouses** usually contain only a single kind of inventory, but **distribution centers** that do final assembly contain all three kinds. **Cross docks**, which are used only to transfer goods between trucks, do not contain any separately managed

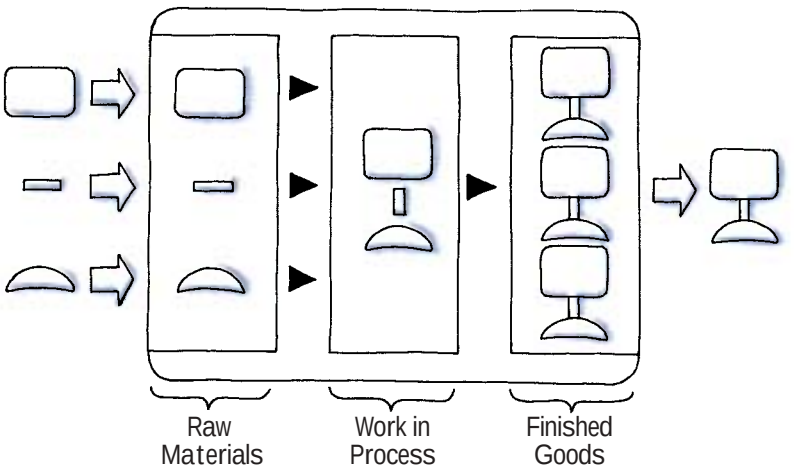


Figure 2.2
Three Kinds of Inventory

inventory. Retail stores also vary in this regard: Custom bicycle shops have all three types of inventory, warehouse-style stores contain only one, and some appliance stores carry none at all.

Lanes are used by vehicles and containers

Lanes are used to move inventory between facilities along a particular mode of transportation, using a combination of vehicles and containers. Some vehicles, such as truck tractors and railway engines, can be decoupled from their containers, whereas other vehicles, such as delivery vans and tanker ships, have the container built in. Decoupling is an important consideration because it offers more flexibility in routing, dispatching, temporary storage, and other transportation activities. In the case of pipelines, the functions of the vehicle and the container are merged with the lane itself, with pumps providing the motive force and pipes containing the inventory in transit.

Transportation modes offer tradeoffs

Each mode of transportation offers a unique mix of speed, cost, availability, and capability. For example, shipping by air is fast, expensive, available from all large cities, and limited to small and lightweight packages. By contrast, shipping by sea is slow, cheap, available only at cities with ports, and virtually unlimited with regard to size and weight. There are also different volume tradeoffs within each mode. In trucking, it is much cheaper to send **full truckload** (**FTL**) **shipments** than it is to use **less-than-truckload** (**LTL**) **shipments**, and the FTL option offers tighter control over the routing and timing of the shipment. However, using FTL shipments requires building up more finished goods inventory and may cause delays in shipments. Similar tradeoffs apply in the other modes.

Shipments can use multiple modes

Shipping within a limited geographical region normally uses a single mode from source to destination. For larger distances, including most international trade, shipments generally use two or more modes, a practice known as **inter-modal transportation**. For

example, a shipment might travel by rail to the nearest seaport, cross the ocean by ship, and travel the rest of the way by truck. Inter-modal shipments are usually enclosed in steel cargo containers that can be transferred between specially fitted rail cars, container ships, and tractor-trailers.

Lanes contain inventory in transit

Like facilities, transportation lanes contain inventory. This **in-transit inventory** bridges the gap between the shipping facility's finished goods inventory and the receiving facility's raw materials inventory (Figure 2.3). In-transit inventory is different from other forms in that it is unavailable for use, is at higher risk of loss from theft and accidents, and is subject to delays due to vehicle breakdown and lane congestion. Along with raw materials, work in process, and finished goods, in-transit inventory represents the fourth major type of inventory.

Containers are often used for storage

The distinction between in-transit inventory and the two inventories it connects is often blurred in practice. Trailers or railcars are frequently used to store finished goods at production facilities until full loads are produced, in which case the goods are still part of the plant's finished goods inventory. But if the storage is brief and the

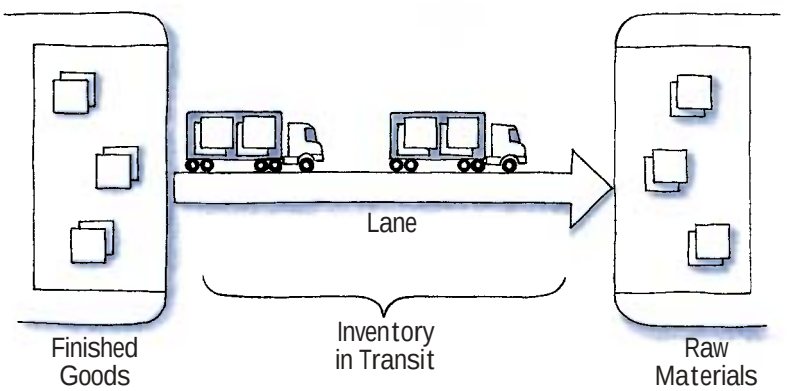


Figure 2.3
Inventory in Transit

destination of the goods is determined by the choice of containers, the goods in the container may be treated as inventory in transit as soon as they are loaded. Similar issues come up at the destination, where full containers may sit for days or weeks in a yard before being unloaded. In one rather perverse practice, railway cars are actually kept on the move, circling in wide arcs around a facility, until there is space to park them in the yard. This is a very expensive way to hold inventory.

Package carriers are viewed as a mode

Although they don't make use of a separate transportation medium, **package carriers** such as UPS and FedEx are commonly viewed as a distinct mode when making transportation decisions. In reality, these **carriers** use a mix of air and highway transport to deliver their packages, using their own fleets of aircraft and trucks. As a practical matter, however, it doesn't matter how a package is conveyed because that decision is out of the shipper's hands, so using a package carrier is viewed as an alternative on a par with shipping by air, land, or water. The tradeoffs discussed for the other modes also apply to package carriers: They are fast, relatively expensive, available in most locations, and limited to relatively small, lightweight products.

Demand, Supply, and Cash

The basic goal is an orderly flow of goods

The essential goal in managing a supply chain is to achieve an orderly flow of goods from extractors to consumers. It should not be surprising, then, that the deepest roots of the discipline can be found in transportation management, which is responsible for moving finished goods to the next link in the chain. Over time, transportation management merged with a related function, materials management, to form the broader discipline of logistics, which handles the flow of materials all the way from suppliers through the three internal inventories and out to customers.

Demand and cash flow are equally important

What distinguishes the current discipline of **supply chain management** (**SCM**) from its predecessors is that it is equally concerned with two other flows: the flow of demand and the flow of cash up the chain, as shown in Figure 2.4. Without these other flows, the goods would never move: It's demand that provides the impetus for that movement, and it's cash that provides the motivation. The great insight of supply chain management is that the key to managing the flow of goods effectively lies in synchronizing all three flows. This synchronization becomes particularly difficult when, as shown in the "stack" notation in Figure 2.4, there can be any number of organizations at each link of the chain.

The basic dynamics of the flows are simple

The basic operation of a supply chain could hardly be simpler. Demand flows up the chain and triggers the movement of supply back down the chain. As supplies reach their destinations, cash flows up the chain and compensates suppliers for their goods. Naturally, the behavior of real-world supply chains is never quite this simple. But recognizing the fundamental elegance of supply chain dynamics provides the best foundation for understanding the complexities that inevitably arise.

Flows are discrete rather than continuous

With a few exceptions, such as oil moving through a pipeline, the three flows in a supply chain are discrete rather than continuous. That is, they move in distinct "packets" that convey particular

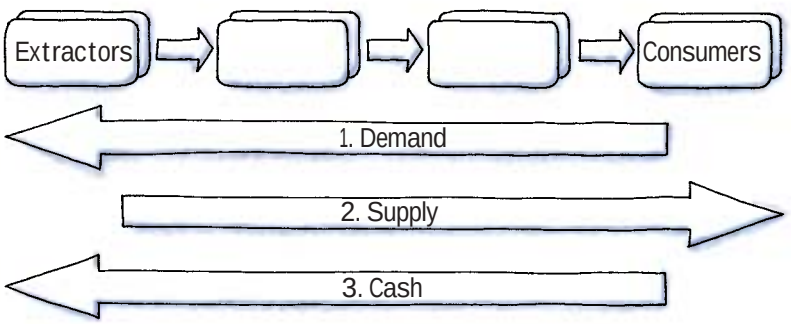


Figure 2.4
Three Basic Flows

quantities at particular times. Demand is normally conveyed through orders, supply through shipments, and cash through payments (Figure 2.5). A great deal of supply chain management is concerned with balancing the tradeoffs between the size and the frequency of these packets. For example, economies of scale favor infrequent orders of large quantities of material, whereas reducing inventory carrying costs requires more frequent shipments of smaller quantities. For any given rate of flow, the smaller the packets become, the closer the chain comes to operating as a continuous flow rather than moving discrete lumps of demand, supply, and cash across the chain.

Each exchange has a customer and supplier

As Figure 2.5 illustrates, each exchange of demand, supply, or cash takes place between a **customer** and a **supplier**. In this book, these terms refer to the parties involved in a transaction across any link of the chain, regardless of their location within the chain. In other words, I use the terms in a relative rather than an absolute sense, the way the terms *buyer* and *seller* are used in discussing a purchase. This is a common usage for these terms but it's not universal; many writers use the term *customer* to refer to the ultimate consumer of the goods, and others use the term *supplier* only for

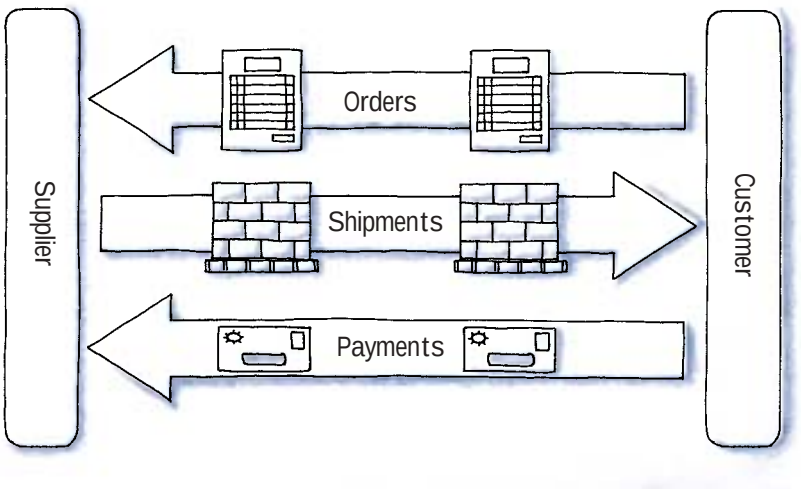


Figure 2.5
Packets of Demand, Supply, and Cash

upstream members of the chain who provide basic materials or assemblies. I avoid confusion in this book by always using the terms in the relative sense, but you should be aware of the inconsistent usage in other discussions. Be particularly alert to the differences in the way various authors use the terms *customer* and *consumer*; the muddling of these concepts often leads to pointless diatribes about who the "real" customer is.

Production may be to stock or to order

Orders trigger the flow of goods, but, depending on the production strategy, they may or may not trigger their immediate production by a supplier (Figure 2.6). In the **make-to-stock** strategy, a supplier makes products in advance of demand and holds them in finished goods inventory, satisfying demand from that inventory as orders come in. In the **make-to-order** strategy, the supplier doesn't build a product until it has an order in hand. There is also an intermediate strategy, **assemble-to-order**, in which a product is partially built in advance of demand, but final assembly is postponed until an order is received. Some companies use a mix of

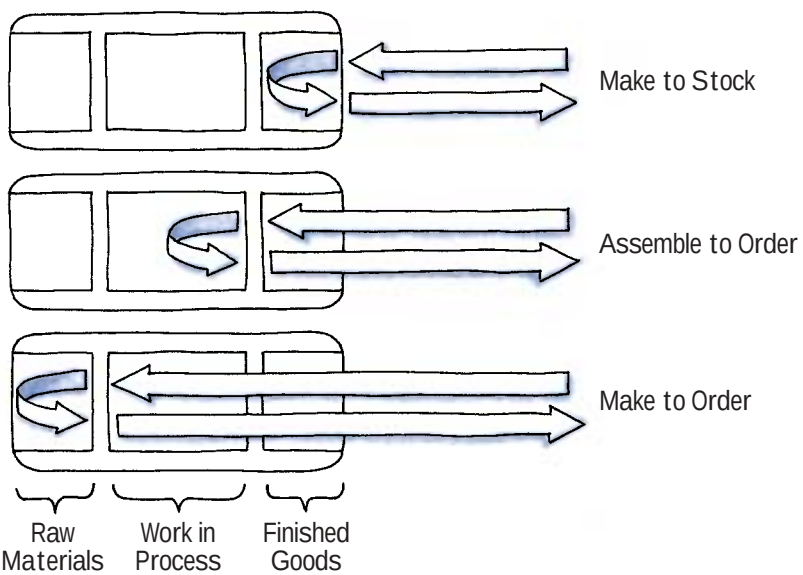


Figure 2.6
Three Strategies for Production

these three techniques, but choose one as their primary strategy. For example, Sony uses make-to-stock, Boeing uses make-to-order, and Dell uses assemble-to-order.

Production type determines push-pull strategy

The choice of production strategy has a major impact on the dynamics of a supply chain. With the classic make-to-stock strategy, inventory is produced in advance of and "pushed" down the chain toward consumers so that it will be on hand when they go to buy it. This strategy relies on demand forecasts to determine how much inventory to build and where to hold it. With make-to-order production, inventory is "pulled" down the chain by immediate orders. Forecasts are less important with make-to-order because there is no danger of making too much or too little inventory, though long-term forecasts are important to setting the correct levels of manufacturing capacity.

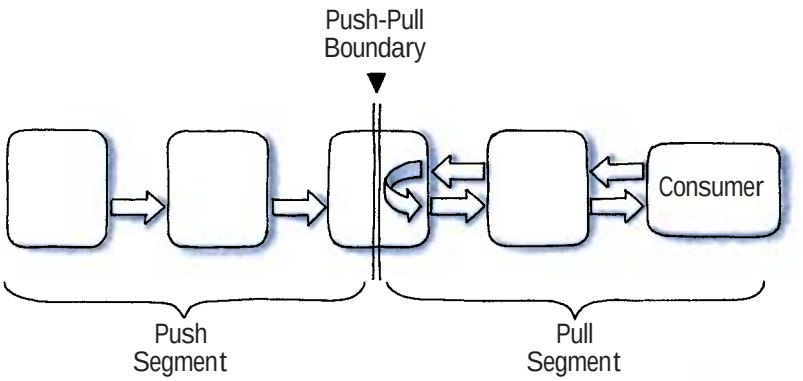
Every chain has push and pull segments

These dynamics are often used to characterize supply chains as either **push chains** or **pull chains**, but in reality every chain is a mixture of push and pull. As long as consumers have a choice about what products they buy and when they buy them, the last link in the chain is always a pull link. At the other end of the chain, the extraction of raw materials from the earth almost always occurs in advance of demand for finished products. In effect, consumers pull and extractors push. Somewhere in between the two is the **push-pull boundary** (Figure 2.7), the point at which the flow of goods switches from being pulled by consumers to being pushed by extractors. In the case of the assemble-to-order strategy, for example, the push-pull boundary is located at the final assembly plant.

Any link can be push or pull

Actually, the push-pull distinction applies to every link in the chain, so it's possible for any link to operate in pull mode even though it is up in the push region of the chain. Ford's supply chain is a push chain right down to the dealer showroom, but it contains many links that are pure pull. For example, Johnson Controls

Figure 2.7
The Push-Pull Boundary



builds a seat from raw materials and delivers it to Ford within four hours of receiving an order, allowing the company to supply seats to Ford based on firm orders for specific configurations. In the context of a massive supply chain involving tens of thousands of companies building against anticipated demand, Johnson Controls is able to supply this particular component on a pull basis.

Cash flow receives the least attention

Of the three primary flows in supply chains, cash flow is the one that receives the least attention. This is understandable: Supply chains exist to move products to consumers, and orders are the mechanism for triggering that movement. But cash is the ultimate driver for the entire process; take it out of the equation and the whole business would come to a halt pretty quickly. Yet cash flow performance is the worst of the three, with producers routinely taking months to pay suppliers for goods that were shipped within days of being ordered. This situation is now changing, and accelerating the flow of cash is coming to be recognized as a key element of supply chain excellence.

Information also moves across the chain

In addition to the three key flows, there is something else that moves across the chain: information. Actually, information is already implicit in the three flows: Orders represent information about immediate demand, some products can be transmitted as

information, and even cash can be exchanged in the form of information. But the more interesting kind of information isn't part of the actual transactions—it is exchanged in order to facilitate those transactions. This information includes demand forecasts, production plans, promotion announcements, and reports of all kinds. Unlike the three basic flows, information can move across the chain at any time, without being part of a particular transaction, and it isn't constrained to move sequentially up or down the chain. Instead, it can be broadcast simultaneously to any subset of the chain, ensuring that they are all operating with the same information at the same time (Figure 2.8).

Information can replace inventory

One of the great insights into the behavior of supply chains is that information can often be substituted for inventory. Instead of requiring every member of the chain to maintain **safety stock** to buffer against uncertainty in demand, that uncertainty can be reduced by sharing information that helps members anticipate coming changes in the flows of demand, supply, and cash. Information is usually far cheaper than inventory, and it has the advantage that it can be in many places at the same time. The result: Substituting information for inventory is a key technique for improving supply chain performance and will be a continuing theme of this book.

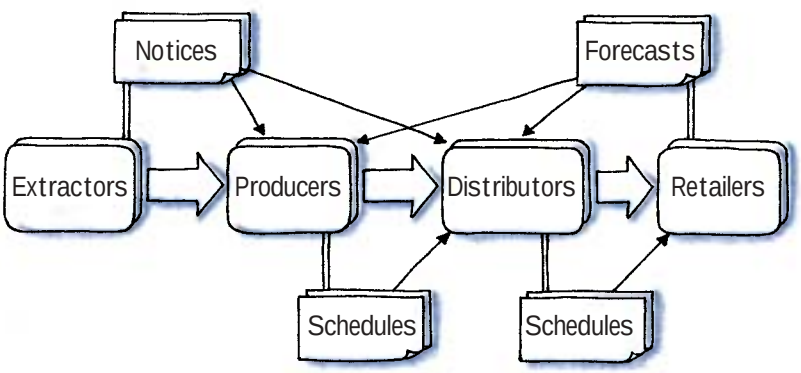


Figure 2.8
Information Broadcasting Across the Chain

Distribution and Procurement

Patterns make chains easier to understand

Although the basic elements of supply chains can be combined in an infinite variety of ways, there are two basic patterns that account for most of the structure. To see these patterns, consider how a supply chain looks from the perspective of a single plant. Every facility downstream of that plant is a destination for its finished goods and forms part of the plant's **distribution network**. Every facility upstream is a source of supplies, and forms part of its **procurement network**. These two networks of the supply chain are radically different from the plant's perspective.

Destinations are grouped into echelons

Some plants ship only to a single destination, but this is rare. The normal pattern is for each plant to serve as many destinations as necessary to satisfy demand within a particular geographical region. These destinations, in turn, may ship the goods onward to still more destinations, and so on, until the products eventually reach their ultimate consumers (Figure 2.9). The successive layers of this supply chain pattern are commonly referred to as **echelons**, and they are numbered outward from the plant as shown in Figure 2.9.

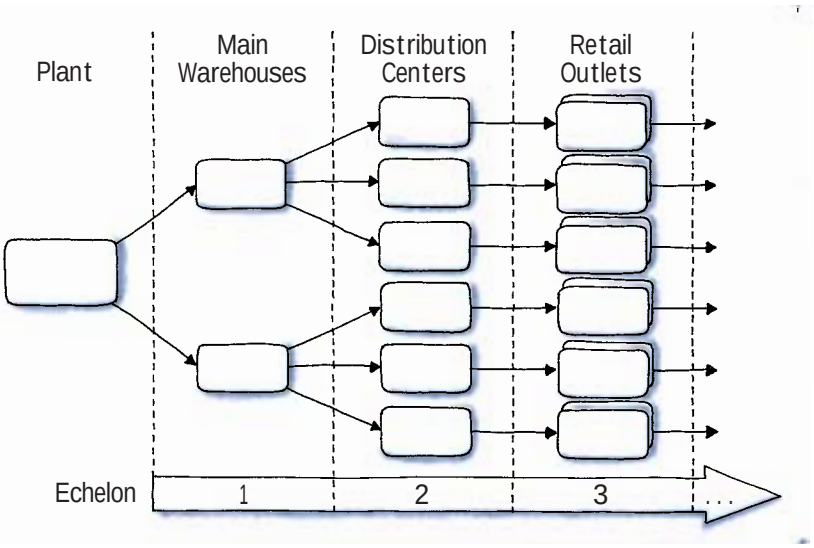


Figure 2.9 Echelons in Distribution

This pattern is a distribution network

The business problem addressed by this portion of a supply chain is distribution, which is basically a matter of choreographing the flow of finished goods from the plant to consumers in a way that satisfies demand in a cost-effective manner. When multiple echelons are under the control of a single company, distribution managers often try to maintain an orderly distribution network by using only the links shown in Figure 2.9; that is, shipments are not normally allowed to skip echelons, and each destination receives shipments from only one facility in the echelon above it. Although these constraints simplify the management of a distribution network, they do not produce the most cost-effective solutions. Constraints on distribution patterns are now being relaxed as more sophisticated tools become available for designing and operating distribution systems.

Distribution is harder with more destinations

As you might expect, the difficulty of managing distribution goes up dramatically as the number of destinations increases. With more facilities to serve, the available inventory has to be divided more finely, increasing the risk of not having the right amount of product at any one facility. In addition, the time and expense of handling the goods increases with each echelon. On the other hand, transportation costs go down with more echelons because products can travel much of the distance in larger, more economical shipments. Finding the right balance between these opposing forces is one of the key tradeoffs in distribution design.

Source facilities are grouped into tiers

Looking upstream, just the opposite pattern is observed. Although it is possible for a plant to obtain all of its supplies from a single source, this rarely happens. Ordinarily, the plant receives supplies from multiple sources, each of which receives its supplies from multiple sources, and so on, up to the point where the raw materials are obtained directly from extractors (Figure 2.10). The successive layers of this supply chain pattern are called **tiers**. Like echelons, tiers are numbered outward from the plant.

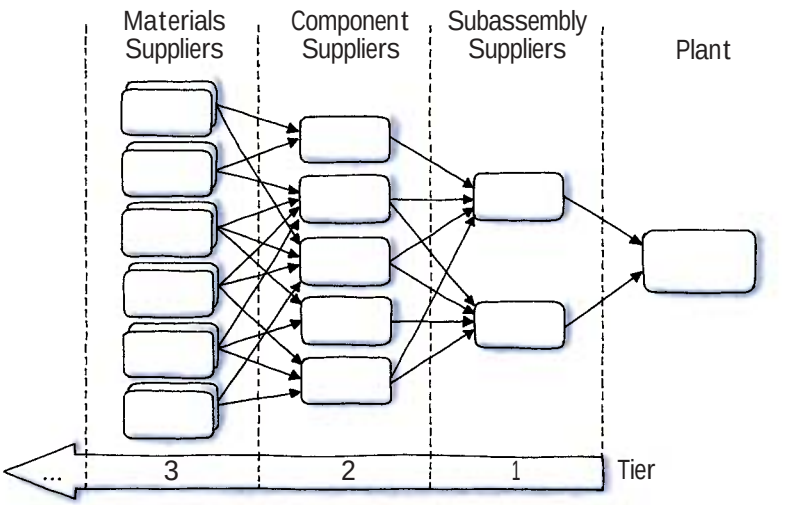


Figure 2.10
Tiers in Procurement

This pattern is a procurement network

The business function supported by this portion of a supply chain is procurement, which involves choreographing the flow of raw materials and subassemblies from their suppliers to the plant in a timely, cost-effective manner. As shown in the illustration, procurement networks tend to be less orderly than distribution networks, with overlapping sources being the rule rather than the exception.

Procurement is harder with more sources

Like distribution, procurement becomes more difficult to manage as the number of sources increases. The essence of successful procurement is having everything arrive as close to a production date as possible without paying more than is necessary to achieve that end. Simply by the laws of chance, the more suppliers involved, the more likely it is that at least one of them will miss its delivery date and delay a production run. In addition, the cost of placing orders and making payments goes up with the number of suppliers, as does the overhead of managing the additional relationships. As with echelons on the distribution side, adding tiers on the procurement side also increases the total time and expense required to bring production materials to the plant.

These patterns overlap extensively

The basic distribution and procurement patterns described in this section can take on a wide variety of configurations. Most important, the sources and destinations may themselves be plants, each of which has its own distribution and procurement network. When there are multiple layers of plants, the distribution and procurement patterns overlap and the distinction between them blurs. For any one plant, the picture is reasonably clear, but for the supply chain as a whole, it can become quite complicated.

Ownership boundaries affect the flows

An important consideration in analyzing supply chains is identifying ownership boundaries. A sequence of facilities owned by the same company makes up its **internal supply chain**, and the links outside of the ownership boundary are its **external supply chain** (Figure 2.11). Internal supply chains often run more smoothly than external chains because they can be centrally controlled, and no buying and selling are required to move the goods. One of the big advantages of the classic strategy of **vertical integration**, in which a single company owns as much of the supply chain as it can acquire, is that it pits an internal supply chain against the competition's harder-to-manage external chains.

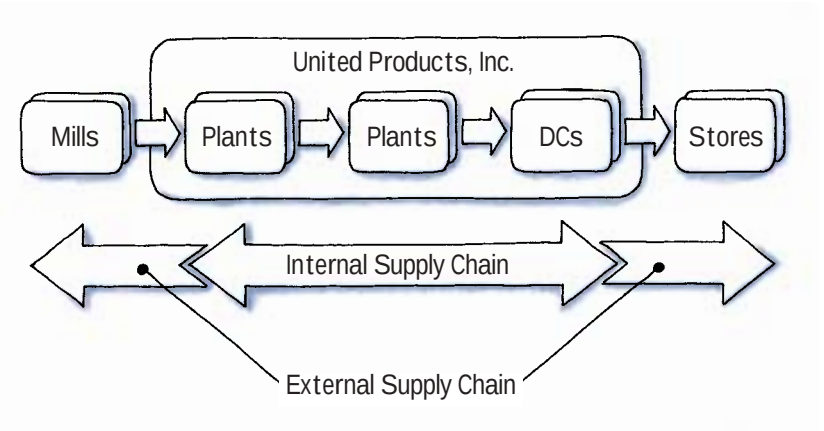


Figure 2.11
Internal and External Supply Chains

Complexity and Variability

Complexity and variability are key concerns

The basic elements of supply chains—the structures, dynamics, and patterns described in the preceding sections—are simple. Yet, as illustrated by the examples in Chapter 1, real-world supply chains are notoriously difficult to manage, and they are liable to catastrophic failure. This contrast between principle and practice invites a crucial question: Where does the difficulty come from? Underneath the many symptoms and their immediate causes, there appear to be two root causes to the difficulty of managing supply chains: complexity and variability. This last section of the chapter takes the measure of each.

Supply chain flows are linked in complex ways

The complexity begins with the way the three primary flows relate to one another. In principle, it's simple—orders trigger shipments, and shipments trigger payments. In practice, the relationship of orders to shipments and payments quickly becomes tortuous (Figure 2.12). A single production run generates orders to many different suppliers, and these orders are usually combined with orders for other production runs to achieve economies of scale in purchasing.

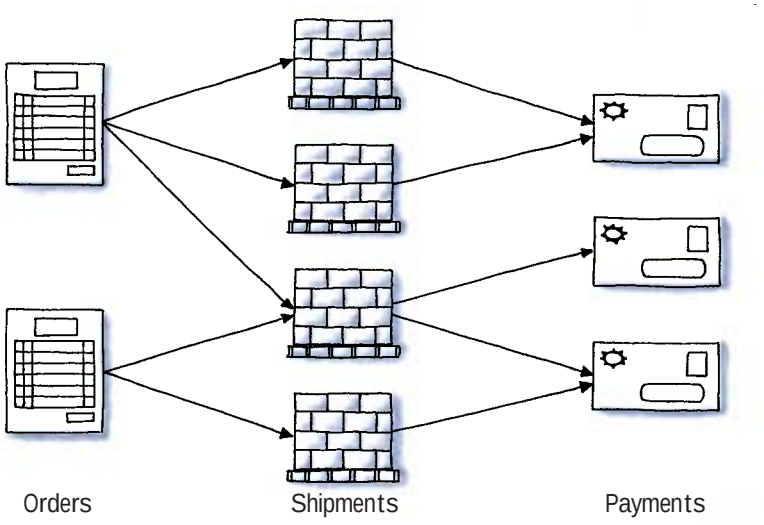


Figure 2.12
Orders, Shipments, and Payments

The shipments fulfilling these orders may further combine orders to reduce the cost of transportation, but large orders may also be split across two or more shipments, and backordered items are often sent in still later shipments. Invoices usually cover multiple shipments, payments may cover multiple invoices, and so on. The simple linkages among the three basic flows are quickly obscured by these groupings and regroupings.

Different groups handle the three flows

Another source of complexity is the way supply chains are managed, with different groups handling each of the three basic flows (Figure 2.13). On the customer side of a transaction, orders might be placed by a centralized purchasing department, shipments received by various local assembly plants, and payments made by a regional accounting department. On the supplier side, orders might be received by satellite sales offices, shipments made from regional distribution centers, and payments received by the accounting office of a parent firm. All of these groups operate according to different—and all too often, deeply incompatible—agendas, and no one group is responsible for the outcome of the entire transaction.

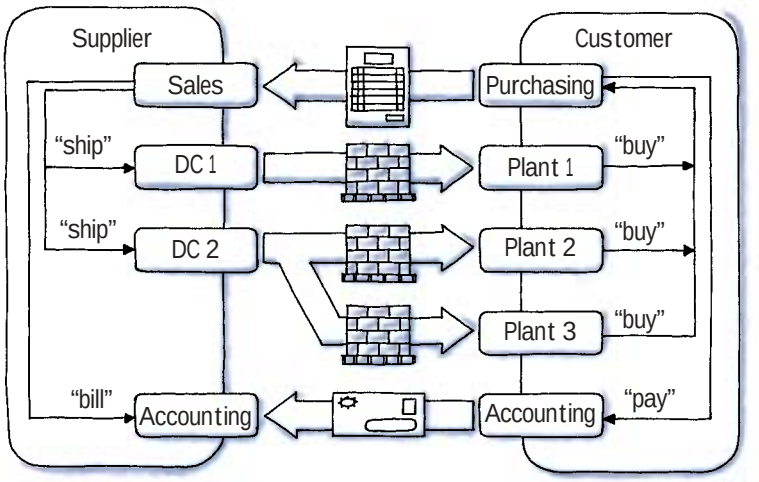


Figure 2.13
Different Groups Handling the Flows

Each flow requires extensive documentation

Complexity is also created by the proliferation of documents associated with orders. For each purchase order generated by a customer, a corresponding sales order is generated by the supplier—despite the fact that the majority of the information in the two documents is identical—and both must be matched against any governing contracts to make sure all of their terms are being honored. Each shipment resulting from the order requires its own documentation, including **packing slips**, **bills of lading**, **advance shipping notices,** and the like, and the billing and payment cycle generates yet another trail of paper. All of these documents must reference the controlling purchase and sales orders, and all the mappings among the documents must (or should) be carefully traced so that both companies are certain that what was ordered was shipped, and that what was shipped was paid for. And these are just the documents that flow between the companies; the number of documents required within each company can be much larger.

Supply chains usually have structural problems

Yet another source of complexity is the structure of the chain itself. The ideal supply chain is neatly organized into echelons and tiers, as described in the preceding section, and all transactions follow an orderly subset of links. In practice, these layered patterns are often obscured by a maze of ad hoc links and sequences that are crucial to the operation of the chain but make it very difficult to understand, much less manage. This is rarely by design; most chains are never actually designed. Rather, they evolve over time through a series of independent decisions—open a plant here, add four more suppliers for a component over there, shut down this warehouse instead of refurbishing it, and so on—few of which take the "big picture" into account.

Variability affects all business processes

The second core challenge of supply chains is coping with variability. No matter how well managed, all business activities exhibit natural variability in their duration, quality, and other attributes. Daily sales, delivery times, production yields, defect rates, maintenance times,

and a thousand other aspects of supply chains all vary around some average value. For some purposes, it is sufficient to know this average and plan for it. But real-world supply chains don't ever "see" average values; what they deal with every day are the actual values that make up those averages. The more variability there is in those values, the more difficult and expensive it is to run the chain.

Inventory is used to buffer variability

A great deal of supply chain management is devoted to coping with this variability. Inventories of finished goods act, in part, as a buffer against variability in demand, and raw material inventories offer comparable protection against variability in supply. Case in point: An audit of a major retailer found it needed $200 million in safety stock just to cover variability in its vendors' deliveries—a very expensive way to compensate for poor reliability. Redundant sources, such as alternate suppliers and transportation options, provide further protection against variation in the availability of materials and services. The list is long: Quality assurance programs attempt to reduce the variability in product quality, forecasting attempts to predict variation in demand, and so on. All of these efforts have some value in the attempt to cope with variability, but each extracts its own costs.

Variability in supply amplifies down the chain

Supply chains are particularly vulnerable to the effects of variability because they involve long sequences of interdependent activities. A relatively small delay in an upstream process, for example, can cascade down the entire supply chain, throwing off production schedules and disrupting any number of deliveries. Similarly, variation in the level of supply for upstream components relative to downstream demand can wreak havoc on a chain, as the electronics industry graphically illustrates with its sporadic chip shortages.

Variability in demand amplifies up the chain

Just as variability in supply can amplify down the chain, variability in demand can amplify back up the chain (Figure 2.14). The classic example of this **demand amplification** is a study conducted by Procter & Gamble in the early 1990s to investigate

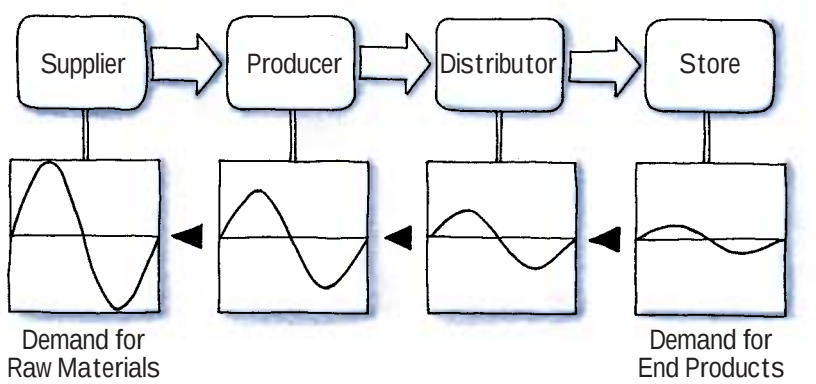


Figure 2.14
Demand Amplification

peculiar fluctuations in the demand for raw materials used in its Pampers brand of diapers. These fluctuations puzzled the company because babies generally go through diapers at a fairly constant rate. Sure enough, a check of sales showed only minor, random variations in the retail sales of Pampers. It turns out that these small variations were being amplified up the supply chain, producing large swings at the level of raw materials. The causes of this effect—which P&G dubbed the **bullwhip effect**—are now well understood and easily countered (see Chapter 13), but demand amplification continues to be a serious problem in many chains.

Scale increases the impact of both problems

The problems associated with complexity and variability are both exacerbated by scale. In the early stages of industrialization, supply chains consisted mostly of local companies working together to bring goods to market, and complex mappings among the three flows were not serious impediments to commerce. Today, with supply chains including thousands of companies spanning the entire planet, complexity and variability have devastating effects on both the efficiency and effectiveness of the supply process. The reasons for this are not subtle; it's a simple matter of mechanics. As the number of contributors to a finished product goes up, the likelihood of errors and delays inevitably escalates, and the ensuing disruptions become increasingly severe with each additional link in the chain.

Complexity and variability can be reduced

Supply chains aren't likely to get any smaller in the years to come, but both complexity and variability can be greatly reduced. The complexity of modern supply chains is ultimately a self-inflicted wound, the product of business practices that date back to the Industrial Revolution. Although variability itself is a fact of life, there is a ready arsenal of weapons to prevent it from attacking supply chains. The real business challenge doesn't lie in complexity and variability themselves, but in the failure to recognize the havoc they wreak on supply chains and make the necessary corrections. If you understand the importance of attacking these problems, and choose your weapons carefully, you can beat them.

That was a whirlwind tour of supply chains, but it gave you a quick look at the major landmarks and showed you the lay of the land, which should help you keep your bearings as you explore this region further. More important, you now understand the fundamental problems of supply chains and are ready to see how they can be solved, which is the subject of the third and final chapter of Part I.

3

Winning as a Team

If complexity and variability are what make supply chain management a hard game to master, then the best tactics are those that lead to simplicity and stability. Indeed, most of the innovations in supply chain management over the past 20 years have attempted to both simplify and stabilize the flow of demand, supply, and cash. These innovations include the extension of just-in-time manufacturing techniques out to the supply chain, plus a variety of specialized programs for managing the replenishment of retail inventories. Unfortunately, the gains produced by these programs have often come at the expense of other links in the chain, and that doesn't improve the competitiveness of the chain as a whole. A brief look at game theory reveals why these programs are falling short and points the way to the winning strategy: integrating the members of the supply chain into a smoothly functioning team by making sure that every member's win contributes to the success of all the others.

JIT Supply Programs

JIT has transformed manufacturing

Of the many efforts to improve the flow of raw materials into production facilities, most have involved extending the reach of the **just-in-time** (**JIT**) **manufacturing** method upstream toward suppliers. One of the key elements of the JIT approach is eliminating excess inventory throughout the production process by timing the movement of materials to each workstation to arrive just at the moment they are needed for the next operation. This practice minimizes inventories throughout the production process, helping manufacturing companies reduce holding costs, minimize obsolescence, and improve their return on assets. These benefits have led to the widespread adoption of JIT throughout industries that use repetitive production techniques.

Frequent shipments reduce total inventory

Of the three inventories held in production facilities, the work-in-process (WIP) inventory is most easily reduced using JIT. But WIP is usually the smallest and least expensive of the inventories, and tackling the other two requires changing the way suppliers deliver raw materials and customers receive finished goods. In order to bring down the inventory of raw materials, JIT producers work with their suppliers to switch over from large shipments of materials that go to central receiving facilities to small, frequent shipments that go directly from trucks to the factory floor (Figure 3.1). The change is a dramatic one, often taking a company from monthly orders and shipments to multiple shipments a day with precisely timed arrivals. Most JIT producers have a similar program on the outbound side, using small, frequent deliveries to minimize their inventory of finished goods.

JIT requires close partnerships with suppliers

As soon as manufacturers begin to make these kinds of changes, JIT quickly expands from a production initiative to a much broader program that requires systematic changes in supply chain management. Toyota, the company that pioneered the JIT method in the 1970s, was keenly aware of this aspect of its program, and it worked closely with its suppliers to convert their operations to JIT as well, precisely coordinating the flow of goods from suppliers to production plants. In order to support the close relationship

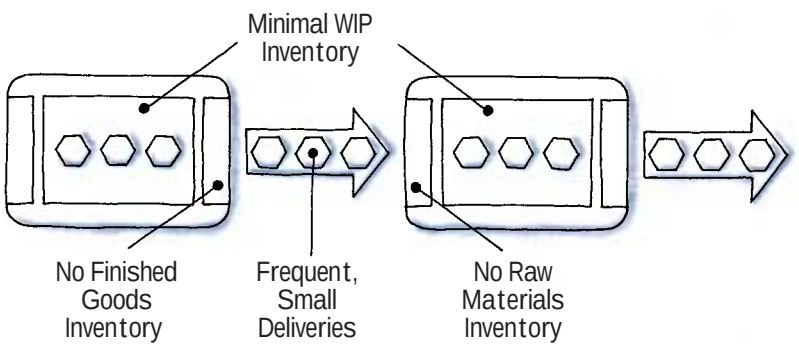


Figure 3.1
Just-in-Time Supply

required by this new kind of production, Toyota used a uniquely Japanese form of joint partnership, called a **keiretsu**, with its key suppliers. In Toyota's case, the keiretsu involved taking a 20% to 50% equity position in each supplier and replacing 20% of its key executives with Toyota personnel.

Simpler ordering reduces complexity

JIT practices offer important insights into how supply chains can be improved. Although the apparent focus of JIT is on reducing inventory, the true spirit of the method is a systematic pursuit of quality, one aspect of which is eliminating any unnecessary complexity. In the case of supply chain transactions, this philosophy has led to a much needed streamlining of the order-shipment-payment cycle. Instead of accumulating large orders mixing many different kinds of materials, producers place many orders for individual materials, often paying for these materials on delivery rather than accumulating lump sums. In addition, a great deal of documentation has been stripped away. For example, traditional orders are often eliminated in favor of continuously updated delivery schedules, and billing documents may be eliminated altogether. One of the great contributions of JIT to supply chain management is to provide a clear demonstration of just how simple the basic flows can become.

Consistent performance reduces variability

Along with reducing complexity, the JIT philosophy of quality also seeks to reduce variability in every stage of production. To this end, each operation is analyzed, refined, and rehearsed until it can be completed both quickly and consistently. In the case of supply chains, this level of rigor not only accelerates the movement of goods, it also adds an unprecedented level of precision to deliveries. This precision allows inventories of raw materials to be reduced to a fraction of their normal levels without causing shutdowns on the line.

JIT can make supply chains fragile

Of course, not every form of variability can be eliminated, and herein lies the downside of JIT: It can make supply chains so fragile that any interruption in the flow of supplies brings the entire chain

to a halt. Toyota learned this in 1997 when a fire at one of its suppliers shut down Toyota's production lines for an entire week. The following year, strikes in two GM parts plants led to the shutdown of almost all of the company's assembly plants within a matter of days. A year later, seven DaimlerChrysler plants and three GM plants were forced into half-shifts when flooding in one supplier's plant created a shortage of a single part. After the terrorist attacks of September 11, 2001, many plants in the United States had to be closed due to breakdowns in the transportation system. Ford, for example, shut down five North American plants due to parts shortages, many of them due to delays in bringing trucks across the Canadian border.

Manufacturers are now cautious about JIT

Shutdowns such as these can quickly wipe out the savings associated with reduced inventory levels. For a large manufacturer, having a plant shut down can cost as much as $10,000 a minute. Given this kind of financial impact, many firms that adopted JIT wholeheartedly are now rethinking their position and taking a more conservative approach. Honda, for one, now has a policy of maintaining dual suppliers for all its raw materials. Ford, while reaffirming its commitment to its JIT program in the wake of the terrorist attacks, immediately began developing plans to stockpile engines and other key parts at some U.S. plants.

Simplicity and consistency remain key goals

Even with appropriate risk management, JIT isn't the right approach for every supply chain. It doesn't work in job shops, which do not use production lines, and it's not relevant to process manufacturing. Even within its natural domain, repetitive production, it's not a good choice for low-volume products or for products with uncertain demand. But these are limitations, not defects; for the right kind of production environment, JIT can lead to dramatic improvements. More important, however, is the way the JIT effort illustrates how much can be done to reduce complexity and variability in supply

chains. JIT's emphasis on simplicity and consistency can be used to advantage at every link of the chain, regardless of whether other aspects of the technique are employed.

Retail Replenishment Programs

Retail replenishment is a tough problem

The second major class of supply chain programs deals with the distribution side, and is concerned with replenishing retail inventories. Historically, the link between retail stores and their immediate suppliers has been a difficult juncture in the supply chain. In the past, retail inventories were managed by independent storeowners, who often lacked sophisticated tools for forecasting demand and planning replenishment. Yet this is precisely the point in the chain that can be the hardest to manage because it is the first point to feel the impact of changing consumer preferences. It is also the point where the chain becomes visible to the consumer, so it's critical to manage it well. If the desired product isn't on the shelf when a consumer walks in to buy it, even the most perfect sequence of supply operations is a failure.

Early efforts shifted control of inventory

The first generation of retail replenishment programs was based on shifting the control of inventories (Figure 3.2). In the traditional arrangement, retailers manage their own inventories and replenish them as they see fit. The problem with this arrangement is that producers are often in a better position than retailers to track emerging patterns in demand. In addition, producers can remove cost and uncertainty from this link in the chain by centralizing control of the replenishment process. One way to leverage these advantages is **consignment**, in which producers retain both ownership and control over inventories of their products at a retailer's site. Consignment has proved to be an effective tool for selling products that retailers might not be willing to carry on conventional terms, but it's not the first choice for producers because they have to wait longer before they get paid for their products.

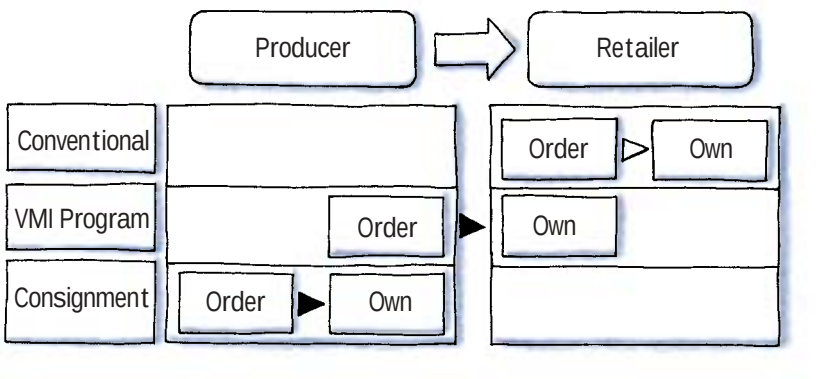


Figure 3.2
Inventory Management Relationships

VMI transfers ownership but not control

A more recent development, **vendor-managed inventory** (**VMI**), is shown in the middle row of Figure 3.2. The innovative aspect of VMI is the way it separates control from ownership, both of which usually transfer at the same time. In VMI, a producer receives continuous updates on a retailer's inventory level and replenishes it as needed, with the retailer taking ownership of the goods on delivery. This gives producers better visibility of sales of their products, helping them anticipate demand and better plan supply. The retailers benefit because they no longer have to track inventory levels or place orders for products under a VMI program. They also save money because they usually need less inventory, sometimes as little as half of what they would otherwise keep in stock.

Quick response applies JIT to the retail link

In addition to VMI, several other programs have been developed to smooth the flow of goods through retail stores. One of the earliest was the **quick response** (**QR**) program, an effort on the part of the apparel industry in the 1980s to combine some of the techniques of JIT with technologies for monitoring inventory levels in real time. As shown in Figure 3.3, electronic **point of sale** (**POS**) systems automatically captured data about clothing sales as they occurred, then transmitted this data to producers using **electronic data interchange** (**EDI**) connections. Producers responded with daily shipments of pre-tagged items that could go directly from their trucks to the selling floor.

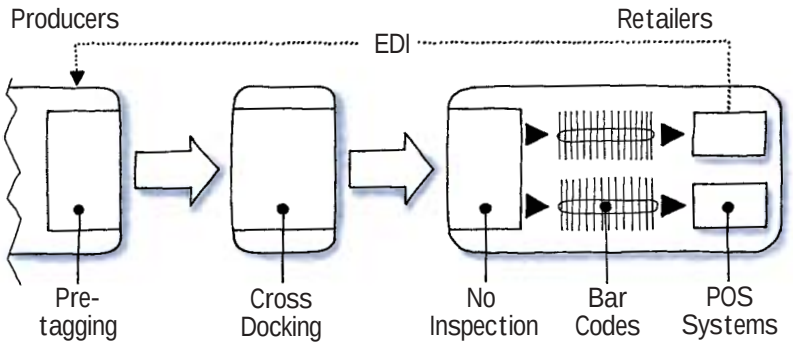


Figure 3.3
The Quick Response Program

Continuous replenishment added VMI

In the late 1980s, the apparel industry rolled out an extension of the QR program known as **continuous replenishment** (**CR**). As shown in Figure 3.4, this program incorporated VMI for better inventory control, and it introduced joint forecasting so that producers and retailers could pool their understanding of consumer demand to better predict future sales. Another important aspect of this program was that a replenishment agreement acted as a standing purchase commitment. This allowed members of the program to eliminate individual purchase orders altogether, further streamlining the replenishment process.

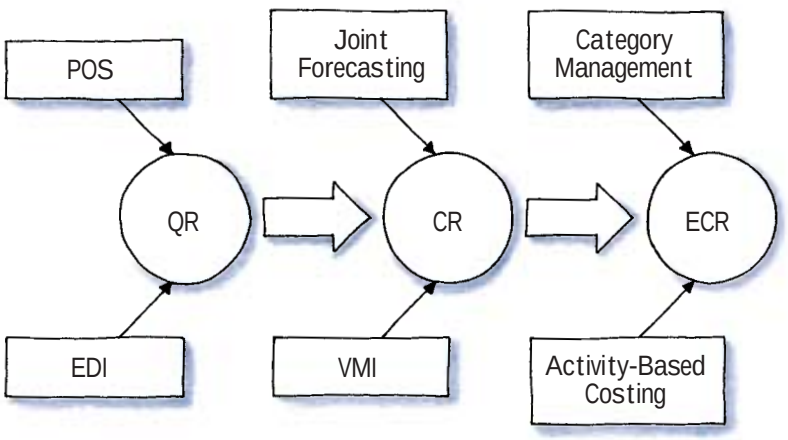


Figure 3.4
Retail Replenishment Programs

ECR added category management

In 1993, the grocery industry launched its own version of continuous replenishment, calling it the **efficient consumer response** (**ECR**) program. ECR's major contribution was the addition of **category management**, which organizes promotion and replenishment activities around groups of products that consumers view as roughly equivalent in satisfying their needs. This addition helps grocery stores determine the best mix of products to put on their shelves to make sure their customers' needs are met even if there are occasional shortages. This program also encourages the use of activity-based costing (described in Chapter 9) to determine the profitability of each product category.

The programs attack complexity and variability

Like the JIT programs described earlier, retail replenishment programs reflect a continuing effort to simplify and stabilize supply chain flows. For example, the elimination of orders in continuous replenishment removed a major source of time and cost that added no value to the end consumer. These programs also pioneered important techniques for coping with variability, including some that aren't employed in the JIT effort. Most notably, the use of real-time data on sales allows retailers to respond quickly to variations in consumer buying patterns, and the addition of joint forecasting allows retailers to prepare for some of these shifts before they hit the stores.

CPFR is the most ambitious program yet

The most ambitious replenishment program to date is **collaborative planning, forecasting, and replenishment** (**CPFR**), a multi-industry effort that was formalized in 1998 (Figure 3.5). Although CPFR is not a direct extension of any of the preceding programs, it draws on the experience gained with all three. Being the first clean-sheet design since the commercialization of the Internet, CPFR abandons EDI and private networks in favor of Internet communication. In addition to the direct communication of real-time data, trading partners use centralized information servers to view and update shared plans and forecasts.

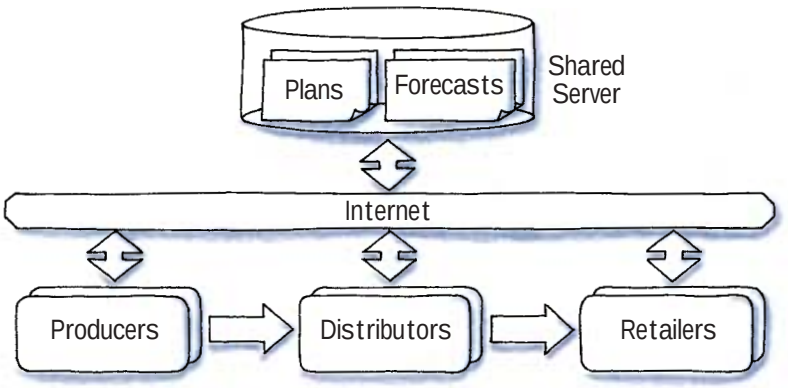


Figure 3.5
The CPFR Program

Adoption of CPFR has just begun

In short, the CPFR program relies on advanced, Internet-based tools to pool information about demand and supply, allowing trading partners to coordinate their inventory decisions and smooth the flow of goods across the chain. The use of such tools offers important advantages, but it also requires companies to make substantial investments in new technologies. Another obstacle is cultural: CPFR requires companies to share highly detailed information about their operations, and many are reluctant to do that. CPFR is beginning to win converts, but it's too soon to tell how widely the program will be embraced.

The Problem with Programs

All the programs have declared victory

All of the programs described in this chapter were introduced with great fanfare, and there are solid statistics to demonstrate that each of them has succeeded in reducing inventories and accelerating the flow of goods across the chain. These glowing reviews are bolstered by continuing reports in the business press about the remarkable economies produced over the past two decades through the relentless reduction of inventory. There's just one problem with these impressive results: They may not be real. Last year, a team of researchers at Ohio State University conducted a comprehensive analysis of the inventory levels reported by U.S.

corporations over the past 20 years, and they reached a startling conclusion: The Great Inventory Reduction of the late twentieth century never happened.

The programs aren't reducing inventory

The study did reveal a modest overall decline in total inventory since 1980, but most of that was due to a small number of industries that made structural changes in their supply chains. For example, the elimination of distributors and retailers in the direct sales model perfected by Dell, together with other advanced supply chain techniques, allowed the computer industry to cut its total inventories in half over the 20-year period. These are truly impressive gains, and they have contributed to the dramatic reductions in prices within this industry. But for other industries, including the two that have most ardently pursued retail replenishment programs—apparel and grocery—inventory levels have remained absolutely flat over the life of those programs.

They're just moving inventory elsewhere

What's going on here? Are these programs just a sham? No; the problem is subtler than that. The inventory levels of the companies participating in these programs have, in fact, dropped, but it now appears that most of those reductions were achieved by displacing inventory within the chain rather than actually eliminating it. This may be good for the companies reporting success, but it's hard on other members of their chains, and it does nothing to make those chains more efficient or competitive overall. These programs may be intended to create a new level of cooperation in the supply chain, bringing companies together as true trading partners, but, as often happens in business, the benefits of that cooperation appear to accrue mostly to the dominant party.

Retailers have slashed their inventories

The renowned success of Wal-Mart in mastering its supply chain provides a good case in point. Through a variant of the classic vertical integration strategy, Wal-Mart has largely eliminated the

distributors, carriers, and other middlemen that used to intervene between producers and retail outlets (Figure 3.6). The scale of this effort is staggering: Wal-Mart's trucks carry 50 million pallets of goods each week to 500 million square feet of retail space to serve 15 million customers a day. With economies of scale such as these, Wal-Mart has been able to eliminate a great deal of excess cost in its supply chain. These efficiencies are reflected in the national data: Retail is one of the few sectors that has made dramatic progress in reducing its total inventory, neatly paralleling the rise of mega-retailers such as Wal-Mart.

Manufacturers now hold more finished goods

Wal-Mart's massive scale also allows it to dictate terms to manufacturers, reversing the historical dominance of producers in the supply chains for consumer goods. For example, companies that want access to Wal-Mart's vast retail channel have to ship large volumes of goods to many different locations, meet precise delivery schedules with high reliability, and react instantly to changing levels of demand throughout the Wal-Mart empire. These requirements translate directly into increased inventories of finished goods, and that's exactly what the data show. In the industries that serve mega-retailers such as Wal-Mart, inventories of finished goods have not just remained flat, they have actually gone up over the last 20 years.

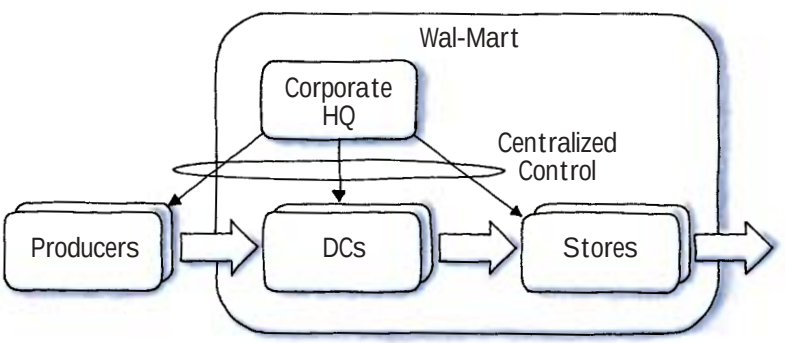


Figure 3.6
The Wal-Mart Model

Producers push the problem upstream

Of course, producers can compensate for this pressure to some extent by streamlining their internal operations and putting pressure on their own suppliers for more prompt performance, reducing their inventories of raw materials and work in process. And that's just what the data indicate; it is reductions in raw materials and WIP inventories that have kept total inventories from rising. Of course, increasing the pressure on suppliers to hold inventory to the last minute and respond rapidly to demand signals requires them to keep more finished goods on hand, and so on, up the chain. In short, the dramatic reductions in inventory achieved at the retail level have come, in large part, from pushing inventory up the chain, not from taking it out of the chain.

JIT also pushes inventory up the chain

This pattern of pushing inventory up the chain is also found in JIT programs. Here again, requiring suppliers to make precisely timed deliveries and respond rapidly to changing consumption reduces a producer's inventory of raw materials at the cost of forcing suppliers to hold more finished goods to buffer variability in demand. The standard response to this problem is for the suppliers to adopt JIT as well, but that only works if customers and suppliers precisely synchronize their operations. When U.S. companies first adopted JIT in the 1980s, they sometimes found that total inventory costs went up rather than down. The problem wasn't within the four walls: Both customers and suppliers ran exemplary JIT shops, each keeping on-site inventory to a minimum. The problem lay in the link between them. In order to handle coordination problems, companies often kept inventory in third-party warehouses to provide a buffer stock (Figure 3.7). The inventory hadn't been eliminated after all; it had just been moved to more expensive facilities.

JIT pushes inventory down the chain as well

One important difference between programs at the production level and those at the retail level is that producers are in the middle of the chain rather than at the end, so they have the option of

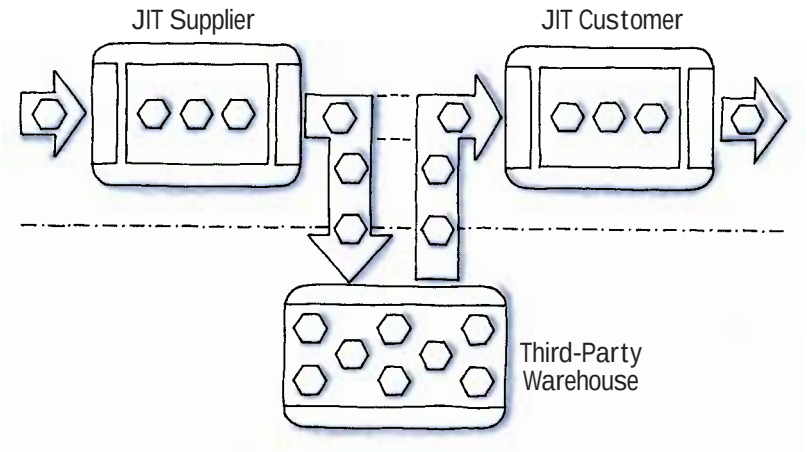


Figure 3.7
Hidden Inventory in JIT

pushing inventory downstream as well as upstream (Figure 3.8). Not surprisingly, this is exactly what happens. The best example comes from the automobile industry; having sorted out most of the supplier aspects of JIT, U.S. auto plants now operate with as little as three hours of inventory on hand. But the inventory of cars and trucks sitting at dealerships now runs as high as three months' worth of supply. JIT may be a success for the automakers, but it isn't making their supply chains more efficient. Of all the ways in which the industry could hold inventory, finished goods is by far the most expensive form.

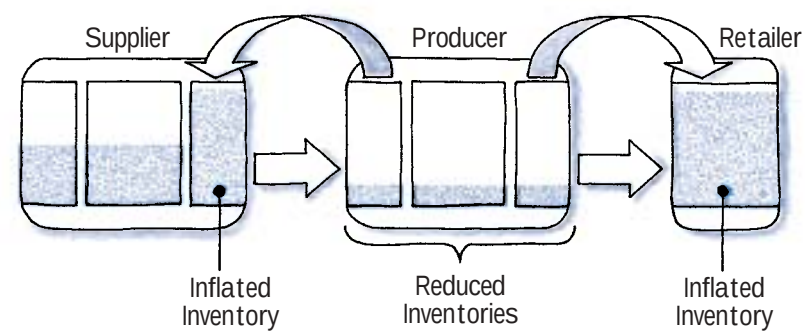


Figure 3.8
Producer Displacing Inventory

Trading partners still act like competitors

Viewed in the larger context of trade relationships, this pattern of pushing the burden up and down the chain rather than eliminating it altogether is not surprising. Although adjacent members of a supply chain are often called trading partners, more often than not this is a euphemism to draw attention away from a relationship that remains economically adversarial. No matter how much they may wish to cooperate, the bottom line is that the members of a supply chain are in competition with each other to increase their share of the consumer's dollar. When competition *between* chains drives down prices, the competition *within* chains heats up as each member of the chain tries to maintain its profit margins. If there is any imbalance of power within the chain—and there almost always is—the profits eventually gravitate to the power players, and the smaller players have to take what they can get.

True partnership is a real possibility

Supply chain relationships don't have to be like this. When companies act as true trading partners, working together to pull time and cost out of the chain, they can create a situation in which everyone makes more money. Chrysler's SCORE program—at least in its early years—was an excellent example of how much can be achieved this way. The company's $1.7 billion in savings didn't come out of its suppliers' hides; suppliers saved money right along with Chrysler. The savings came from finding better ways to build a car. What made this program different is that SCORE fostered true innovation rather than just escalating the competition for a fixed amount of money. The Ohio State researchers mentioned at the beginning of this section reached the same conclusion, based on their study of national data. In their words, "efforts to increase efficiency through the exercise of power simply change the location of the inefficiency." The only way to get genuine improvements is to redesign the supply chain to increase its efficiency as a whole.

The idea of replacing competition between trading partners with cooperation, creating win-win relationships, is so obvious and so

often repeated that it no longer has much currency. Attempts to build such relationships can and do succeed, but failure is the more common result, and today's managers are right to be suspicious of trading partners that talk about building win-win relationships without showing where the additional winnings will come from. They know that no matter how friendly things get, there will always be a dollar-for-dollar tradeoff between their profits and those of their "partners," so cooperation will never truly replace the natural competition between them.

Win-win relationships are hard to build

The dilemma, then, is this: Adjacent members of a supply chain may have very real opportunities to increase their shared profits, but the underlying tension over how the profits are divided can prevent them from realizing those opportunities. And even if they do find a way to increase their total profit, they may do so by pushing inventory or other costs onto other members of the chain. This situation makes any attempt to improve the performance of the chain as a whole a difficult proposition at best. The only way out of the dilemma is somehow to separate the effects of cooperation from those of competition, recognizing that both exist and devising a way to distribute the profits from cooperation in a manner that is fair to all parties. That's hard to do under the best of circumstances, but the techniques of game theory can make it a little bit easier.

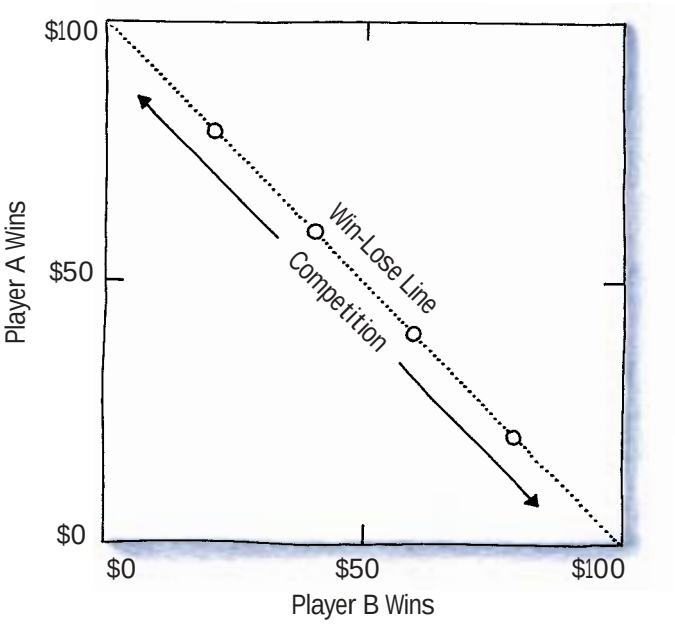
Game theory offers some vital insights

Insights from Game Theory

When trading partners compete with each other over a fixed sum of money, they are playing what game theorists call a **zero-sum game**. In zero-sum games, there's a fixed amount of money at stake, and players compete to see who can win the largest share. In Figure 3.9, two players, A and B, are competing for stakes of $100. The range of possible outcomes, from A taking everything to B getting it all, forms the diagonal line labeled the *win-lose line* in the diagram. The outcome of the game is a single point on this line. For

Transactions are played as zero-sum games

Figure 3.9
A Zero-Sum Game



clarity—these aren't standard terms—I'll call the line describing the possible outcomes the *tradeoff curve*, and I'll refer to the point describing the outcome as the *tradeoff point*. In the case of a zero-sum game, the tradeoff curve is the same as the win-lose line, and movement of the tradeoff point along this line represents competition in its purest form. Most supply chain transactions play out as zero-sum games, with the two parties vying with each other to push the outcome in their direction along the win-lose line.

Few transactions are really zero-sum

If there are ways in which the parties involved in a transaction can influence the total winnings in addition to determining how they divide up those winnings, the transaction turns into a non-zero-sum game. A non-zero-sum game can go either way, depending on the relationship between the two parties. If that relationship is cooperative, the parties can push the tradeoff curve up into the win-win region, as shown in the left panel of Figure 3.10. If the relationship is antagonistic, they can do each other more harm than good, moving the tradeoff curve down into the lose-lose region.

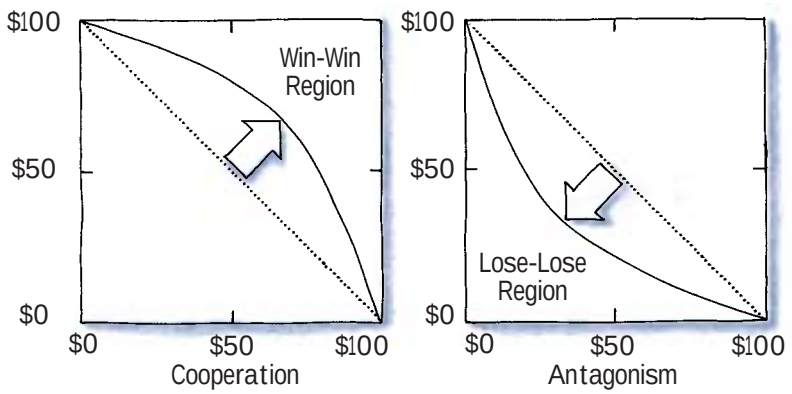


Figure 3.10
Non-Zero-Sum Games

The core contribution of game theory to economics is the insight that few business transactions are restricted to pure competition. Much of what we think of as win-lose transactions are actually much richer than this.

Lose-lose relationships are common

The focus of the following discussion is on moving trading relationships up into the win-win range, but that shouldn't obscure the fact that relationships often degenerate into lose-lose propositions. It is all too easy for the adversarial aspects of competition to dominate a relationship, even to the point where harming the other party becomes more important than winning the game. This is often seen in the competition between supply chains, where price wars and other forms of "cutthroat" competition can plunge companies into the lose-lose region. But it is also found *within* supply chains, as evidenced by the hidden JIT inventory shown in Figure 3.7 and in the higher carrying costs of inventory at auto dealers rather than plants. One of the dangers of thinking of trading relationships as zero-sum games is that it is all too easy for struggles along the win-lose line to slide off the line into the lose-lose region.

Cooperation can increase the total winnings

On a more positive note, trading partners that want to improve their combined profits rather than just fight over a fixed amount of money can look for ways to change their relationship into a positive-sum

game. This is not to say that they can eliminate the element of competition altogether; no matter how far they push the tradeoff curve into the win-win region, there can still be a struggle over who gets the lion's share of the winnings. The difference is a matter of emphasis rather than kind. In a cooperative game, the players focus on how to increase their total winnings and relegate the allocation of those winnings to a secondary concern. In a competitive game, the winnings are considered fixed and the allocation is everything.

SCORE put cooperation ahead of competition

This is why Chrysler's SCORE program was so successful. It completely recast the relationship to focus on cooperation and provided a simple set of mechanics to resolve the competitive element. Current prices were taken as a given, and reductions in those prices were limited to actual savings resulting from improved techniques. That limited the competitive element to the amount of the savings, and the program was very flexible within that range. In the early days, Chrysler often accepted whatever savings a supplier chose to pass on, without questioning the actual amount. Some suppliers no doubt kept more than half of the savings, but others passed along most or even all of the savings in an effort to win more business. Since everyone was winning at this point, no one worried too much about keeping score.

Cooperation requires changing the relationship

The first lesson to be drawn from game theory, then, is that trading partners should place most of the emphasis on maximizing the total winnings. The more successful they are in this effort, the less important the allocation of those winnings becomes. This often requires a major shift in the way customers and suppliers view their relationship, and making that shift is often harder than finding opportunities for savings. In fact, studies of why supply chain partnerships so often fail reveal that the failure is usually due more to attitudes than economics. It takes a sustained effort to build a positive-sum relationship, but, at least for key links in the chain,

the return on that investment of time and energy can be among the best in business.

Competition is never completely eliminated

Of course, the question of just where to place the tradeoff point in any given exchange doesn't ever go away, and even the best of relationships can become tense when there is freshly minted money lying on the table. There are many ways to resolve this question, but the preferred choice should always be to pick the point that maximizes the total winnings, compensating for any inequities through some other exchange. This is not only the best "average" outcome across the two companies, it is also the way to maximize the competitiveness of their supply chain.

Tradeoffs aren't always symmetrical

This is best seen through an example. Suppose a customer and supplier are each spending $5 a unit to verify the quality of a certain component. Figure 3.11 shows how this situation can be repre-

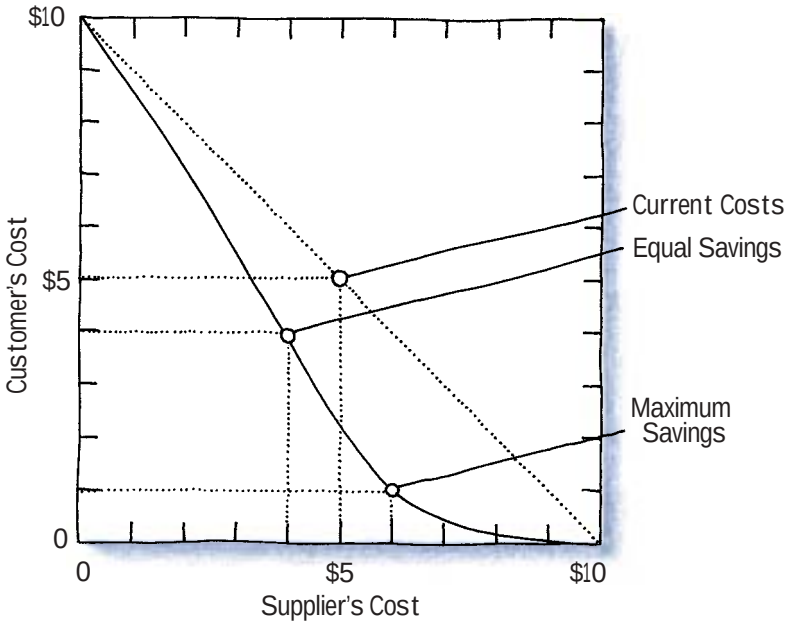


Figure 3.11 Allocating Cost Savings

sented as a zero-sum game. In this case the cooperative region is in the lower left rather than the upper right because the companies benefit by reducing costs, whereas in the earlier example they benefited by increasing profits. The tradeoff curve in the diagram represents the results of a joint study showing that a cooperative inspection program could eliminate several redundant operations, reducing the total expenditure on quality control. According to the study, the tradeoff curve is asymmetrical; the largest savings will be realized if the supplier takes on more of the burden of quality assurance because this eliminates the additional expense of shipping and returning defective components. Assuming the companies can agree on this program, how should they split the savings?

The best policy is to maximize total winnings

In the real world, the most likely outcome is that the customer would express outrage at having to spend so much to compensate for poor quality and would insist that the supplier get its act together and eliminate the defects. But suppose that, in the spirit of cooperation, the two agree to share the savings equally, choosing the tradeoff point labeled *equal savings*. This isn't a bad choice; both companies spend less money on quality control, and the total costs for the component go down by $2, allowing the supply chain to improve its margins. But a better choice would be to pick the point that maximizes the total savings. In this example, the two companies can shave an additional $1 per component off their combined costs if the supplier actually increases its total cost. This may not be fair to the supplier, but this inequity is easily rectified by having the producer compensate the supplier in other ways. The simplest solution is for the producer to pay more for components shipped under the new quality program.

Relationships span many transactions

This last point—that the customer can compensate the supplier for its added expense through side payments or some other exchange—reveals another important contribution of game theory. Although it may make sense for companies to view spot purchases and other isolated transactions as zero-sum games, that kind of

thinking breaks down when it comes to sustained relationships, which span multiple transactions and include multiple tradeoffs. Even if a company insists on applying zero-sum logic to an entire relationship, it is still better off choosing optimal points for individual transactions and making up the difference elsewhere. But the best relationship is achieved by setting the competitive component aside long enough to explore the full benefits that can be realized through cooperation. There is always a way to balance out the books later if one party doesn't realize its full share of the benefits in a particular transaction.

Modeling reveals the real tradeoffs

Another key insight from applying game theory is that decisions such as these can't be made intuitively; they are simply too complex for that. Even a trivial example of the sort shown in Figure 3.11 outstrips our ability to discover the best solution by thinking in terms of who "ought" to carry a cost or what a fair division of savings might be. The key to taking win-win relationships out of the realm of warm fuzzies and making them a working reality is to use formal models to find optimal values. For some decisions, a simple spreadsheet showing cost tradeoffs is enough; others may require modeling the entire supply chain. Chapter 5 provides an overview of the various kinds of models and their applications; the important point here is simply that modeling is an indispensable tool for making the complex decisions required in supply chain management.

Winning Through Collaboration

Most efforts have been point solutions

Although supply chain management has come a long way from its origins in transportation management, the discipline still tends to reflect the original focus on managing the flow of goods across a single link in the chain. As the examples in this chapter illustrate, it is all too easy for such point solutions to simply push problems up or down the chain rather than actually solving them. Even when two or more trading partners cooperate to improve their overall

position, they often do so at the expense of other members of the chain. In game theory terms, they are creating a local positive-sum game, but their cooperative relationship may actually drive their interactions with other members of the chain into the lose-lose region.

Competitiveness requires teamwork

This is not the way to build a winning chain. The new competition between supply chains isn't based on the effectiveness of individual links; it's based on the ability of the chain as a whole to bring better products to the market faster and cheaper than other chains. The key to doing this is to apply the logic of game theory across the entire chain, pushing the chain as a whole as far as possible into the win-win region. This can only happen if all the members of the chain are willing to play as a team, optimizing the tradeoffs at every link in order to pull time and cost out of the chain.

The goal is integrated planning and action

In effect, the members of this team need to plan and act with the integrity of a single organization, working together to simplify and stabilize the flow of demand, supply, and cash across the chain. This pooling of interests, this synergy of planning and acting, is the essence of supply chain integration. Succinctly put, supply chain integration means that the members of the chain come together to form a larger whole, one in which the parts are carefully aligned and synchronized so that the chain behaves as a single, coordinated system.

Vertical integration was the classic choice

Supply chain integration isn't an all-or-none proposition: It varies in both form and degree, as shown in Figure 3.12. The classic form, shown on the left side of the figure, is vertical integration, in which all the members of the chain are owned by the same company. Vertical integration is still practiced in some segments of the chain, as seen in Wal-Mart's ownership of the distribution channel, but it's hard to achieve across the entire chain today because so many companies are involved. Henry Ford was a great believer in vertical

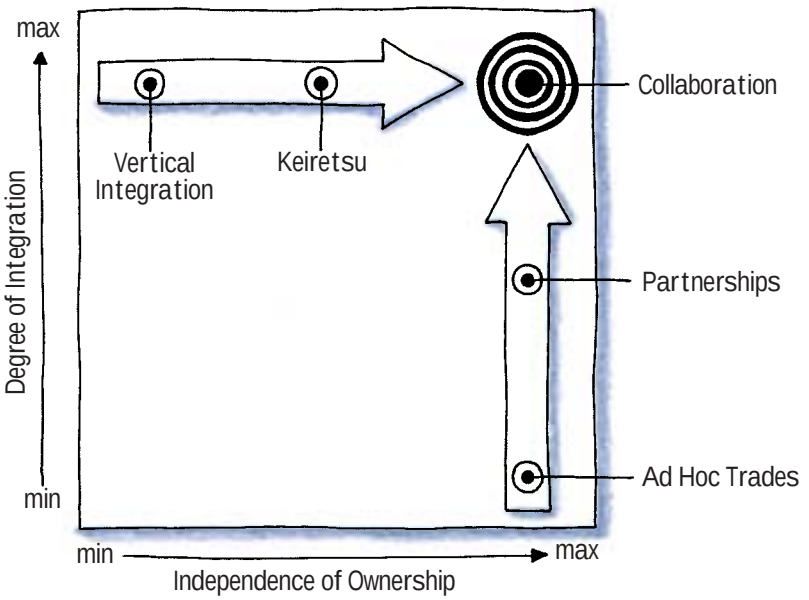


Figure 3.12
Strategies for Integration

integration, and he made sure his company owned everything from rubber trees to sales lots. Today, Ford's supply chain includes more than 100,000 companies. Even if it were possible for Ford to own all those companies, the inevitable overhead and bureaucracy would negate most of the advantages of common ownership.

Companies now focus on core competence

Today, it is far more common for companies to focus on their core competence and cooperate with other companies to assemble complete supply chains. But the form of that cooperation varies widely, as shown in Figure 3.12. The keiretsu is forged by establishing overlapping ownership and management among formerly independent trading partners, as described earlier in this chapter. It generally achieves levels of integration nearly as good as those of vertical integration, but this may be due as much to Japanese culture as to the business structure. The diametrical opposite of vertical integration is the ad hoc supply chain shown in the lower right of Figure 3.12, a group of independently owned companies bound only by need and market mechanisms. This kind of chain requires the least

governance and is the most flexible, in that its membership can change with each transaction. But it would be hard to envision a less integrated solution to the problems of coordinating a chain.

Virtual integration is now the preferred path

Attempts to gain a high degree of integration without compromising independent ownership—an approach called **virtual integration**—are shown as movement up the right side of Figure 3.12. Partnership agreements between adjacent members of the chain are the usual first step toward vertical integration, but they are at best a partial solution because they only span a single link. True integration requires the members of a supply chain to coordinate the flow of demand, supply, and cash across the chain as a whole, not just across a single link.

Two trends point toward collaboration

As indicated in Figure 3.12, the current push for collaboration across the chain represents the natural convergence of two major trends in supply chain management. One trend is away from common ownership and toward independent companies. The other trend is away from ad hoc transactions and toward tighter integration. The place where those two trends meet—the spot marked with the bull's-eye—is the goal of supply chain collaboration: a team of companies achieving a high degree of integration across the supply chain while retaining independent ownership and control.

Collaboration isn't a new idea

Supply chain collaboration isn't a new idea; JIT, quick response, efficient consumer response, and the other programs described in this chapter are all early forms of collaboration, but they are limited to a small subset of the larger supply chain. In the future, collaboration has to span enough links in the chain to truly pull time and cost out of the chain, not just displace it within the chain.

Collaboration will be difficult to achieve

Achieving this level of collaboration will require managers to take a much wider perspective on the supply chain than they do today, thinking of their companies as part of a larger whole rather than

the center of the business universe. This won't come easily; one recent survey revealed that more than 80% of all supply chain initiatives are completely contained within a single company, and most of the remainder deal only with immediate trading partners. Another survey, reported in *Supply Chain Management Review* (see Notes on Sources), reinforces the point with this rather bleak conclusion: "We did not find a single incidence of extensive analysis of the total supply chain to understand the inter-relationships or to set the goals," adding that ". . . no company has a model of the supply chain on which to test different modes of operation or the impact of different strategies."

You don't have to do it all at once

This may be a bleak conclusion for the supply chain industry as a whole, but it represents a tremendous opportunity for companies that are ready to move to the next level. Integrating a supply chain through collaboration may not be easy, but you don't need to get your chain anywhere near the bull's-eye to score a big win. Given the current state of supply chains, just making progress in that direction can be enough to give you a solid competitive advantage. Imagine a perfectly integrated chain as a champion marathon runner, clicking off a steady stream of six-minute miles by maintaining perfect synchrony in every movement. The corresponding image for a conventional chain would be Dr. Frankenstein's monster lurching down the village lane, struggling to make an ad hoc assembly of muscles propel its body forward. If that's the competition, you don't have to be an Olympic runner to come in first. If you can walk, you can win.

The essential message you should take away from Part I is this: Supply chains are the new arena of corporate competition, the core problem in managing supply chains is dealing with complexity and variability, and collaboration among trading partners is essential to coping with these

problems. This is the mission; should you choose to accept it, you will need some specialized tools to help you succeed. Part II presents these tools by (1) explaining how to look at supply chains from a systems perspective, (2) showing you three different ways to model supply chains, and (3) giving you a quick tour of supply chain software. Once you have these tools in hand, you'll be ready to master your own supply chain.