CHAPTER 17
COORDINATION IN A SUPPLY CHAIN

Learning Objectives

After reading this chapter, you will be able to:

1. Describe supply chain coordination, the bullwhip effect, and their impact on performance.
2. Identify causes of the bullwhip effect and obstacles to coordination in a supply chain.
3. Discuss managerial levers that help achieve coordination in a supply chain.
4. Describe actions that facilitate the building of strategic partnerships and trust within a supply chain.
5. Understand the different forms of CPFR possible in a supply chain.

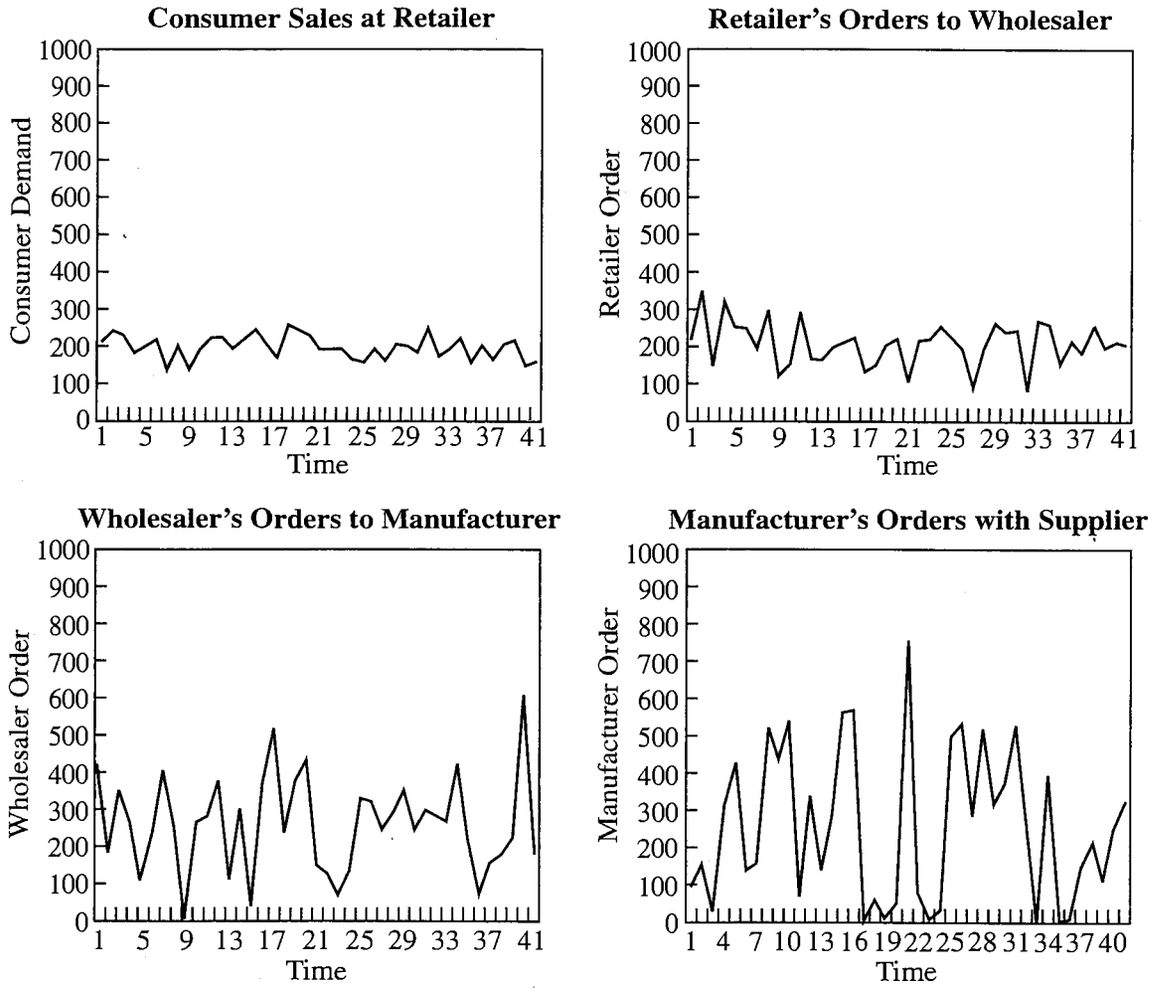
In this chapter, we discuss how lack of coordination leads to a degradation of responsiveness and an increase in cost within a supply chain. We describe various obstacles that lead to this lack of coordination and exacerbate variability through the supply chain. We then identify appropriate managerial levers that can help overcome the obstacles and achieve coordination. In this context, we also discuss actions that facilitate strategic partnerships and the building of trust within a supply chain.

17.1 LACK OF SUPPLY CHAIN COORDINATION AND THE BULLWHIP EFFECT

Supply chain coordination improves if all stages of the chain take actions that together increase total supply chain profits. Supply chain coordination requires each stage of the supply chain to take into account the impact its actions have on other stages.

A lack of coordination occurs either because different stages of the supply chain have objectives that conflict or because information moving between stages is delayed and distorted. Different stages of a supply chain may have conflicting objectives if each stage has a different owner. As a result, each stage tries to maximize its own profits, resulting in actions that often diminish total supply chain profits (see Chapters 10 and 12). Today, supply chains consist of stages with many different owners. For example, Ford Motor Company has thousands of suppliers from Goodyear to Motorola, and each of these suppliers has many suppliers in turn. Information is distorted as it moves across the supply chain because complete information is not shared between stages. This distortion is exaggerated by the fact that supply chains today produce a large amount of product variety. For example, Ford produces many different models with several options for each model. The increased variety makes it difficult for Ford to coordinate information exchange with thousands of suppliers and dealers. The

FIGURE 17-1 Demand Fluctuations at Different Stages of a Supply Chain



fundamental challenge today is for supply chains to achieve coordination in spite of multiple ownership and increased product variety.

Many firms have observed the *bullwhip effect,* in which fluctuations in orders increase as they move up the supply chain from retailers to wholesalers to manufacturers to suppliers, as shown in Figure 17-1.

The bullwhip effect distorts demand information within the supply chain, with each stage having a different estimate of what demand looks like. The result is a loss of supply chain coordination.

Proctor & Gamble (P&G) has observed the bullwhip effect in the supply chain for Pampers diapers.[1] The company found that raw material orders from P&G to its suppliers fluctuated significantly over time. Farther down the chain, when sales at retail stores were studied, it was found that the fluctuations, while present, were small. It is reasonable to assume that the consumers of diapers (babies) at the last stage of the supply chain used them at a steady rate. Although consumption of the end product was stable, orders for raw material were highly variable, increasing costs and making it difficult for supply to match demand.

[1]Lee, Padmanabhan, and Whang (1997).

HP also found that the fluctuation in orders increased significantly as they moved from the resellers up the supply chain to the printer division to the integrated circuit division.[2] Once again, while product demand showed some variability, orders placed with the integrated circuit division were much more variable. This made it difficult for HP to fill orders on time and increased the cost of doing so.

Studies of the apparel and grocery industry have shown a similar phenomenon; the fluctuation in orders increases as we move upstream in the supply chain from retail to manufacturing. Barilla, an Italian manufacturer of pasta, observed that weekly orders placed by a local distribution center fluctuated by up to a factor of 70 in the course of the year, whereas weekly sales at the distribution center (representing orders placed by supermarkets) fluctuated by a factor of less than three.[3] Barilla was thus facing demand that was much more variable than customer demand. This led to increased inventories, poorer product availability, and a drop in profits.

A similar phenomenon, over a longer time frame, has been observed in several industries that are quite prone to "boom and bust" cycles. A good example is the production of memory chips for personal computers. Between 1985 and 1998 there were at least two cycles during which prices of memory chips fluctuated by a factor of more than three. These large fluctuations in price were driven by either large shortages or surpluses in capacity. The shortages were exacerbated by panic buying and overordering that was followed by a sudden drop in demand.

In the next section we consider how lack of coordination affects supply chain performance.

17.2 THE EFFECT ON PERFORMANCE OF LACK OF COORDINATION

A supply chain lacks coordination if each stage optimizes only its local objective, without considering the impact on the complete chain. Total supply chain profits are thus less than what could be achieved through coordination (see Chapters 10 and 12). Each stage of the supply chain, in trying to optimize its local objective, takes actions that end up hurting the performance of the entire supply chain.

Lack of coordination also results if information distortion occurs within the supply chain. Consider the bullwhip effect P&G observed in the diaper supply chain. As a result of the bullwhip effect, orders P&G receives from its distributors are much more variable than demand for diapers at retailers. We discuss the impact of this increase in variability on various measures of performance in the diaper supply chain.

MANUFACTURING COST

The bullwhip effect increases manufacturing cost in the supply chain. As a result of the bullwhip effect, P&G and its suppliers must satisfy a stream of orders that is much more variable than customer demand. P&G can respond to the increased variability by either building excess capacity or holding excess inventory (see Chapter 11), both of which increase the manufacturing cost per unit produced.

[2]Ibid.

[3]Hammond (1994).

INVENTORY COST

The bullwhip effect increases inventory cost in the supply chain. To handle the increased variability in demand, P&G has to carry a higher level of inventory than would be required in the absence of the bullwhip effect. As a result, inventory costs in the supply chain increase. The high levels of inventory also increase the warehousing space required and thus the warehousing cost incurred.

REPLENISHMENT LEAD TIME

The bullwhip effect increases replenishment lead times in the supply chain. The increased variability as a result of the bullwhip effect makes scheduling at P&G and supplier plants much more difficult compared to a situation with level demand. There are times when the available capacity and inventory cannot supply the orders coming in. This results in higher replenishment lead times in the supply chain from both P&G and its suppliers.

TRANSPORTATION COST

The bullwhip effect increases transportation cost in the supply chain. The transportation requirements over time at P&G and its suppliers are correlated with the orders being filled. As a result of the bullwhip effect, transportation requirements fluctuate significantly over time. This raises transportation cost because surplus transportation capacity needs to be maintained to cover high-demand periods.

LABOR COST FOR SHIPPING AND RECEIVING

The bullwhip effect increases labor costs associated with shipping and receiving in the supply chain. Labor requirements for shipping at P&G and its suppliers fluctuate with orders. A similar fluctuation occurs for the labor requirements for receiving at distributors and retailers. The various stages have the option of carrying excess labor capacity or varying labor capacity in response to the fluctuation in orders. Either option increases total labor cost.

LEVEL OF PRODUCT AVAILABILITY

The bullwhip effect hurts the level of product availability and results in more stockouts in the supply chain. The large fluctuations in orders make it harder for P&G to supply all distributor and retailer orders on time. This increases the likelihood that retailers will run out of stock, resulting in lost sales for the supply chain.

RELATIONSHIPS ACROSS THE SUPPLY CHAIN

The bullwhip effect has a negative effect on performance at every stage and thus hurts the relationships between different stages of the supply chain. There is a tendency to assign blame to other stages of the supply chain because each stage feels it is doing the best it can. The bullwhip effect thus leads to a loss of trust between different stages of the supply chain and makes any potential coordination efforts more difficult.

From the earlier discussion, it follows that the bullwhip effect and the resulting lack of coordination have a significant negative impact on the supply chain's performance. The bullwhip effect moves a supply chain away from the efficient frontier by increasing cost and decreasing responsiveness. The impact of the bullwhip effect on different performance measures is summarized in Table 17-1.

TABLE 17-1 Impact of Bullwhip Effect on Supply Chain Performance

Performance Measure	*Impact of Bullwhip Effect*
Manufacturing cost	Increases
Inventory cost	Increases
Replenishment lead time	Increases
Transportation cost	Increases
Shipping and receiving cost	Increases
Level of product availability	Decreases
Profitability	Decreases

KEY POINT The bullwhip effect reduces the profitability of a supply chain by making it more expensive to provide a given level of product availability.

In the next section we discuss various obstacles to achieving coordination in the supply chain.

17.3 OBSTACLES TO COORDINATION IN A SUPPLY CHAIN

Any factor that leads to either local optimization by different stages of the supply chain, or an increase in information delay, distortion, and variability within the supply chain, is an obstacle to coordination. If managers in a supply chain are able to identify the key obstacles, they can then take suitable actions to help achieve coordination. We divide the major obstacles into five categories:

- Incentive obstacles
- Information-processing obstacles
- Operational obstacles
- Pricing obstacles
- Behavioral obstacles

INCENTIVE OBSTACLES

Incentive obstacles occur in situations when incentives offered to different stages or participants in a supply chain lead to actions that increase variability and reduce total supply chain profits.

LOCAL OPTIMIZATION WITHIN FUNCTIONS OR STAGES OF A SUPPLY CHAIN

Incentives that focus only on the local impact of an action result in decisions that do not maximize total supply chain profits. For example, if the compensation of a transportation manager at a firm is linked to the average transportation cost per unit, the manager is likely to take actions that lower transportation costs even if they increase inventory costs or hurt customer service. It is natural for any participant in the supply chain to take actions that optimize performance measures along which they are evaluated. For example, managers at a retailer such as K-Mart make all their purchasing and inventory decisions to maximize K-Mart profits, not total supply chain profits. Buying decisions

based on maximizing profits at a single stage of the supply chain lead to ordering policies that do not maximize supply chain profits (see Chapters 10 and 12).

Sales Force Incentives

Improperly structured sales force incentives are a significant obstacle to coordination in a supply chain. In many firms, sales force incentives are based on the amount the sales force sells during an evaluation period of a month or quarter. The sales typically measured by a manufacturer are the quantity sold to distributors or retailers (sell-in), not the quantity sold to final customers (sell-through). Measuring performance based on sell-in is often justified on the grounds that the manufacturer's sales force does not control sell-through. For example, Barilla offered its sales force incentives based on the quantity sold to distributors during a four- to six-week promotion period. To maximize their bonuses, the Barilla sales force urged distributors to buy more pasta toward the end of the evaluation period, even if distributors were not selling as much to retailers. The sales force offered discounts they controlled to spur end-of-period sales. This increased variability in the order pattern, with a jump in orders toward the end of the evaluation period followed by very few orders at the beginning of the next evaluation period. Order sizes from distributors to Barilla fluctuated by a factor of up to 70 from one week to the next. A sales force incentive based on sell-in thus results in order variability being larger than customer demand variability.

INFORMATION-PROCESSING OBSTACLES

Information-processing obstacles occur in situations when demand information is distorted as it moves between different stages of the supply chain, leading to increased variability in orders within the supply chain.

Forecasting Based on Orders and Not Customer Demand

When stages within a supply chain make forecasts that are based on orders they receive, any variability in customer demand is magnified as orders move up the supply chain to manufacturers and suppliers. In supply chains that exhibit the bullwhip effect, the fundamental means of communication between different stages are the orders that are placed. Each stage views its primary role within the supply chain as one of filling orders placed by its downstream partner. Thus, each stage views its demand as the stream of orders received and produces a forecast based on this information.

In such a scenario, a small change in customer demand becomes magnified as it moves up the supply chain in the form of customer orders. Consider the impact of a random increase in customer demand at a retailer. The retailer may interpret part of this random increase as a growth trend. This interpretation will lead the retailer to order more than the observed increase in demand because the retailer expects growth to continue into the future and thus orders to cover for future anticipated growth. The increase in the order placed with the wholesaler is thus larger than the observed increase in demand at the retailer. Part of the increase is a one-time increase. The wholesaler, however, has no way to interpret the order increase correctly. The wholesaler simply observes a jump in the order size and infers a growth trend. The growth trend inferred by the wholesaler will be larger than that inferred by the retailer (recall that the retailer increased the order size to account for future growth). The wholesaler will thus place an even larger order with the manufacturer. As we go further up the supply chain, the order size will be magnified.

Now assume that periods of random increase are followed by periods of random decrease in demand. Using the same forecasting logic as earlier, the retailer will now anticipate a declining trend and reduce order size. This reduction will also become magnified as we move up the supply chain.

KEY POINT The fact that each stage in a supply chain forecasts demand based on the stream of orders received from the downstream stage results in a magnification of fluctuations in demand as we move up the supply chain from the retailer to the manufacturer.

Lack of Information Sharing

The lack of information sharing between stages of the supply chain magnifies the bullwhip effect. For example, a retailer such as Wal-Mart may increase the size of a particular order because of a planned promotion. If the manufacturer is not aware of the planned promotion, it may interpret the larger order as a permanent increase in demand and place orders with suppliers accordingly. The manufacturer and suppliers thus have a lot of inventory right after Wal-Mart finishes its promotion. Given the excess inventory, as future Wal-Mart orders return to normal, manufacturer orders will be smaller than before. The lack of information sharing between the retailer and manufacturer thus leads to a large fluctuation in manufacturer orders.

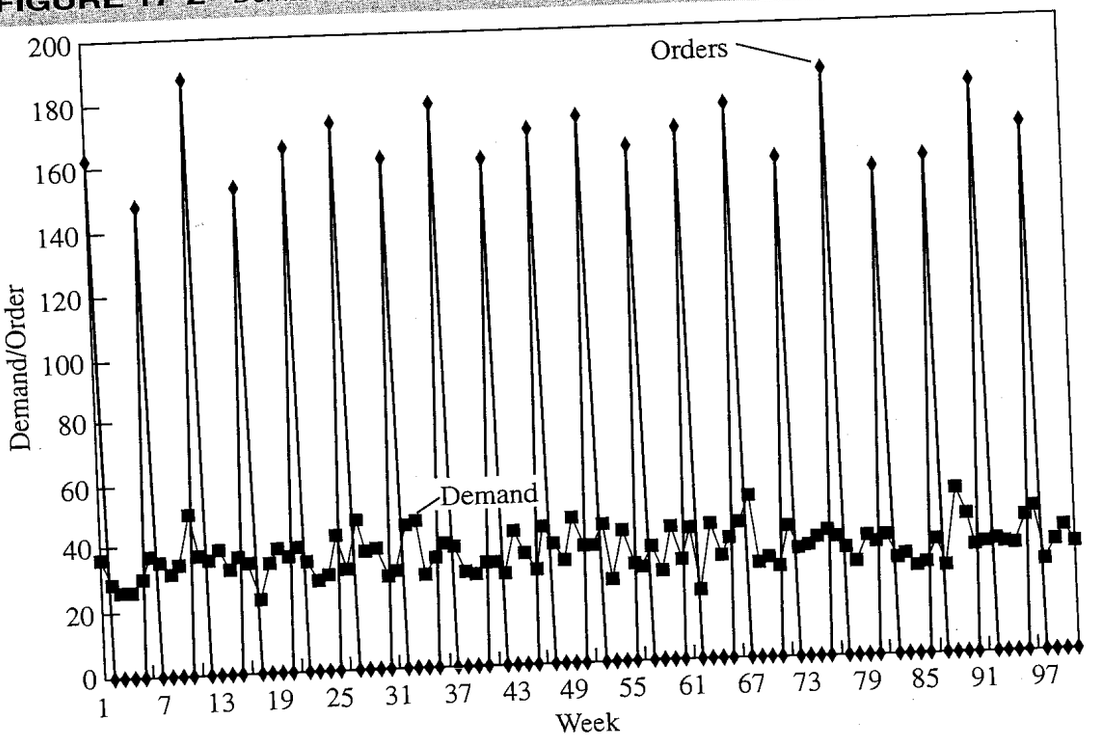
OPERATIONAL OBSTACLES

Operational obstacles occur when actions taken in the course of placing and filling orders lead to an increase in variability.

Ordering in Large Lots

When a firm places orders in lot sizes that are much larger than the lot sizes in which demand arises, variability of orders is magnified up the supply chain. Firms may order in large lots because there is a significant fixed cost associated with placing, receiving, or transporting an order (see Chapter 10). Large lots may also occur if the supplier offers quantity discounts based on lot size (see Chapter 10). Figure 17-2 shows both the

FIGURE 17-2 Demand and Order Stream with Orders Every Five Weeks



demand and the order stream for a firm that places an order every five weeks. Observe that the order stream is far more erratic than the demand stream.

Because orders are batched and placed every five weeks, the order stream has four weeks without orders followed by a large order that equals five weeks of demand. A manufacturer supplying several retailers who batch their orders faces an order stream that is much more variable than the demand the retailers experience. If the manufacturer further batches its orders to suppliers, the effect is further magnified. In many instances there are certain focal-point periods, such as the first or the last week of a month, when a majority of the orders arrive. This concentration of orders further exacerbates the impact of batching.

Large Replenishment Lead Times

The bullwhip effect is magnified if replenishment lead times between stages are long. Consider a situation in which a retailer has misinterpreted a random increase in demand as a growth trend. If the retailer faces a lead time of two weeks, it will incorporate the anticipated growth over two weeks when placing the order. In contrast, if the retailer faces a lead time of two months, it will incorporate into its order the anticipated growth over two months (which will be much larger). The same applies when a random decrease in demand is interpreted as a declining trend.

Rationing and Shortage Gaming

Rationing schemes that allocate limited production in proportion to the orders placed by retailers lead to a magnification of the bullwhip effect. This can occur when a high-demand product is in short supply. HP, for example, has faced many situations in which a new product has demand that far exceeds supply. In such a situation, manufacturers come up with a variety of mechanisms to ration the scarce supply of product among various distributors or retailers. One commonly used rationing scheme is to allocate the available supply of product based on orders placed. Under this rationing scheme, if the supply available is 75 percent of the total orders received, each retailer receives 75 percent of its order.

This rationing scheme results in a game in which retailers try to increase the size of their orders to increase the amount supplied to them. A retailer needing 75 units orders 100 units in the hope of getting 75. The net impact of this rationing scheme is to artificially inflate orders for the product. In addition, a retailer ordering based on what it expects to sell gets less and as a result loses sales, whereas a retailer that inflates its order is rewarded.

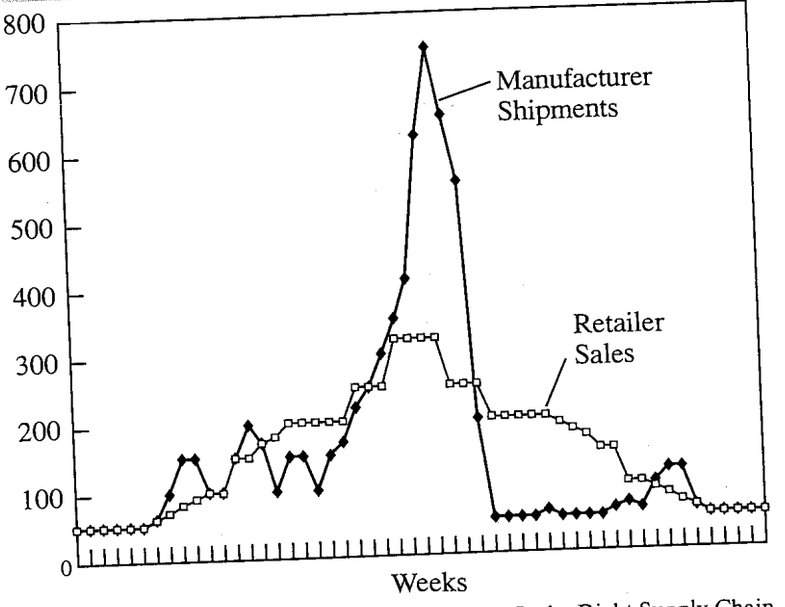
If the manufacturer is using orders to forecast future demand, it will interpret the increase in orders as an increase in demand even though customer demand is unchanged. The manufacturer may respond by building enough capacity to be able to fill all orders received. Once sufficient capacity becomes available, orders return to their normal level because they were inflated in response to the rationing scheme. The manufacturer is now left with a surplus of product and capacity. These boom-and-bust cycles then tend to alternate.

This phenomenon is fairly common in the computer industry, in which alternating periods of component shortages followed by a component surplus are often observed. In particular, memory chip manufacturing has experienced a couple of such cycles over the last decade.

PRICING OBSTACLES

Pricing obstacles arise when the pricing policies for a product lead to an increase in variability of orders placed.

FIGURE 17-3 Retailer Sales and Manufacturer Shipments of Soup



Source: Adapted from Marshall L. Fisher, "What Is the Right Supply Chain for Your Product?" *Harvard Business Review* (March–April 1997): 83–93.

Lot Size–Based Quantity Discounts

Lot size–based quantity discounts increase the lot size of orders placed within the supply chain (see Chapter 10). As discussed earlier, the resulting large lots magnify the bullwhip effect within the supply chain.

Price Fluctuations

Trade promotions and other short-term discounts offered by a manufacturer result in forward buying, by which a wholesaler or retailer purchases large lots during the discounting period to cover demand during future periods. Forward buying results in large orders during the promotion period followed by very small orders after that (see Chapter 10), as shown in Figure 17-3 for chicken noodle soup.

Observe that the shipments during the peak period are higher than the sales during the peak period because of a promotion offered during this period. The peak shipment period is followed by a period of very low shipments from the manufacturer, indicating significant forward buying by distributors. The promotion thus results in a variability in manufacturer shipments that is significantly higher than the variability in retailer sales.

BEHAVIORAL OBSTACLES

Behavioral obstacles are problems in learning within organizations that contribute to the bullwhip effect. These problems are often related to the way the supply chain is structured and the communications between different stages. Some of the behavioral obstacles are as follows.

1. Each stage of the supply chain views its actions locally and is unable to see the impact of its actions on other stages.

2. Different stages of the supply chain react to the current local situation rather than trying to identify the root causes.
3. Based on local analysis, different stages of the supply chain blame each other for the fluctuations, with successive stages in the supply chain becoming enemies rather than partners.
4. No stage of the supply chain learns from its actions over time because the most significant consequences of the actions any one stage takes occur elsewhere. The result is a vicious cycle in which actions taken by a stage create the very problems that the stage blames on others.
5. A lack of trust among supply chain partners causes them to be opportunistic at the expense of overall supply chain performance. The lack of trust also results in significant duplication of effort. More important, information available at different stages is either not shared or is ignored because it is not trusted.

17.4 MANAGERIAL LEVERS TO ACHIEVE COORDINATION

Having identified obstacles to coordination, we now focus on actions a manager can take to help overcome the obstacles and achieve coordination in the supply chain. The following managerial actions increase total supply chain profits and moderate the bullwhip effect.

- Aligning of goals and incentives
- Improving information accuracy
- Improving operational performance
- Designing pricing strategies to stabilize orders
- Building partnerships and trust

ALIGNING OF GOALS AND INCENTIVES

Managers can improve coordination within the supply chain by aligning goals and incentives so that every participant in supply chain activities works to maximize total supply chain profits.

Aligning Incentives Across Functions

One key to coordinated decisions within a firm is to ensure that the objective any function uses to evaluate a decision is aligned with the firm's overall objective. All facility, transportation, and inventory decisions should be evaluated based on their effect on profitability, not total costs, or even worse, just local costs. This helps avoid situations such as a transportation manager making decisions that lower transportation cost but increase overall supply chain costs (see Chapter 13).

Pricing for Coordination

A manufacturer can use lot size–based quantity discounts to achieve coordination for commodity products if the manufacturer has large fixed costs associated with each lot (see Chapter 10). For products for which a firm has market power, a manager can use two-part tariffs and volume discounts to help achieve coordination (see Chapter 10). Given demand uncertainty, manufacturers can use buy-back, revenue-sharing, and quantity flexibility contracts to spur retailers to provide levels of product availability that maximize supply chain profits. Buy-back contracts have been used in the publishing industry to increase total supply chain profits. Quantity flexibility contracts have helped Benetton increase supply chain profits.

Altering Sales Force Incentives from Sell-In to Sell-Through

Any change that reduces the incentive for a salesperson to push product to the retailer reduces the bullwhip effect. If sales force incentives are based on sales over a rolling horizon, the incentive to push product is reduced. This helps reduce forward buying and the resulting fluctuation in orders. Managers can also link incentives for the sales staff to sell-through by the retailer rather than sell-in to the retailer. This action eliminates any motivation the sales staff may have to encourage forward buying. Elimination of forward buying helps reduce fluctuations in the order stream.

IMPROVING INFORMATION ACCURACY

Managers can achieve coordination by improving the accuracy of information available to different stages in the supply chain.

Sharing Point-of-Sale Data

Sharing point-of-sale (POS) data across the supply chain can help reduce the bullwhip effect. A primary cause for the bullwhip effect is the fact that each stage of the supply chain uses orders to forecast future demand. Given that orders received by different stages vary, forecasts at different stages also vary. In reality, the only demand that the supply chain needs to satisfy is from the final customer. If retailers share POS data with other supply chain stages, all supply chain stages can forecast future demand based on customer demand. Sharing of POS data helps reduce the bullwhip effect because all stages now respond to the same change in customer demand. Observe that sharing aggregate POS data is sufficient to dampen the bullwhip effect. We do not necessarily need to share detailed POS data. Use of appropriate information systems facilitates the sharing of such data (see Chapter 16).

Companies can also use the Internet to share data with suppliers. For direct-sales companies such as Dell, and companies involved in e-commerce, POS data are available in a form that can easily be shared. Dell shares demand data as well as current inventory positions of components with many of its suppliers via the Internet, thereby helping to avoid unnecessary fluctuations in supply and orders placed. P&G has convinced many retailers to share demand data. P&G in turn shares the data with its suppliers, improving coordination in the supply chain.

Implementing Collaborative Forecasting and Planning

Once point-of-sale data are shared, different stages of the supply chain must forecast and plan jointly if complete coordination is to be achieved. Without collaborative planning, sharing of POS data does not guarantee coordination. A retailer may have observed large demand in the month of January because it ran a promotion. If no promotion is planned in the upcoming January, the retailer's forecast will differ from the manufacturer's forecast even if both have past POS data. The manufacturer must be aware of the retailer's promotion plans to achieve coordination. The key is to ensure that the entire supply chain is operating with a common forecast. To facilitate this type of coordination in the supply chain environment, the Voluntary Interindustry Commerce Standards (VICS) Association has set up a Collaborative Planning, Forecasting, and Replenishment (CPFR) committee to identify best practices and design guidelines for collaborative planning and forecasting. These practices are detailed later in the chapter.

Designing Single-Stage Control of Replenishment

Designing a supply chain in which a single stage controls replenishment decisions for the entire supply chain can help diminish the bullwhip effect. As we mentioned earlier, a key cause of the bullwhip effect is the fact that each stage of the supply chain uses

orders from the previous stage as its historical demand. As a result, each stage views its role as one of replenishing orders placed by the next stage. In reality, the key replenishment is at the retailer, because that is where the final customer purchases. When a single stage controls replenishment decisions for the entire chain, the problem of multiple forecasts is eliminated and coordination within the supply chain follows.

For a manufacturer such as Dell that sells directly to customers, single control of replenishment is automatic because there is no intermediary between the manufacturer and the customer. The manufacturer automatically becomes the single point of control for replenishment decisions. When sales occur through retailers, there are several industry practices such as continuous replenishment programs (CRP) and vendor-managed inventories (VMI) that are detailed later in the chapter.

IMPROVING OPERATIONAL PERFORMANCE

Managers can help dampen the bullwhip effect by improving operational performance and designing appropriate product rationing schemes in case of shortages.

Reducing Replenishment Lead Time

By reducing the replenishment lead time, managers can decrease the uncertainty of demand during the lead time (see Chapter 11). A reduction in lead time is especially beneficial for seasonal items because it allows for multiple orders to be placed in the season with a significant increase in the accuracy of the forecast (see Chapter 12). Thus, a reduction in replenishment lead time helps dampen the bullwhip effect by reducing the underlying uncertainty of demand.

Managers can take a variety of actions at different stages of the supply chain to help reduce replenishment lead times. Ordering electronically, either through e-commerce on the Internet or through older methods such as electronic data interchange (EDI), can significantly cut the lead time associated with order placement and information transfer. At manufacturing plants, increased flexibility and cellular manufacturing can be used to achieve a significant reduction in lead times. A dampening of the bullwhip effect further reduces lead times because of stabilized demand and, as a result, improved scheduling. This is particularly true when manufacturing produces a large variety of products. ASNs can be used to reduce the lead time as well as effort associated with receiving. Cross-docking can be used to reduce the lead time associated with moving the product between stages in the supply chain. Wal-Mart has used many of the aforementioned approaches to significantly reduce lead time within its supply chain.

Reducing Lot Sizes

Managers can dampen the bullwhip effect by implementing operational improvements that reduce lot sizes. A reduction of lot sizes decreases the amount of fluctuation that can accumulate between any pair of stages of a supply chain, thus decreasing the bullwhip effect. To reduce lot sizes, managers must take actions that help reduce the fixed costs associated with ordering, transporting, and receiving each lot (see Chapter 10). Wal-Mart and Seven-Eleven Japan have been very successful at reducing replenishment lot sizes by aggregating deliveries across many products and suppliers.

Computer-assisted ordering (CAO) refers to the substitution through technology of the functions of a retail order clerk in preparing an order through the use of computers that integrate information about product sales, market factors affecting demand, inventory levels, product receipts, and desired service levels. CAO and EDI help reduce the fixed costs associated with placing each order. Today, the growing use of Web-based ordering by companies such as W.W. Grainger and McMaster-Carr has

facilitated ordering in small lots because of reduced ordering costs for customers and reduced fulfillment costs for companies themselves. The growth of B2B e-commerce is also reducing ordering costs. For example, General Motors and Ford will require many of their suppliers to be equipped to receive orders on the Web in an attempt to make ordering more efficient. More discussion of this idea is included in Chapter 16.

In some cases, managers can simplify ordering by eliminating the use of purchase orders. In the auto industry, some suppliers are paid based on the number of cars produced, eliminating the need for individual purchase orders. This eliminates the order processing cost associated with each replenishment order. Information systems also facilitate the settlement of financial transactions, eliminating the cost associated with individual purchase orders.

The large gap in the prices of TL and LTL shipping encourages shipment in TL quantities. In fact, with the efforts to reduce order processing costs, transportation costs are now the major barrier to smaller lots in most supply chains. Managers can reduce lot sizes without increasing transportation costs by filling a truck using smaller lots from a variety of products (see Chapter 10). P&G, for example, requires all orders from retailers to be a full TL. The TL, however, may be built from any combination of products. A retailer can thus order small lots of each product as long as a sufficiently large variety of products is included on each truck. Seven-Eleven Japan has used this strategy with combined trucks, where the separation is by the temperature at which the truck is maintained. All products to be shipped at a particular temperature are on the same truck. This has allowed Seven-Eleven Japan to reduce the number of trucks sent to retail outlets while keeping product variety high. Some firms in the grocery industry use trucks with different compartments, each at a different temperature and carrying a variety of products, to help reduce lot sizes.

Managers can also reduce lot sizes by using milk runs that combine shipments for several retailers on a single truck, as we saw in Chapter 13. In many cases third-party transporters combine shipments to competing retail outlets on a single truck. This reduces the fixed transportation cost per retailer and allows each retailer to order in smaller lots. In Japan, Toyota uses a single truck from a supplier to supply multiple assembly plants, which enables managers to reduce the lot size received by any one plant. Managers can also reduce lot sizes by combining shipments from multiple suppliers on a single truck. In the United States, Toyota uses this approach to reduce the lot size it receives from any one supplier.

As smaller lots are ordered and delivered, both the pressure on and the cost of receiving can grow significantly. Thus, managers must implement technologies that simplify the receiving process and reduce the cost associated with receiving. For example, ASNs identify shipment content, count, and time of delivery electronically and help reduce unloading time and increase cross-dock efficiency. ASNs can be used to update inventory records electronically, thus reducing the cost of receiving. Bar coding of pallets also facilitates receiving and delivery. DEX and NEX are two receiving technologies that allow the direct updating of inventory records once the item count has been verified.

Each of these technologies works to simplify the task of shipping, transporting, and receiving complex orders with small lots of many products. This facilitates the reduction of lot size, counteracting the bullwhip effect.

Another simple way to minimize the impact of batching is to encourage different customers to order in such a way that demand is evenly distributed over time. Frequently, customers that order once a week tend to do so on either a Monday or Friday. Customers that order once a month tend to do so either at the beginning or the end of the month. In such situations it is better to evenly distribute customers ordering once a week across all days of the week, and customers ordering once a month across

all days of the month. In fact, regular ordering days may be scheduled in advance for each customer. This generally does not affect retailers, but it does level out the order stream arriving at the manufacturer, thus dampening the bullwhip effect.

Rationing Based on Past Sales and Sharing Information to Limit Gaming

To diminish the bullwhip effect, managers can design rationing schemes that discourage retailers from artificially inflating their orders in the case of a shortage. One approach, referred to as *turn-and-earn,* is to allocate the available supply based on past retailer sales rather than current retailer orders. Tying allocation to past sales removes any incentive a retailer may have to inflate orders, as a result dampening the bullwhip effect. In fact, during low-demand periods, the turn-and-earn approach pushes retailers to try and sell more to increase the allocation they receive during periods of shortage. Several firms, including General Motors, have historically used the turn-and-earn mechanism to ration available product in case of a shortage. Others, such as HP, have historically allocated based on retailer orders but are now switching to using past sales.

Other firms have tried to share information across the supply chain to minimize shortage situations. Firms such as Sport Obermeyer offer incentives to their large customers to preorder at least a part of their annual order. This information allows Sport Obermeyer to improve the accuracy of its own forecast and allocate production capacity accordingly. Once capacity has been allocated appropriately across different products, it is less likely that shortage situations will arise, thus dampening the bullwhip effect. The availability of flexible capacity can also help in this regard, because flexible capacity can easily be shifted from a product whose demand is lower than expected to one whose demand is higher than expected.

DESIGNING PRICING STRATEGIES TO STABILIZE ORDERS

Managers can diminish the bullwhip effect by devising pricing strategies that encourage retailers to order in smaller lots and reduce forward buying.

Moving from Lot Size–Based to Volume-Based Quantity Discounts

As a result of lot size–based quantity discounts, retailers increase their lot size to take full advantage of the discount. Offering volume-based quantity discounts eliminates the incentive to increase the size of a single lot because volume-based discounts consider the total purchases during a specified period (say, a year) rather than purchases in a single lot (see Chapter 10). Volume-based quantity discounts result in smaller lot sizes, thus reducing order variability in the supply chain. Volume-based discounts with a fixed end date at which discounts will be evaluated may lead to large lots close to the end date. Offering the discounts over a rolling time horizon helps dampen this effect. HP is experimenting with a move away from lot size–based discounts to volume-based discounts.

Stabilizing Pricing

Managers can dampen the bullwhip effect by eliminating promotions and charging an EDLP. The elimination of promotions removes forward buying by retailers and results in orders that match customer demand. P&G, Campbell Soup, and several other manufacturers have implemented EDLP to dampen the bullwhip effect.

Managers can place limits on the quantity that may be purchased during a promotion to decrease forward buying. This limit should be retailer specific and linked to historical sales by the retailer. Another approach is to tie the promotion dollars paid to the retailer to the amount of sell-through rather than the amount purchased by the retailer. As a result, retailers obtain no benefit from forward buying and purchase more only if they can sell more. Promotions based on sell-through significantly dampen the bullwhip

effect. The presence of specific information systems facilitates the tying of promotions directly to customer sales.

BUILDING STRATEGIC PARTNERSHIPS AND TRUST

Managers find it easier to use the levers discussed earlier to diminish the bullwhip effect and achieve coordination if trust and strategic partnerships are built within the supply chain. Sharing of accurate information that is trusted by every stage results in a better matching of supply and demand throughout the supply chain and a lower cost. A better relationship also tends to lower the transaction cost between supply chain stages. For example, a supplier can eliminate its forecasting effort if it trusts orders and forecast information received from the retailer. Similarly, the retailer can lessen the receiving effort by decreasing counting and inspections if it trusts the supplier's quality and delivery. In general, stages in a supply chain can eliminate duplicated effort on the basis of improved trust and a better relationship. This lowering of transaction cost along with accurate shared information helps mitigate the bullwhip effect. Wal-Mart and P&G have been trying to build a strategic partnership that will be mutually beneficial and help reduce the bullwhip effect.

Managerial levers that help a supply chain achieve better coordination fall into two broad categories. *Action-oriented levers* include information sharing, changing of incentives, operational improvements, and stabilization of pricing. *Relationship-oriented levers* involve the building of cooperation and trust within the supply chain. In the next section we discuss relationship-oriented levers in greater detail.

17.5 BUILDING STRATEGIC PARTNERSHIPS AND TRUST WITHIN A SUPPLY CHAIN

A *trust-based relationship* between two stages of a supply chain includes *dependability* of the two stages, and the ability of each stage to make a *leap of faith*.[4] Trust involves a belief that each stage is interested in the others' welfare and will not take actions without considering their impact on the other stages. Cooperation and trust within the supply chain help improve performance for the following reasons.

1. When stages trust each other, they are more likely to take the other party's objectives into consideration when making decisions.
2. Action-oriented managerial levers to achieve coordination become easier to implement. Sharing of information is natural between parties that trust each other. Similarly, operational improvements are easier to implement and appropriate pricing schemes are easier to design if both parties are aiming for the common good.
3. An increase in supply chain productivity results, either by elimination of duplicated effort or by allocating effort to the appropriate stage. For example, a manufacturer receives material from a supplier without inspecting it if the supplier shares process control charts. Another example might be a situation in which a distributor aids the postponement strategy of a manufacturer by performing customization just before the point of sale.
4. A greater sharing of detailed sales and production information results. This sharing allows the supply chain to coordinate production and distribution decisions. As a result, the supply chain is better able to match supply and demand, resulting in better coordination.

[4]See Kumar (1996).

TABLE 17-2 Comparison of Retailers by Level of Trust

Measure of Comparison	*Low Trust*	*High Trust*
Retailers' development of alternative supply sources	100	78
Retailers' commitment to the manufacturer	100	112
Retailers' sales of manufacturer product line	100	178
Retailers' performance as rated by manufacturer	100	111

Source: Adapted from N. Kumar, "The Power of Trust in Manufacturer-Retailer Relationships," *Harvard Business Review* (November–December 1996): 92–106.

The benefits of trust are highlighted in Table 17-2 in the context of a replacement automotive parts supply chain. The table contains average ratings of over 400 retailers classified into low or high categories (and scaled relative to the level of low-trust respondents) based on their trust in the manufacturer. For example, the average retailer with high trust toward its manufacturers developed fewer alternative supply sources, was more committed to the manufacturer, sold more of the manufacturer's products, and was rated higher by the manufacturer. It also highlights that the retailers themselves were likely happier when they had greater trust in the manufacturer because they were less likely to search for alternative supply sources.

Historically, supply chain relationships have been based on either power or trust. In a power-based relationship, the stronger party dictates its view. Although exploiting power may be advantageous in the short term, its negative consequences are felt in the long term for three main reasons:

1. Exploiting power often results in one stage of the supply chain maximizing its profits, often at the expense of other stages. This decreases total supply chain profits.
2. Exploiting power to extract unfair concessions can hurt a company once the balance of power changes. This reversal of power has occurred over the last two decades, with retailers in Europe and the United States becoming more powerful than manufacturers in many supply chains.
3. When a stage of a supply chain systematically exploits its power advantage, the other stages seek ways to resist. In many instances in which retailers have tried to exploit their power, manufacturers have sought ways to access the consumer directly. These include selling over the Internet and setting up company stores. The result can be a decrease in supply chain profits because different stages are competing rather than cooperating.

Although everybody agrees that cooperation and trust in a supply chain are valuable, these qualities are very hard to initiate and sustain. There are two views regarding how cooperation and trust can be built into any supply chain relationship:

- ***Deterrence-based view.*** In this view the parties involved use a variety of formal contracts to ensure cooperation. With the contracts in place, parties are assumed to behave in a trusting manner purely for reasons of self-interest.
- ***Process-based view.*** With this view, trust and cooperation are built over time as a result of a series of interactions between the parties involved. Positive interactions strengthen the belief in the cooperation of the other party.

In most practical situations, neither view holds exclusively. It is impossible to design a contract that will take into account every contingency that may arise in the future. Thus, parties that may not yet trust each other have to rely on the building of trust to resolve issues that are not included in the contract. Conversely, parties that

trust each other and have a long relationship still rely on contracts. In most effective partnerships, a combination of the two approaches is used. An example is the situation in which suppliers sign an initial contract containing contingencies with manufacturers and then the manufacturers never want to refer to the contract again. Their hope is that all contingencies can be resolved through negotiation in a way that is best for the supply chain.

In most strong supply chain relationships, the initial period often relies more on the deterrence-based view. Over time, the relationship evolves toward a greater reliance on the process-based view. From the supply chain perspective, the ideal goal is *co-identification,* in which each party considers the other party's objective as its own. Co-identification ensures that each stage accounts for total supply chain profits when making decisions.

There are two phases to any long-term supply chain relationship. In the *design phase,* ground rules are established and the relationship is initiated. In the *management phase,* interactions based on the ground rules occur and the relationship as well as the ground rules evolve. A manager seeking to build a supply chain relationship must consider how cooperation and trust can be encouraged during both phases of the relationship. Careful consideration is very important, because in most supply chains, power tends to be concentrated in relatively few hands. The concentration of power often leads managers to ignore the effort required to build trust and cooperation, hurting supply chain performance in the long term.

Next we discuss how a manager can design a supply chain relationship to encourage cooperation and trust.

DESIGNING A RELATIONSHIP WITH COOPERATION AND TRUST

The key steps in designing effective supply chain partnerships are as follows:

1. Assessing the value of the relationship
2. Identifying operational roles and decision rights for each party
3. Creating effective contracts
4. Designing effective conflict resolution mechanisms

Assessing the Value of the Relationship

The first step in designing a supply chain relationship is to clearly identify the mutual benefit that the relationship provides. In most supply chains, each member of the partnership brings distinct skills, all of which are needed to supply a customer order. For example, a manufacturer produces the product, a carrier transports it between stages, and a retailer makes the product available to the final customer. The next step is to identify the criteria used for evaluating the relationship as well as the contribution of each party. A common criterion is the increase in total profits as a result of the relationship. *Equity,* defined here as "fair dealing," should be another important criterion when evaluating and designing a relationship.[5] Equity measures the fairness of the division of the total profits among the parties involved.

Stages of the supply chain are unlikely to work at utilizing the various managerial levers that achieve coordination unless they are confident that the resulting increase in profits will be shared equitably. For example, when suppliers work hard to reduce replenishment lead times, the supply chain benefits because of reduced safety inventories at manufacturers and retailers. Suppliers are unlikely to put in the effort if

[5]Ring and Van de Ven (1994).

the manufacturers and retailers are not willing to share the increase in profits with them. Thus, a supply chain relationship is likely to be sustainable only if it increases total profits and this increase is shared equitably among the parties involved.

The next step is to clarify the contribution of each party as well as the benefits that will accrue to each. For example, if a manufacturer and distributor are to implement postponement together, it is important to clarify the role of each party in implementing postponement, the value of this strategy to the supply chain, and how the increased profits are to be shared between the parties. Flexible mechanisms should be designed that allow the partners to monitor the relationship periodically and adjust both contributions and the allocation of resulting benefits. For example, DiamlerChrysler negotiates a certain level of improvement per year with each supplier. It does not, however, specify areas within which the improvement must be achieved. This flexibility allows suppliers to identify areas where the largest improvement can result with the minimum effort and creates a win–win situation for both sides.

Identifying Operational Roles and Decision Rights for Each Party

When identifying operational roles and decision rights for different parties in a supply chain relationship, managers must consider the resulting interdependence between the parties. A source of conflict may arise if the tasks are divided in a way that makes one party more dependent on the other. In many partnerships, an inefficient allocation of tasks results simply because neither party is willing to give the other a perceived upper hand based on the tasks assigned.

The allocation of tasks results in a *sequential interdependence* if the activities of one partner precede the other. Traditionally, supply chain relationships have been sequential, with one stage completing all its tasks and then handing off to the next stage. In *reciprocal interdependence,* parties come together and exchange information and inputs in both directions. P&G and Wal-Mart are attempting to create reciprocal interdependence through collaborative forecasting and replenishment teams. The teams contain people from both Wal-Mart and P&G. Wal-Mart brings in demand information and P&G brings in information on available capacity. The teams then decide on the production and replenishment policy that is best for the supply chain.

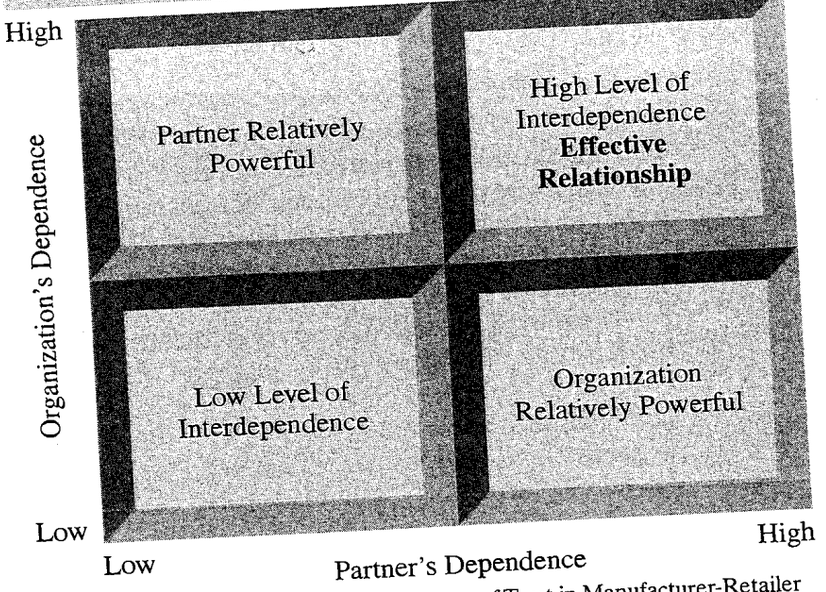
Reciprocal interdependence requires a significant effort to manage and can increase transaction costs if not managed properly. However, reciprocal interdependence is more likely to result in decisions that maximize supply chain profitability because all decisions must take the objectives of both parties into account. Thus, greater reciprocal interdependence in the allocation of operational roles and decision rights increases the chances of an effective relationship, as shown in Figure 17-4.

Managers must ensure that tasks that are required from each party for a successful handoff of the product from one to the other are well defined. Consider the relationship among Dell, Sony, and Airborne. Dell takes orders for computers it assembles and monitors that Sony manufactures. Airborne picks up computers from the Dell warehouse in Texas and monitors from the Sony warehouse in Mexico. It then merges the two and sends a combined order to the customer. For an order to be filled on time, all three parties must coordinate and complete their tasks. To achieve cooperation, managers must also put in place some mechanism, such as appropriate information systems, that helps accurately track all failures to their source.

Creating Effective Contracts

Managers can help promote trust by creating contracts that encourage negotiation as unplanned contingencies arise. Contracts are most effective for governance when *complete information* is available and all future contingencies can be accounted for. In

FIGURE 17-4 Effect of Interdependence on Supply Chain Relationships



Source: Adapted from N. Kumar, "The Power of Trust in Manufacturer-Retailer Relationships," *Harvard Business Review* (November–December 1996): 92–106.

practice, uncertainty with respect to the future makes it impossible to design a contract with all contingencies included. Thus, it is essential that the supplier and the retailer develop a relationship that allows trust to compensate for gaps in the contract.

The relationship often develops initially between individuals that have been assigned from each side. Over time, the informal understandings and commitments between the individuals tend to be formalized when new contracts are drawn up. When designing the partnership and initial contract, it should be understood that informal understandings will operate side by side and these will contribute to the development of the formal contract over time. Thus, contracts that evolve over time are likely to be much more effective than contracts that are completely defined at the beginning of the partnership.

Over the long term, contracts can only play a partial role in maintaining effective partnerships in a supply chain. A good example is the relationship between Caterpillar and its dealerships, in which either the dealer or Caterpillar can terminate agreements without cause with 90 days' notice. Clearly it is not the contract alone that keeps the relationship effective. A combination of a contract, the mutual benefit of the relationship, along with trust that compensates for gaps in the contract, results in effective supply chain partnerships.

Designing Effective Conflict-Resolution Mechanisms

Effective conflict-resolution mechanisms can significantly strengthen any supply chain relationship. Conflicts are bound to arise in any relationship. Unsatisfactory resolutions cause the partnership to worsen, whereas satisfactory resolutions strengthen the partnership. A good conflict-resolution mechanism should give the parties an opportunity to communicate and work through their differences, in the process building greater trust.

An initial formal specification of rules and guidelines for financial procedures and technological transactions can help build trust between partners. The specification of

rules and guidelines facilitates the sharing of information among the partners in the supply chain. The sharing of information over time helps move the relationship from deterrence-based trust to process-based trust. Once process-based trust is built between the parties, it facilitates conflict resolution.

To facilitate communication, frequent meetings should be held between managers and staff assigned to the partnership. These meetings allow issues to be raised and discussed before they turn into major conflicts. They also provide a basis for resolution at a higher level, should resolution not take place at the lower level. An important goal of meetings and other formal conflict-resolution mechanisms is to ensure that disputes about financial or technological issues do not turn into interpersonal squabbles.

When designing conflict-resolution mechanisms, it is important to be sensitive to the context of the partnership. In the United States, parties are sometimes comfortable returning to the detailed contract to resolve a dispute. The help of a court or an intermediary can also be sought to interpret the contract. Thus, detailed contracts can be quite effective in the United States. In Asia, in contrast, conflict-resolution mechanisms involving courts are unlikely to be very effective. Parties are much more comfortable negotiating resolutions to every conflict directly. Flexible contracts that allow for such negotiation are effective in building trust in that context.

MANAGING SUPPLY CHAIN RELATIONSHIPS FOR COOPERATION AND TRUST

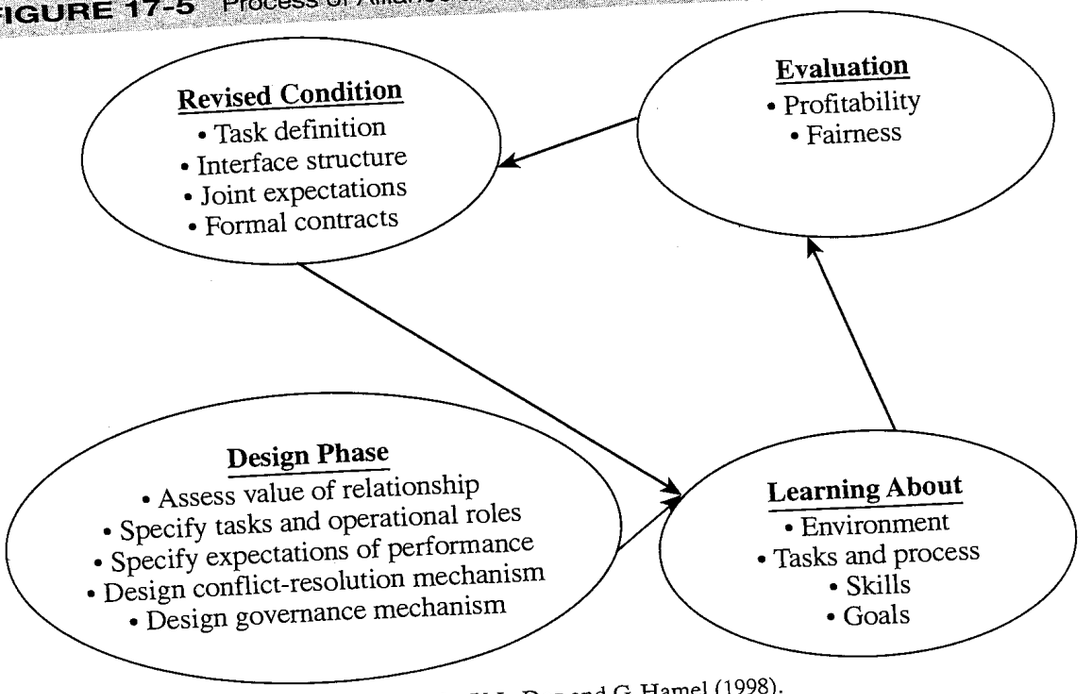
Effectively managed supply chain relationships foster cooperation and trust, thus increasing supply chain coordination. In contrast, poorly managed relationships lead to each party being opportunistic, resulting in a loss of total supply chain profits. The management of a relationship is often seen as a tedious and routine task. Top management, in particular, is often very involved in the design of a new partnership but rarely involved in its management. This has led to a mixed record in running successful supply chain alliances and partnerships.

Figure 17-5 shows the basic process by which any supply chain partnership or alliance evolves. Once the partnership has been designed and established, both partners learn about the environment in which the partnership will operate, the tasks and processes to be performed by each partner, the skills required and available on each side, and the emerging goals of each side. The performance of each side is evaluated based on the improvement in profitability and on equity or fairness. At this stage, a better evaluation of the value of the partnership becomes available, which provides both parties in the supply chain partnership an opportunity to revise the conditions of the partnership to improve profitability and fairness. It is important that the initial contracts be designed with sufficient flexibility to facilitate such alterations. Formal contracts may be restructured to reflect the changes. As the business environment and company goals change, the cycle repeats itself and the relationship evolves. Any successful supply chain partnership will go through many such cycles.

A supply chain partnership falters if the perceived benefit from the relationship diminishes or one party is seen as being opportunistic. Problems arise when communication between the two parties is weak and the mutual benefit of the relationship is not reiterated regularly. When managing a supply chain relationship, managers should focus on the following factors to improve the chances of success of a supply chain partnership:

1. The presence of flexibility, trust, and commitment in both parties helps a supply chain relationship succeed. In particular, commitment of top management on both sides is crucial for success.

FIGURE 17-5 Process of Alliance and Partnership Evolution



Source: Adapted from *Alliance Advantage* by Y. L. Doz and G. Hamel (1998).

2. Good organizational arrangements, especially for information sharing and conflict resolution, improve chances of success. Lack of information sharing and the inability to resolve conflicts are the two major factors that lead to the breakdown of supply chain partnerships.
3. Mechanisms that make the actions of each party and resulting outcomes visible help avoid conflicts and resolve disputes. Such mechanisms make it harder for either party to be opportunistic and help identify defective processes, increasing the value of the relationship for both parties.
4. The more fairly the stronger partner treats the weaker, vulnerable partner, the stronger the supply chain relationship tends to be.

The issue of fairness is extremely important in the supply chain context because most relationships involve parties with unequal power. Unanticipated situations that hurt one party more than the other often arise. The more powerful party often has greater control over how the resolution occurs. The fairness of the resolution influences the strength of the relationship in the future.

The relationship between Marks & Spencer and a manufacturer of a kitchen product provides an excellent example of a fair sharing of benefits.[6] A few months after the product's introduction, the manufacturer realized that costs had been miscalculated and exceeded the price at which the product was being sold to Marks & Spencer. Meanwhile, given its low retail price, customers found the product an outstanding value and made it a big hit. When the manufacturer brought the problem to the attention of Marks & Spencer, its managers helped the manufacturer reengineer both the product and the process to lower cost. Marks & Spencer also lowered its margin to provide a sufficient profit for the manufacturer. The outcome was one in which the

[6]Kumar (1996).

relationship was strengthened between the two partners because Marks & Spencer's fairness allowed a resolution that recognized the manufacturer's needs. In the long run, both partners benefited and a higher level of trust developed.

Procedures and policies govern the interaction between parties in a supply chain relationship. It is thus important that the weaker party perceive the fairness of the stronger party's procedures and policies for dealing with its partners. The stronger party is in control of its policies and procedures and should not bias the policies in a way that is opportunistic and does not benefit the entire supply chain. Fair procedures should encourage two-way communication between the partners. The procedures should be impartial and should allow the weaker party an opportunity to appeal the stronger party's decisions. Finally, the stronger party should be willing to explain all its decisions.

17.6 CONTINUOUS REPLENISHMENT AND VENDOR-MANAGED INVENTORIES

The bullwhip effect can be dampened by practices that assign replenishment responsibility across the supply chain to a single entity. A single point of replenishment decisions ensures visibility and a common forecast that drives orders across the supply chain. Two common industry practices that assign a single point of responsibility are continuous replenishment programs and vendor-managed inventories.

In *continuous replenishment programs* (CRP), the wholesaler or manufacturer replenishes a retailer regularly based on POS data. CRP may be supplier, distributor, or third-party managed. In most instances CRP systems are driven by actual withdrawals of inventory from retailer warehouses rather than POS data at the retailer level. Tying CRP systems to warehouse withdrawals is easier to implement and retailers are often more comfortable sharing data at this level. IT systems that are linked across the supply chain provide a good information infrastructure on which a continuous replenishment program may be based. In CRP, inventory at the retailer is owned by the retailer.

With vendor-managed inventory (VMI), the manufacturer or supplier is responsible for all decisions regarding product inventories at the retailer. As a result, the control of the replenishment decision moves to the manufacturer instead of the retailer. In many instances of VMI, the inventory is owned by the supplier until it is sold by the retailer. VMI requires the retailer to share demand information with the manufacturer to allow it to make inventory replenishment decisions. VMI can allow a manufacturer to increase its profits as well as profits for the entire supply chain if both retailer and manufacturer margins are considered when making inventory decisions. VMI also helps by conveying customer demand data to the manufacturer, which can then plan production accordingly. This helps improve manufacturer forecasts and better match manufacturer production with customer demand.

VMI has been implemented with significant success by, among others, K-Mart (with about 50 suppliers) and Fred Meyer. K-Mart has seen inventory turns on seasonal items increase from 3 to between 9 and 11, and for nonseasonal items from 12–15 to 17–20. Fred Meyer has seen inventories drop by 30 to 40 percent while fill rates have increased to 98 percent. Other firms with successful implementations include Campbell Soup, Frito-Lay, and Proctor & Gamble.

One drawback of VMI arises because retailers often sell products from competing manufacturers that are substitutes in the customer's mind. For example, a customer may substitute detergent manufactured by Proctor & Gamble with detergent manufactured

by Lever Brothers. If the retailer has a VMI agreement with both manufacturers, each manufacturer will ignore the impact of substitution when making their inventory decisions. As a result, inventories at the retailer will be higher than optimal. In such a setting, the retailer may be better positioned to decide on the replenishment policy. Another possibility is for the retailer to define a category leader from among the supplier and have the category leader manage replenishment decisions for all suppliers in the category. Wal-Mart follows such a practice and assigns a category leader for most of its products. For example, HP was its category leader for printers and managed all printer replenishment.

17.7 COLLABORATIVE PLANNING, FORECASTING, AND REPLENISHMENT (CPFR)

The Voluntary Interindustry Commerce Standards Association (VICS) has defined CPFR as "a business practice that combines the intelligence of multiple partners in the planning and fulfillment of customer demand." According to VICS, since 1998, "over 300 companies have implemented the process." In this section we describe CPFR and some successful implementations. It is important to understand that successful CPFR can only be built on a foundation in which the two parties have synchronized their data and established standards for exchanging information. Much of the material in this section is an adaptation of material from the VICS Web site, www.vics.org/committees/cpfr.

Sellers and buyers in a supply chain may collaborate along any or all of the following four supply chain activities.

1. ***Strategy and planning.*** The partners determine the scope of the collaboration and assign roles, responsibilities, and clear checkpoints. In a joint business plan they then identify significant events such as promotions, new product introductions, store openings/closings, and changes in inventory policy that affect demand and supply.
2. ***Demand and supply management.*** A collaborative sales forecast projects the partners' best estimate of consumer demand at the point of sale. This is then converted to a collaborative order plan that determines future orders and delivery requirements based on sales forecasts, inventory positions, and replenishment lead times.
3. ***Execution.*** As forecasts become firm, they are converted to actual orders. The fulfillment of these orders then involves production, shipping, receiving, and stocking of products.
4. ***Analysis.*** The key analysis tasks focus on identifying exceptions and evaluating metrics that are used to assess performance or identify trends.

A fundamental aspect of successful collaboration is the identification and resolution of exceptions. Exceptions refer to a gap between forecasts made by the two sides or some other performance metric that is falling or is likely to fall outside acceptable bounds. These metrics may include inventories that exceed targets or product availability that falls below targets. For successful CPFR, it is very important to have a process in place that allows the two parties to resolve exceptions. Detailed processes for identifying and resolving exceptions are discussed in the VICS CPFR Voluntary Guidelines V 2.0 (2002).

One successful CPFR implementation has involved Henkel, a German detergent manufacturer, and Eroski, a Spanish food retailer. Prior to CPFR, Eroski saw frequent stockouts of Henkel products, especially during promotions. At the inception of CPFR

TABLE 17-3 Four Common CPFR Scenarios

CPFR Scenario	*Where Applied in Supply Chain*	*Industries Where Applied*
Retail event collaboration	Highly promoted channels or categories	All industries other than those that practice EDLP
DC replenishment collaboration	Retail DC or distributor DC	Drugstores, hardware, grocery
Store replenishment collaboration	Direct store delivery or retail DC-to-store delivery	Mass merchants, club stores
Collaborative assortment planning	Apparel and seasonal goods	Department stores, specialty retail

in December 1999, 70 percent of the sales forecasts had an average error of over 50 percent and only 5 percent of the forecasts had errors under 20 percent. Within four months of the CPFR implementation, however, 70 percent of the sales forecasts had errors under 20 percent and only 5 percent had errors over 50 percent. CPFR resulted in a customer service level of 98 percent and an average inventory of only five days. This was accomplished despite 15 to 20 products being promoted every month. Another successful implementation involved Johnson & Johnson and Superdrug, a chain in the United Kingdom. Over the three-month trial period beginning April 2000, Superdrug saw inventory levels at its DCs drop by 13 percent, while product availability at its DCs increased by 1.6 percent. As reported by Steerman (2003), Sears and Michelin also saw significant benefits from their CPFR initiative in 2001. In-stock levels at Sears improved by 4.3 percent, DCs-to-stores fill rate improved by 10.7 percent, and overall inventory levels fell by 25 percent.

VICS has identified the four scenarios in Table 17-3 as the most common areas where large-scale CPFR deployments have taken place between a retailer and a manufacturer.

Next, we describe each of the four scenarios.

RETAIL EVENT COLLABORATION

In many retail environments, such as supermarkets, promotions and other retail events have a significant impact on demand. Stockouts, excess inventory, and unplanned logistics costs during these events affect financial performance for both the retailer and the manufacturer. In such a setting, collaboration between retailers and suppliers to plan, forecast, and replenish promotions is very effective.

Retail event collaboration requires the two parties to identify brands and specific SKUs that are included in the collaboration. Details of the event such as timing, duration, price point, advertising, and display tactics are shared. It is important for the retailer to update this information as changes occur. Event-specific forecasts are then created and shared. These forecasts are then converted to planned orders and deliveries. As the event unfolds, sales are monitored to identify any changes or exceptions, which are resolved through an iterative process between the two parties.

P&G has implemented some form of retail event collaboration with a variety of partners including Wal-Mart.

DC REPLENISHMENT COLLABORATION

DC replenishment collaboration is perhaps the most common form of collaboration observed in practice and also the simplest to implement. In this scenario the two trading partners collaborate on forecasting DC withdrawals or anticipated demand from the

DC to the manufacturer. These forecasts are converted to a stream of orders from the DC to the manufacturer that are committed or locked over a specified time horizon. This information allows the manufacturer to build anticipated orders into future production plans and build the committed orders on demand. The result is a reduction in production cost at the manufacturer and a reduction of inventory and stockouts at the retailer.

DC replenishment collaboration is relatively easy to implement because it requires collaboration on an aggregate forecast and does not require sharing of detailed point-of-sale data. As a result, it is often the best scenario with which to start collaboration. Over time, this form of collaboration can be extended to include all storage points in the supply chain from retail shelves to raw material warehouses. According to Hammond (1994), Barilla implemented this form of collaboration with its distributors.

STORE REPLENISHMENT COLLABORATION

In store replenishment collaboration, trading partners collaborate on store-level point-of-sale forecasts. These forecasts are then converted to a series of store-level orders, with orders committed over a specified time horizon. This form of collaboration is much harder to implement than a DC-level collaboration, especially if stores are small. Store replenishment collaboration is easier for large stores such as Costco and Home Depot. The benefits of store-level collaboration include greater visibility of sales for the manufacturer, improved replenishment accuracy, improved product availability, and reduced inventories. This form of collaboration is very beneficial for new products and promotions. Manufacturers and their suppliers can use this information to improve operational execution.

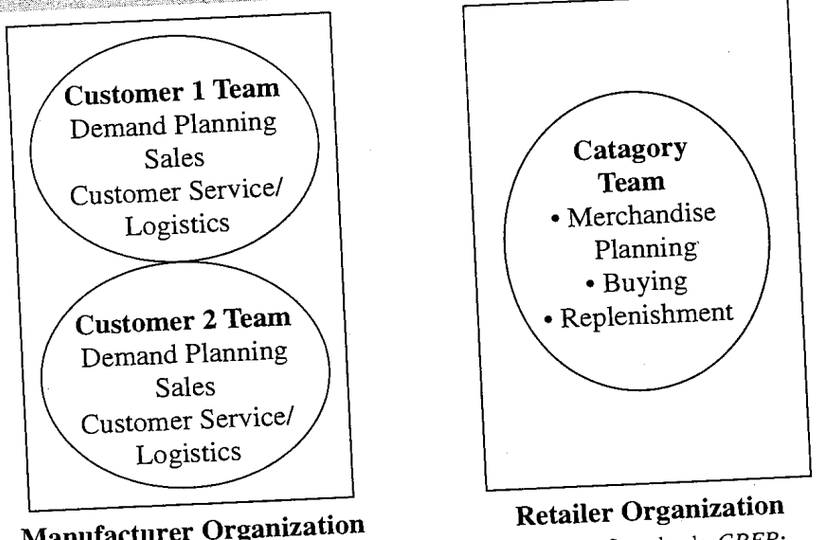
COLLABORATIVE ASSORTMENT PLANNING

Fashion apparel and other seasonal goods follow a seasonal pattern of demand. Thus, collaborative planning in these categories has a horizon of a single season and is performed at seasonal intervals. Given the seasonal nature, forecasts rely less on historical data and more on collaborative interpretation of industry trends, macroeconomic factors, and customer tastes. In this form of collaboration, the trading partners develop an assortment plan jointly. The output is a planned purchase order at the style/color/size level. The planned order is shared electronically in advance of a show, where sample products are viewed and final merchandising decisions are made. The planned orders help the manufacturer purchase long-lead-time raw materials and plan capacity. This form of collaboration is most useful if capacity is flexible enough to accommodate a variety of product mix and raw materials have some commonality across end products.

ORGANIZATIONAL AND TECHNOLOGY REQUIREMENTS FOR SUCCESSFUL CPFR

A successful CPFR implementation requires changes in the organizational structure and, to be scalable, requires the implementation of appropriate technology. Effective collaboration requires manufacturers to set up cross-functional, customer-specific teams that include sales, demand planning, and logistics, at least for large customers. Such a focus has become feasible with the consolidation in retailing. For smaller customers such teams can be focused by geography or sales channel. Retailers should also attempt to organize merchandise planning, buying, and replenishment into teams around suppliers. This can be difficult given the large number of suppliers that consolidated retailers have. They can

FIGURE 17-6 Collaborative Organizational Structure



Source: Adapted from Voluntary Interindustry Commerce Standards, *CPFR: An Overview*, 2004.

then organize the teams by categories that include multiple suppliers. For retailers that have multiple levels of inventory such as DCs and retail stores, it is important to combine the replenishment teams at the two levels. Without collaborative inventory management at the two levels, duplication of inventories is common. The proposed organizational structure is illustrated in Figure 17-6.

The CPFR process is not dependent on technology but requires technology to be scalable. CPFR technologies have been developed to facilitate sharing of forecasts and historical information, evaluating exception conditions, and enabling revisions. These solutions must be integrated with enterprise systems that record all supply chain transactions.

RISKS AND HURDLES FOR A CPFR IMPLEMENTATION

It is important to realize that there are risks and hurdles for a successful CPFR implementation. Given the large-scale sharing of information, there is a risk of information misuse. Often one or both of the CPFR partners has relationships with the partner's competitors. Another risk is that if one of the partners changes its scale or technology, the other partner is forced to follow suit or lose the collaborative relationship. Finally, the implementation of CPFR and the resolution of exceptions require close interactions between two entities whose cultures may be very different. The inability to foster a collaborative culture across the partner organizations can be a major hurdle for the success of CPFR. One of the biggest hurdles to success is often that partners attempt something like store-level collaboration, which requires a higher organizational and technology investment. It is often best to start with something like event- or DC-level collaboration, which is more focused and easier to collaborate on. One of the biggest hurdles for successful CPFR, however, is that demand information shared with partners is often not used within the organization in an integrated manner. It is important to have integrated demand, supply, logistics, and corporate planning within the organization to maximize the benefits of a CPFR effort with a partner.

17.8 THE ROLE OF IT IN COORDINATION

The enablement of coordination can be viewed as the ultimate goal of IT in the supply chain. Much of what we have discussed in the various IT sections so far has elements of coordination—sharing forecasts, visibility of inventory levels, transmitting arrival times—but much of what we have talked about has been internal supply chain operations. In this chapter we are truly focusing on improving interenterprise operations. At the highest level, there are two ways in which IT can help to improve this area.

The first is information availability. Significant benefit from interenterprise coordination arises just from the sharing of information between companies. IT enables this in two ways. The first is the actual physical sharing of this information. Through applications that enable data to be viewed on the Internet to the integration of companies systems, IT provides the "plumbing" to make the actual sharing of information happen. IT also helps in sorting these data and preparing them for viewing. The amount of data available is overwhelming and so just making the data visible to everyone is not necessarily helpful. IT structures the data and allows users to pull the figurative needle out of the haystack of data through intelligent organization and searches.

The second way that IT helps improve coordination is to use the visible information to make decisions. IT enables the use of supply chain information to make many of the inventory, production, transportation, sourcing, and pricing decisions.

There are perhaps more pitfalls in using IT for coordination than in any other area. This is primarily because of the complexity and difficulty of the task at hand. Certainly the technical challenges are significant. One example is the integration of disparate systems so that the information we discussed above is available to multiple enterprises. Another problem is that different companies often have very different operating processes. For coordination to be effective, these processes must somehow interact in a way that makes sense. Overcoming this problem within a company is difficult, and it is even more so when more than one company is involved. However, the biggest hurdle to making these IT systems work is the trust factor that we have discussed at length in this chapter. Companies that do not have a degree of trust in their interactions are very unlikely to get much in the way of benefit from investing in coordination software, regardless of how good the technology is.

The major companies that provide software in this area are the supply chain software providers from the ERP ranks such as SAP and Oracle and the best-of-players such as i2 Technologies and Manugistics. This area is in some sense the youngest of all the software areas we have discussed. Few companies do this well, and most don't do it at all, so there may be the potential for new software companies to make headway in offering products in this area. However, it is likely that the ERP players will firmly occupy this space as it becomes more mature.

17.9 ACHIEVING COORDINATION IN PRACTICE

1. ***Quantify the bullwhip effect.*** Companies often have no idea that the bullwhip effect plays a significant role in their supply chain. Managers should start by comparing the variability in the orders they receive from their customers with the variability in orders they place with their suppliers. This helps a firm quantify its own contribution to the bullwhip effect. Once its contribution is visible, it becomes easier for a firm to accept the fact that all stages in the supply chain contribute to the bullwhip effect, leading to a significant loss in profits. In the absence of this concrete information, companies try to

react better to the variability rather than eliminate the variability itself. This leads companies to invest significant amounts in inventory management and scheduling systems, only to see little improvement in performance or profits. Evidence of the size of the bullwhip effect is very effective in getting different stages of the supply chain to focus on efforts to achieve coordination and eliminate the variability created within the supply chain.

2. ***Get top management commitment for coordination.*** More than any other aspect of supply chain management, coordination can succeed only with top management's commitment. Coordination requires managers at all stages of the supply chain to subordinate their local interests to the greater interest of the firm and even the supply chain. Coordination often requires the resolution of trade-offs in a way that requires many functions in the supply chain to change their traditional practices. These changes often run counter to approaches that were put in place when each function focused only on its local objective. Such changes within a supply chain cannot be implemented without strong top management commitment. Top management commitment was a key factor in helping Wal-Mart and P&G set up collaborative forecasting and replenishment teams.

3. ***Devote resources to coordination.*** Coordination cannot be achieved without all parties involved devoting significant managerial resources to this effort. Companies often do not devote resources to coordination because they either assume that lack of coordination is something they have to live with or they hope that coordination will occur on its own. The problem with this approach is that it leaves all managers involved with only the separate areas that they control, while no one is responsible for highlighting the impact one manager's actions have on other parts of the supply chain. One of the best ways to solve coordination problems is through teams made up of members from different companies throughout the supply chain. These teams should be made responsible for coordination and given the power to implement the changes required. Setting up a coordination team is fruitless unless the team has the power to act, because the team will run into conflict with functional managers who are currently maximizing local objectives. Coordination teams can be effective only once a sufficient level of trust builds between members from different firms. If they are used properly, coordination teams can provide significant benefit, as has happened with the collaborative forecasting and replenishment teams set up by Wal-Mart and P&G.

4. ***Focus on communication with other stages.*** Good communication with other stages of a supply chain often creates situations that highlight the value of coordination for both sides. Companies often do not communicate with other stages of the supply chain and are unwilling to share information. However, often all companies in the supply chain are frustrated by the lack of coordination and would be happy to share information if it helped the supply chain operate in a more effective manner. Regular communication among the parties involved facilitates change in such a setting. For instance, a major PC company had been ordering its microprocessors in batches of several weeks of production. It was trying to move to a build-to-order environment in which it would place microprocessor orders on a daily basis. The PC company assumed that the microprocessor supplier would be reluctant to go along with this approach. However, once communication was opened up with the supplier, the opposite turned out to be true. The supplier also wanted to reduce lot sizes and increase the frequency of orders. It had just assumed that the PC manufacturer wanted large lots and thus never requested a change. Regular communication helps different stages of the supply chain share their goals and identify common goals and mutually beneficial actions that improve coordination.

5. ***Try to achieve coordination in the entire supply chain network.*** The full benefit of coordination is achieved only when the entire supply chain network is coordinated. It

is not enough for two stages in a supply chain to coordinate. The most powerful party in a supply chain should make an effort to achieve coordination in the entire network. Toyota has been very effective in achieving knowledge sharing and coordination in its entire network.

6. ***Use technology to improve connectivity in the supply chain.*** The Internet and a variety of different types of software systems can be used to increase the visibility of information throughout the supply chain. Until now, most IT implementations have achieved visibility of information only within a firm. Visibility across the supply chain still requires additional effort in most cases. From the discussion in this chapter, it should be clear that the major benefits of IT systems can be realized only if the systems help increase visibility across the supply chain and facilitate coordination. If firms are to realize the full benefit of the huge investments they make in current IT systems, particularly ERP systems, it is crucial that they make the extra effort required to use these systems to facilitate collaborative forecasting and planning across the supply chain. The Internet should be used to share information and increase connectivity in the supply chain. The growth of Internet exchanges can be very effective in this regard.

7. ***Share the benefits of coordination equitably.*** The greatest hurdle to coordination in the supply chain is the feeling on the part of any stage that the benefits of coordination are not being shared equitably. Managers from the stronger party in the supply chain relationship must be sensitive to this fact and ensure that all parties perceive that the way benefits are shared is fair.

17.10 SUMMARY OF LEARNING OBJECTIVES

1. Describe supply chain coordination and the bullwhip effect and their impact on supply chain performance.

   Supply chain coordination requires all stages to take actions that maximize total supply chain profits. A lack of coordination results if different stages focus on optimizing their local objectives or if information is distorted as it moves across the supply chain. The phenomenon that fluctuation in orders increases as one moves up the supply chain from retailers to wholesalers to manufacturers to suppliers is referred to as the bullwhip effect. The bullwhip effect results in an increase in all costs in the supply chain and a decrease in customer service levels. The bullwhip effect moves all parties in the supply chain away from the efficient frontier and results in a decrease of both customer satisfaction and profitability within the supply chain.

2. Identify causes of the bullwhip effect and obstacles to coordination in a supply chain.

   A key obstacle to coordination in the supply chain is misaligned incentives that result in different stages optimizing local objectives instead of total supply chain profits. Other obstacles include lack of information sharing, operational inefficiencies leading to large replenishment lead times and large lots, sales force incentives that encourage forward buying, rationing schemes that encourage inflation of orders, promotions that encourage forward buying, and a lack of trust that makes any effort toward coordination difficult.

3. Discuss managerial levers that help achieve coordination in a supply chain.

   Managers can help achieve coordination in the supply chain by aligning goals and incentives across different functions and stages of the supply chain. Other actions that managers can take to achieve coordination include sharing of sales information and collaborative forecasting and planning, implementation of single-point control of replenishment, improving operations to reduce lead times and lot sizes, EDLP and other strategies that limit forward buying, and the building of trust and strategic partnerships within the supply chain.

4. Describe actions that facilitate the building of strategic partnerships and trust within a supply chain.

   A manager can help build trust and strategic partnerships by designing a relationship in which the mutual benefit to both sides is clear, both parties are mutually interdependent, contracts are allowed to evolve over time, and conflicts are resolved effectively. When managing the relationship, flexibility, information sharing, visibility of effort and performance of each party, and fairness from the stronger party when distributing costs and benefits help foster trust and facilitate coordination in the supply chain.

5. Understand the different forms of CPFR possible in a supply chain.

   Partners may set CPFR relationships to collaborate on store events, DC replenishment, store replenishment, or assortment planning. DC replenishment collaboration is often the easiest to implement because it requires aggregate-level data. Store replenishment collaboration requires a higher level of investment in technology and data sharing to be successful.

Discussion Questions

1. What is the bullwhip effect and how does it relate to lack of coordination in a supply chain?
2. What is the impact of lack of coordination on the performance of a supply chain?
3. In what way can improper incentives lead to a lack of coordination in a supply chain? What countermeasures can be used to offset this effect?
4. What problems result if each stage of a supply chain views its demand as the orders placed by the downstream stage? How should firms within a supply chain communicate to facilitate coordination?
5. What factors lead to a batching of orders within a supply chain? How does this affect coordination? What actions can minimize large batches and improve coordination?
6. How do trade promotions and price fluctuations affect coordination in a supply chain? What pricing and promotion policies can facilitate coordination?
7. How is the building of strategic partnerships and trust valuable within a supply chain?
8. What issues must be considered when designing a supply chain relationship to improve the chances of developing cooperation and trust?
9. What issues must be considered when managing a supply chain relationship to improve the chances of developing cooperation and trust?
10. What are the different CPFR scenarios and how do they benefit supply chain partners?

Bibliography

Bowersox, Donald J., David J. Closs, and Theodore P. Stank. "21st Century Logistics: Making Supply Chain Integration a Reality." *Supply Chain Management Review* (Fall 1999): 44–9.

Brunell, Tom. "Managing a Multicompany Supply Chain." *Supply Chain Management Review* (Spring 1999): 45–52.

Child, John, and David Faulkner. *Strategies of Cooperation.* Oxford, England: Oxford University Press, 1998.

Crum, Colleen, and George E. Palmatier. "Demand Collaboration: What's Holding Us Back?" *Supply Chain Management Review* (January–February 2004): 54–61.

Doz, Yves L. "The Evolution of Cooperation in Strategic Alliances: Initial Conditions or Learning Process?" *Strategic Management Journal* 17 (1997): 55–83.

Doz, Yves L., and Gary Hamel. *Alliance Advantage.* Boston: Harvard Business School Press, 1998.

Dyer, Jeffrey H., and Kentaro Nobeoka. "Creating and Managing a High-Performance Knowledge-Sharing Network: The Toyota Case." *Strategic Management Journal* 21 (March 2000): 345–67.

Gulati, Ranjay, and Harbir Singh. "The Architecture of Cooperation: Managing Coordination Costs and Appropriation Concerns in Strategic Alliances." *Administrative Science Quarterly* 43 (1998): 781–814.

Hammond, Janice H. 1994. *Barilla Spa (A–D)*. Harvard Business School Case 9–694–046.

Continuous Replenishment: An ECR Best Practices Report. Washington, D. C.: Grocery Manufacturer's Association, 1994.

Computer Assisted Ordering: Practices and Benefits Report. Washington, D. C.: Grocery Manufacturer's Association, 1994.

Kumar, Nirmalya. "The Power of Trust in Manufacturer–Retailer Relationships." *Harvard Business Review* (November–December 1996): 92–106.

Lee, Hau L., V. Padmanabhan, and Seungjin Whang. "The Bullwhip Effect in Supply Chains," *Sloan Management Review* (Spring 1997): 93–102.

Mariotti, John L. "The Trust Factor in Supply Chain Management." *Supply Chain Management Review* (Spring 1999): 70–7.

Ring, P. S., and A. H. Van de Ven. "Developmental Processes of Cooperative Interorganizational Relationships." *Academy of Management Review* 19 (1994): 90–118.

Sabath, Robert E., and John Fontanella. "The Unfulfilled Promise of Supply Chain Collaboration." *Supply Chain Management Review* (July–August 2002): 24–9.

Senge, Peter M. *The Fifth Discipline*. New York: Currency and Doubleday, 1990.

Smeltzer, Larry R. "Integration Means Everybody—Big and Small." *Supply Chain Management Review* (September–October 2001): 36–44.

Steerman, Hank. "A Practical Look at CPFR: The Sears-Michelin Experience." *Supply Chain Management Review* (July–August 2003): 46–53.

Voluntary Interindustry Commerce Standards. *CPFR: An Overview*, 2004.

Voluntary Interindustry Commerce Standards. *Collaborative Planning, Forecasting, and Replenishment*, Version 2.0, 2002.