Coordination and technology in the Supply Chain

16.1 Lack of Supply Chain Coordination and the Bullwhip Effect
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16.8 Learning Objectives

After reading this chapter, you will be able to
1. Describe supply chain coordination and the bullwhip effect and their impact on performance.
2. Identify causes of the bullwhip effect and obstacles to coordination in the supply chain.
3. Discuss managerial levers that help achieve coordination in the supply chain.
4. Describe actions that facilitate the building of strategic partnerships and trust within the 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 the supply chain.

16.1 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 gets delayed and distorted. Different stages of a supply chain may have objectives that conflict if each stage has 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 potentially hundreds, or even thousands, of independently owned enterprises. 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 within 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 many options for each model. The increased variety makes it difficult for Ford to coordinate information exchange with thousands of
suppliers and dealers. The fundamental challenge today is for supply chains to achieve coordination in spite of multiple ownership and increased product variety.

Many firms have observed the bull-whip 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 16.1. The bullwhip effect distorts demand information within the supply chain, with different stages having a very different estimate of what demand looks like. The result is a loss of supply chain coordination.

Procter & Gamble (P&G) has observed the bullwhip effect in the supply chain for Pampers diapers. The company found that raw material orders from P&G to its suppliers fluctuated significantly over time. Further 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.

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. 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.

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

**16.2 EFFECT OF LACK OF COORDINATION ON PERFORMANCE**

Lack of coordination results if each stage of the supply chain only optimizes 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. As an example, consider the bullwhip effect P&G observed within 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 try to 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.

**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 within the supply chain from both P&G and its suppliers.

Transportation Cost
The bullwhip effect increases transportation cost within 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 will occur 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 stock outs within 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 negatively impacts performance at every stage and thus hurts the relationships between different stages of the supply chain. There is the 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 16.1.
**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.

**TABLE 16.1 Impact of Bullwhip Effect on Supply Chain Performance**

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Impact of Bullwhip Effect</th>
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<tbody>
<tr>
<td>Manufacturing cost</td>
<td>Increases</td>
</tr>
<tr>
<td>Inventory cost</td>
<td>Increases</td>
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<tr>
<td>Replenishment lead time</td>
<td>Increases</td>
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<tr>
<td>Transportation cost</td>
<td>Increases</td>
</tr>
<tr>
<td>Shipping and receiving cost</td>
<td>Increases</td>
</tr>
<tr>
<td>Level of product availability</td>
<td>Decreases</td>
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<tr>
<td>Profitability</td>
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### 16.3 OBSTACLES TO COORDINATION IN THE 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 that 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 refer to situations where 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 a transportation manager at a firm has her compensation linked to the average transportation cost per unit, she 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 the 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 towards 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 refer to situations where 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 to be 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 the retailer. The retailer may interpret part of this random increase to be 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
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, they 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 has finished their 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 refer to actions taken in the course of placing and filling orders that 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 16.2 shows both the demand and the order stream for a firm placing 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 will face an order stream that is much more variable than the demand the retailers experience. If the manufacturer further batches their orders to suppliers, the effect is further magnified. In many instances there are certain focal point periods like 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 where a retailer has misinterpreted a random increase in demand as a growth trend. If the retailer faces a lead time of two weeks, they will incorporate the anticipated growth over two weeks when placing the order. In contrast, if the retailer faces a lead time of two months, they will incorporate into their 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. A situation where a high-demand product is in short supply often arises within the supply chain. HP, for example, has faced many situations where 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 their 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 will order 100 units in the hope that 75 will then be made available. The net impact of this rationing scheme is to artificially inflate orders for the product. In addition, a retailer ordering based on what they expect to sell will get less and as a result lose sales, whereas a retailer inflating its order is rewarded.

If the manufacturer is using orders to forecast future demand, they 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 where 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 refer to situations in which the pricing policies for a product lead to an increase in variability of orders placed.

Lots 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 where 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 16.3 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 refer to 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 communication 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 where actions taken by a stage create the problems that the stage blames on others.
5. A lack of trust between 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.

### 16.4 MANAGERIAL LEVERS TO ACHIEVE COORDINATION

Having identified obstacles to coordination, we now focus on actions a manager may take to help overcome the obstacles and achieve coordination in the supply chain. The following managerial actions in the supply chain 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 such that every participant in supply chain activities works to maximize total
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 impact 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 14).

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 where 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 will reduce 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. Another action that managers can take is to link incentives for the sales staff to sell-through by the retailer rather than sell-in to the retailer. This action eliminates any motivation that sales staff may have to encourage forward buying. The 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 Sales Data

Sharing point of sales (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 17). Companies have also used the Internet to share data with suppliers. For direct sales companies like Dell, and companies involved in e-commerce, POS data is 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 on 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 sales data is 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 to a common forecast. Wal-Mart has observed that a lack of collaborative planning has a significant impact on its supply chain performance. Wal-Mart has a joint initiative with P&G called collaborative forecasting and replenishment (CFAR) that has had significant success in this regard. Teams consisting of managers from both Wal-Mart and P&G jointly forecast sales of P&G products at Wal-Mart stores and then jointly plan replenishment strategies. This ensures that there is no gap between what Wal-Mart plans to sell and what P&G plans to produce. 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. The use of IT systems helps facilitate collaborative forecasting and planning within the supply chain (see Chapter 17).

**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 for 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 like 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 that result in single point control of replenishment. In *continuous replenishment programs* (CRP), the wholesaler or manufacturer replenishes a retailer regularly based on POS data. CRP could 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 VMI, the distributor or manufacturer monitors and manages inventories at the wholesaler or retailer. This centralizes the replenishment decision for all retailers at the upstream distributor or manufacturer. This practice existed in retailing before the growth of
enabling technologies. Frito-Lay truck drivers restock retailer shelves and make restocking decisions rather than having the retailer manage the inventory. The existence of suitable information systems facilitates the implementation of VMI. 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 non-seasonal items from 12-15 to 17-20. Fred Meyer has seen inventories reduce by 30 to 40 percent while fill rates have increased to 98 percent.

In each of the instances cited earlier, the single forecast and control of replenishment by a single stage are what help eliminate the increased fluctuations because of the bullwhip effect.

**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. Electronic Data Interchange (EDI) and other electronic forms of communication can be used to 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 is producing 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 successfully 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 7-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 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 17.

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. 7-Eleven Japan has effectively 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 7-Eleven 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 having milk runs that combine shipments for several retailers on a single truck (see Chapter 14). 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 electronically identify shipment content, count, and time of delivery 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.

Rationing Based on Past Sales and Share 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-eam, 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 like HP have historically allocated based on retailer orders but are now switching to past sales.

Other firms have tried to share information across the supply chain to minimize shortage situations. Firms like 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.

16.5 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. Trust involves a belief that each stage is interested in the other's welfare and would not take actions without considering their impact on the other stage. Cooperation and trust within the supply chain help improve performance for the following reasons:

A more natural aligning of incentives and objectives is achieved. When stages trust each other, they are more likely to take the other party's objective into consideration when making decisions.

1. 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.

2. 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 as long as the supplier shares process control charts. Another example may be the situation in which a distributor aids the postponement strategy of a manufacturer by performing customization just before the point of sale.

3. 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.

Historically, supply chain relationships have been based either on 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 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 where retailers have tried to exploit their power, manufacturers have sought ways to directly access the consumer. 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 is 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 they 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*, where 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 and Contributions**

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 as fair dealing, should be another important criterion when evaluating and designing a relationship. 

Equity measures the fairness of the division of the total profits between 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 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 between 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 periodically monitor the relationship and adjust both contributions and the allocation of resulting benefits. For example, Daimler Chrysler 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 the 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. Reciprocal interdependence increases the interactions between the two parties, increasing the chances of trust and cooperation if positive interactions occur. Reciprocal interdependence also makes it harder for one party to be opportunistic and take self-serving actions that hurt the other party. Thus, greater reciprocal interdependence in the allocation of operational roles and decision rights increases the chances of an effective relationship, as shown in Figure 16.4.

Managers must ensure that tasks that are required from each party for a successful handoff of the product from one to the other be well defined. Consider the relationship between Dell, Sony, and Airborne. Dell takes orders for computers it assembles and monitors that Sony manufactures. Airborne picks up the computer from the Dell warehouse in Texas and the monitor 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.

**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.

**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.
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 only succeed 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.

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 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 only be effective once a sufficient level of trust builds between members from different firms. If used properly, coordination teams can provide significant benefit as is the case 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 with 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 between the parties involved facilitates change in such a setting.
5. **Try to achieve coordination in the entire supply chain network:** The complete benefit of coordination is only achieved when the entire supply chain network is coordinated.

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 only visibility of information 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 only be realized 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 their 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.

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.

**DISCUSSION QUESTIONS**

1. What is the bullwhip effect and how does it relate to lack of coordination in the supply chain?
2. What is the impact of lack of coordination on the performance of the supply chain?
3. In what way can improper incentives lead to a lack of coordination in the supply chain? What countermeasures can be used to offset this effect?
4. What problems result if each stage of the supply chain views its demand as the orders placed by the downstream stage? How should firms within the supply chain communicate to facilitate coordination?
5. What factors lead to a batching of orders within a supply chain? How does this impact coordination? What actions can minimize large batches and improve coordination?
6. How do trade promotions and price fluctuations impact coordination in the 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?