

# Managing Supply Chain Inventory: Pitfalls and Opportunities

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**D**O YOU CONSIDER DISTRIBUTION AND INVENTORY COSTS WHEN YOU DESIGN PRODUCTS? CAN YOU KEEP YOUR CUSTOMERS INFORMED OF WHEN THEIR orders will arrive? Do you know what kind of inventory control systems your dealers use? If not, you've succumbed to the pitfalls of inventory management. You're not alone. Manufacturers have been concentrating on quality of incoming materials and outgoing products, but they haven't been paying as much attention to the costs associated with transporting and storing them. Lee and Billington describe fourteen pitfalls of supply chain management and some corresponding opportunities. The more complex your network of suppliers, manufacturers, and distributors, the more likely you can gain operational efficiencies by attending to inventory. ♣

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**M**ost manufacturing enterprises are organized as networks of manufacturing and distribution sites that procure raw materials, transform them into intermediate and finished products, and distribute the finished products to customers. The simplest network consists of one site that performs both manufacturing and distribution. More complex networks, such as those required to manufacture mainframe computers, span multiple sites that may be scattered around the world.

We call these networks supply chains or value-added chains, as shown in Figure 1. Often, multiple managers — manufacturing, operations, logistics, material, distribution, and transportation managers — have responsibility for different parts of a chain. Overall operational performance, as part of the finished product's cost, may be the responsibility of the product division's general manager.

Managing a supply chain is very different from managing one site. The inventory stockpiles at the various sites, including both incoming materials and finished

products, have complex interrelationships. Efficient and effective management of inventory throughout the supply chain significantly improves the ultimate service provided to the customer. In this paper, we describe the many pitfalls of managing supply chain inventories and suggest opportunities for improving management and control. Throughout the discussion, we draw upon our knowledge and experience of supply chain management at electronics, computer, and automobile companies.

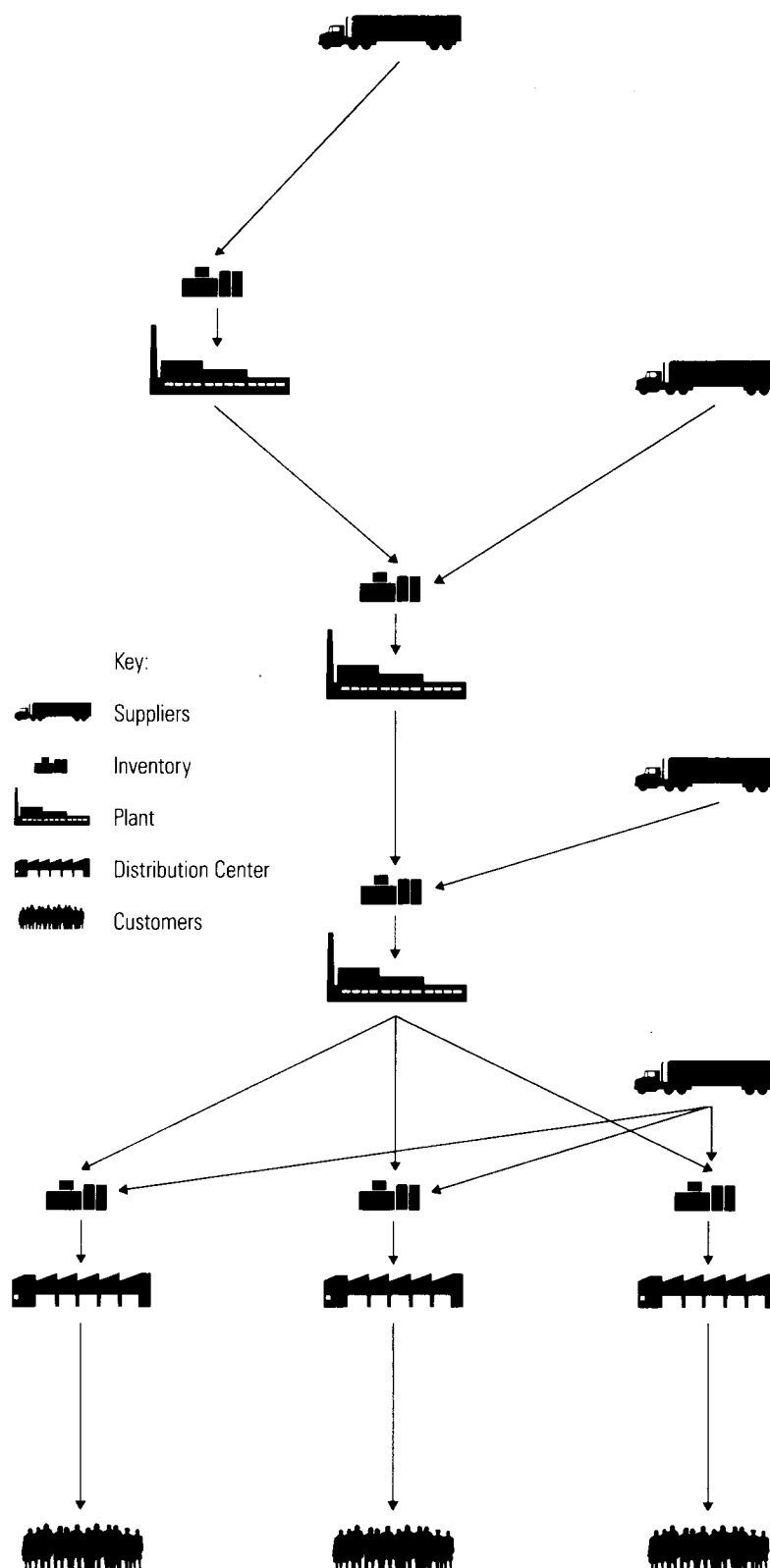
## Common Pitfalls

Pitfalls 1 through 4 address problems related to information definition and supply chain management. Pitfalls 5 through 9 relate to operational problems. Pitfalls 10 through 14 are problems that are strategic and design related.

### Pitfall 1: No Supply Chain Metrics

Although the supply chain's overall performance depends on the sites' joint performance, usually each site is

**Figure 1 An Example of a Supply Chain**



managed by fairly autonomous management teams, each with its own objectives and mission. These objectives may have little to do with the supply chain's overall performance. Worse, these objectives may conflict. The consequence is that the different sites may have operational goals that, if met, result in inefficiencies for the overall chain.

For example, a northern California computer manufacturer's circuit assembly operation used cost per placement as its overriding performance measure. The site focused on reducing placement cost. This was not inherently wrong, but it didn't take into account how the site's performance affected the overall supply chain of computer manufacturing and distribution. Consequently, the site held excessive inventory in order to operate in large lot sizes.

In another case, an Indiana component manufacturing plant of an automobile manufacturer started aggressively cutting inventory, as its performance was explicitly determined by its inventory. As a result, the plant's response times to the final assembly plants and the spare parts distribution centers became longer and highly erratic. The final assembly plants and the parts distribution centers had to keep inventory high to give their customers reasonable service.

We observed that there were no performance measures for the complete supply chain. Many companies have this problem. Those that do have such metrics often do not monitor them regularly. Or their metrics are not directly related to customer satisfaction. For example, some companies use inventory turns for all supply chain inventories as the main performance measure. Yet they do not measure their response time or service fill rates to customers. We

contend that supply chain metrics must be oriented to customer satisfaction. This leads us to the second pitfall.

### **Pitfall 2: Inadequate Definition of Customer Service**

A supply chain must ultimately be measured by its responsiveness to customers. However, there are different definitions of responsive customer service. Most companies measure the average line item fill rate (percentage of line item requests shipped prior to customer due dates). There are variations, such as weighting fill rates by dollar volume. Yet these may not satisfy customers.

A customer order usually involves multiple line items. For example, a personal computer (PC) dealer may order printers, computers, accessories, and software in one order. As the dealer is merely replenishing its own stock, which will be sold to end users, the supplier can ship individual items separately, depending on the availability of these products, without adversely affecting the dealer's business. Line item fill rate would be a good indicator of customer service. Other customers demand a single shipment of all items, such as customers who need service parts to complete a repair job. In these cases, it is important to measure the fill rate in terms of completed orders.

However, measuring order fill rates will not by itself diagnose operational problems. For example, a workstation manufacturer fills orders of multiple products that come from different divisions, and customers demand to receive each order in a single shipment. The manufacturer has merging centers where products are consolidated before they are shipped out. Overall order fill rate is an appropriate performance measure, but measuring it will not help the firm identify which divisions are slowing down order completion.

Conventional fill rate measures also inadequately measure the degree of order lateness. Hence, two supply chains with the same 90 percent product fill rate may differ drastically on how promptly they fill the remaining 10 percent. A large computer and instrument manufacturer was chagrined to learn that the service target it applied to its suppliers was not the same as the one it used to measure its own performance. Employees in the purchasing departments recounted the difficulty of convincing themselves, let alone suppliers, that they should be using a more stringent standard with vendors.

Other critical service measures are often not tracked. These include total order cycle time or total response time to an order; average backorder levels; average lateness or earliness of orders relative to customer due dates;

and backorder profile, that is, backorders that are one week late, two weeks late, and so forth.<sup>1</sup>

### **Pitfall 3: Inaccurate Delivery Status Data**

When customers place orders, they want to know when their products will arrive. While waiting, they may also want updated order delivery status, especially when the order is late. We do not understate the significance of on-time delivery, but we contend that not enough attention is paid to providing customers with timely and accurate updates on the status of late orders. The consequence is dissatisfaction, confusion, and loss of goodwill.

Most companies publish their standard response times to customers, although these may not resemble actual response times. And most companies quote shipment dates. But too often companies cannot systematically retrieve the information they need to set a shipment date; it takes them too long to deliver the quote, let alone the product.

One California PC manufacturer takes more than a week to inform a customer of a shipment date, even when the date is little more than a guess. Another manufacturer ships more than 30 percent of its orders after the promised date, and 40 percent of its actual shipment dates differ from the promised date by more than ten days. At the same company, shipment dates are typically revised several times during the order cycle.

Companies should track delivery performance and keep customers apprised of their order status. The next pitfall underscores the difficulty in maintaining accurate data.

### **Pitfall 4: Inefficient Information Systems**

The databases at different operating sites that describe system environment, inventory/backlog status, future production plans, and so on, are usually not linked. This sometimes happens even on a single site. Consequently, retrieving this information can be a tedious, manual process.

Delays in information retrieval and transmission make it impossible to quote accurate shipment dates to customers, as discussed in Pitfall 3. They also discourage or prohibit short production planning cycles, leading to gross forecast errors and inventory and backorder accumulation. For example, when a northern California PC manufacturer developed a production plan, it had to retrieve information on order forecasts, current backlogs, inventory status, shipability profile of orders (i.e., when shipments are due for the orders), and production capacities from databases at a number of sites and functions

within those sites. Data retrieval was highly laborious. The data was loaded into a spreadsheet model, which developed a production plan. The production plan became the master schedule which was fed to a material requirements planning (MRP) system. Execution of the MRP also usually took a long time. This entire process forced the manufacturer to plan monthly. Long planning cycles increase forecast errors and reduce manufacturing's ability to respond to updated order information. Manufacturing ends up building the wrong products. This leads to high inventory levels *and* high backorder levels.

Often, different needs, organizational cultures, and personal tastes lead the sites to use different operating systems for the same functional tasks. For example, a major computer manufacturer has its multiple sites using twelve different versions of MRP systems that are not compatible with one another. Consequently, data integration and communication are even more difficult and tedious.

#### **Pitfall 5: Ignoring the Impact of Uncertainties**

There are many sources of uncertainties in a supply chain: supplier lead time and delivery performance, quality of incoming materials, manufacturing process time (including machine downtimes, process yields, and reworks), transit times, and demand. To reduce the impact of these uncertainties, supply chain managers must first understand their sources and the magnitude of their impact. It is surprising that many supply chains do not document and track these variables. Consequently, companies may overstock some items but understock others, miscalculate the lead times for material movements along the supply chain, and invest in the wrong resources for performance improvements.

More and more companies are concerned with quality control and keep good statistics on incoming material quality and imperfections in the manufacturing process. The emphasis on just-in-time manufacturing has led to increased monitoring of supplier delivery performance. Little is known, however, about transit times, specifically the lead time from distribution to customers. Too often, when an order leaves the dock, management considers the job complete. Many companies only track their shipment or delivery performance by tracing an order from placement date to shipment date. Transportation technology has reduced delivery lead time, but some variability still exists. Such information is critical for companies evaluating different modes of transportation.

Commercial carriers such as Federal Express do track their delivery performance, and manufacturers can use this information to understand their delivery cycles. But

they must plan carefully. One workstation manufacturer wanted to do this but found that because it used a different order numbering system than its carriers, it was difficult to match order information.

Some companies respond well to uncertainties, but they fail to work on ways to eliminate them. A classic example is that of purchasing managers who routinely modify their inventory stocking policies for purchased parts to avoid stockouts during manufacturing but do nothing to improve their suppliers' delivery performance, one of the root causes of the problem.

#### **Pitfall 6: Simplistic Inventory Stocking Policies**

Understanding and tracking sources of uncertainties is the first step. The next step is to use such information to drive inventory stocking policies. This is a dynamic process; the uncertainties are constantly changing. Some suppliers become more reliable in both delivery and quality; others become less reliable. Demand for some items becomes more predictable as products mature; demand for others becomes more unpredictable. Inventory needs for some components stabilize as multiple products use common parts. Inventory stocking policies should be periodically adjusted to reflect such changes.

Companies commonly use generic stocking policies: all A stock-keeping units (SKUs) have three weeks of safety stock, B SKUs have four weeks, and so on. The classification of items by transaction volume does not necessarily reflect the magnitude of uncertainties in supply and demand. More rigorous techniques should be used. One California automobile parts supply warehouse classifies an item based on the transaction volumes between the warehouse and the supplier. Hence, it has SKUs that are classified as A items whose annual demand is only one-tenth of others that are classified as C items. The irony is that this warehouse uses generic stocking policies for the SKUs. Simple analysis reveals that the company could reduce 40 percent of its inventory investment while maintaining the same level of customer service just by linking stocking policies to the sources of the uncertainties that require inventory in the first place.<sup>3</sup>

#### **Pitfall 7: Discrimination against Internal Customers**

For vertically integrated companies, one entity's outputs are simultaneously inputs to other company entities and products for external customers. Yet, to an independent division, external customers bring in real revenues and thus are more visible and apparently more valuable.

The distribution centers of a PC manufacturer have

explicit customer service measures for external customers, but none for internal customers. Although customer service for internal customers is not tracked, it is common knowledge that it is much poorer than for external customers. The resulting delays at the other internal entities could create significant inventory and backorder problems. Similarly, the manager of a Michigan automobile spare parts distribution network finds that the worst of his suppliers are the company's own manufacturing plants. Such a priority system can hurt the company's overall profitability.

At a California-based computer manufacturer, the distribution centers in Europe and Asia receive supplies from the main distribution center in the United States. To the U.S. distribution center, the European and Asian distribution centers are internal customers, and they often receive lower priority than U.S. external customers. But these other distribution centers are serving external customers, too. Somebody has to pay for the poor service to overseas distribution centers: the distribution centers, in the form of increased buffer stocks, or their customers, in the form of unreliable delivery.

Discriminating against internal customers has a profound impact on the overall supply chain. Often, the purchasing managers of the receiving entities spend a lot of time jockeying with the supplying division's distribution manager to improve their priorities in the system. This effort adds no value; it only increases product cost.

#### **Pitfall 8: Poor Coordination**

If customer orders consist of multiple items that are supplied by different divisions, and if customers demand receipt of all items at the same time, the company will use a merging center. The products will be shipped to the customer as soon as they all arrive. Obviously, tight coordination among the supplying divisions is important. It is useful to give the divisions a target date. Unfortunately, generating a target date can take a long time (see Pitfalls 3 and 4), and arbitrarily generated target dates that do not consider existing backlogs in the supplying divisions are not useful at all. As a result, target dates are often ignored. Lack of coordination results in excessive delays, and ultimately, poor customer service. At the same time, inventory builds up at the merging center.

Another consequence of poor coordination is that some divisions habitually expedite deliveries, which is unnecessary and costly. An east coast workstation manufacturer found that most of its divisions use air freight to ship their products to the merging center, each believing that it is the division holding up the order. These

products sit in the merging center for weeks until the last product comes in. It is especially ironic when the latest division uses the slowest mode of transportation.

As the supply chain becomes globalized, coordination is more critical. Cohen and Lee discuss coordinated resource deployment decisions in a global supply chain.<sup>3</sup>

#### **Pitfall 9: Incomplete Shipment Methods Analysis**

Changing the mode of transportation can significantly affect inventory investment and service performance. However, transportation decisions are often based on economic considerations that do not take into account these important operational factors.

A computer manufacturer based in the northeast was surprised to learn that by shipping by air instead of ocean for one of the supply chain links, it could save millions in inventory investment. These savings would come from inventory reduction in the transportation pipeline and shorter delivery lead times to the distribution centers. The distribution centers would need less safety stock to provide the same level of customer service. The benefits far outweighed the costs, even though the air freight cost three times that of the ocean freight. In the course of the analysis, the manufacturer discovered that product packaging could be redesigned to make air shipments even more attractive.

A manufacturer of computer peripherals planned to ship products from a Japanese plant to U.S. and European distribution centers once a month so that the shipment would completely fill one container for each destination. Monthly shipments automatically set the amount of running inventory, known as cycle stock, at half a month. And monthly shipments made the distribution centers' inventory review period, that is, the period of reviewing stock and making replenishment decisions, at least a month long. This led to excessively high safety stock levels. The company found that the increased inventory costs more than offset the savings of "economical" shipments.

#### **Pitfall 10: Incorrect Assessment of Inventory Costs**

The previous pitfall suggests that economic analysis of the costs and benefits of inventory investment is important in operational decision making. How should the opportunity cost of inventory be valued? This subject has been discussed at length in the academic literature, yet there is no industry standard in practice.<sup>4</sup> Variations exist even within the same company. Most people know that they should include the opportunity cost of capital, warehousing, and storage. The commonly omitted

components of inventory costs include (1) obsolescence, owing to short product life cycles or fixed shelf lives, and (2) costs of reworking existing inventory to meet engineering changes. A manufacturer of computer printer components finds that the above factors increase the holding cost rate of inventory from 24 percent per year to 40 percent!

#### **Pitfall 11: Organizational Barriers**

Sometimes entities of a supply chain belong to different organizations within a company, each organization having its own performance measures and evaluation responsibilities. Organizational barriers that may inhibit coordinated inventory control include differences in objectives and performance metrics, disagreements on inventory ownership, and unwillingness to commit resources to help someone else. Some of the earlier pitfalls (4 and 8) are manifestations of such barriers.

For example, the supply chain for desktop printers at an integrated manufacturing company consists of an integrated circuit (IC) manufacturing site supplying a final printer assembly site. The assembly site belongs to the computer peripherals division, and the IC site belongs to the circuit technology division. Wafer fabrication cycle time is long and variable, so the lead time for supply from the IC site to the assembly site is long — fourteen to sixteen weeks. This lead time could be reduced by changing the levels of inventory in wafer or semifinished IC forms. Reducing lead time would help the assembly site deal with fluctuations in printer demand. It would also reduce the assembly site's finished goods inventory. The overall inventory investment in the supply chain would be reduced. Such a reallocation of inventory investment, however, would result in different levels of performance for the two sites. The IC site is reluctant to increase its inventory, as it is evaluated by a different organization, even though this increase would benefit the whole supply chain.

Most large manufacturing companies have decentralized organizational structures. Such decentralization often creates these types of barriers to more integrated inventory control.

#### **Pitfall 12: Product-Process Design without Supply Chain Consideration**

Many new approaches to product-process design have been introduced.<sup>5</sup> Product designs that enable fast and precise manufacturing and assembly are critical for cost and quality effectiveness, but the implications for supply chain inventory are usually ignored or poorly understood. The result is that all of the anticipated savings

may be lost owing to increased distribution and inventory costs. Similarly, product introduction without proper supply chain planning can create problems like product unavailability, excessively long delivery lead times, and unnecessary expediting costs, which may ultimately affect the product's success.

A U.S. computer peripherals manufacturer makes printers for worldwide distribution. The printers have a few country-specific components, such as the power supply and owner's manual. The U.S. factory produces to meet demand forecasts, but by the time the printers reach regional distribution centers, demand has changed. Because the printers have been prepared for specific countries, the distribution centers have no flexibility to respond to changing demand patterns. The result is simultaneously high inventory stockpiles and backlogs.

This manufacturer is now redesigning the assembly process so that the distribution centers can add the country-specific components. The U.S. factory will ship a generic product. Tremendous savings in inventory investment and flexibility are expected. It is worth noting that design changes are not sufficient to successfully "design for supply chain management." In this example, the distribution centers have to become involved in the final manufacturing stage, but they belong to a different organization within the company than the manufacturing sites. Organizational barriers between these two groups will require significant effort to gain their collaboration (see Pitfall 9).

Design for supply chain management can be a powerful concept for new product introduction. One computer peripheral manufacturer used such a concept to introduce a second model of its product. Rather than develop a product with a different bill of materials and manufacturing process, the company decided to design a generic product that could be made into either model at the distribution centers. This design was more expensive, but it provided much greater flexibility for meeting demand. Flexibility is especially important for a new product, whose demand could be highly variable as well as unpredictable.

#### **Pitfall 13: Separation of Supply Chain Design from Operational Decisions**

When companies add or close a plant or distribution center in a supply chain network, the main consideration is typically fixed costs and the logistics cost implications. The effects of the network change on operational efficiency factors, such as inventory investment and order response time, are often an afterthought. These

second order effects, however, can have a dollar impact of equivalent or greater magnitude.

An IC manufacturer has the following supply chain: the U.S. wafer fabrication operation ships finished ICs

The manager of an automobile parts distribution network finds that his worst suppliers are his own company's manufacturing plants.

to Singapore for testing, which are then shipped back to the U.S. site for final testing, packaging, and shipment to customers. Such a network design has been justified on factors such as better testing technology, better quality workforce, and tax savings. However, the design has effects on inventory and cycle time that are poorly understood. The shipment to and from Singapore adds at least two weeks to the total manufacturing cycle time. Customs procedures add to the variability and length of the lead time and its associated work-in-process inventory cost. Furthermore, the long cycle time significantly affects the operational efficiencies of the manufacturer's customers, which are manufacturers themselves; they have higher inventory and longer manufacturing cycle times. Because these ICs are high-value SKUs, the capital tied up in inventory is significant.

#### **Pitfall 14: Incomplete Supply Chain**

Going beyond the internal supply chain by including external suppliers and customers often exposes new opportunities for improving internal operations. Manufacturers commonly view their immediate customers — such as retailers or other manufacturers — as the end of the supply chain. Manufacturers with a hierarchy of distribution centers concentrate on inventory costs and service only up to the major distribution centers. Manufacturers often have service targets in the form of fill rate, the fraction of customer demands met without delay. “Customer demand” usually refers to orders from dealers. But good service to dealers does not necessarily translate into good service to customers; manufacturers who do not consider the entire supply chain will have operational inefficiencies.

Using fill rates as service targets is problematic for another reason. Dealers have their own inventory control systems. For them, an 85 percent fill rate, say, with highly variant delays for the remaining 15 percent, would probably be worse than a 0 percent off-the-shelf fill rate with a reliable resupply time of one week.

Understanding the dealers' inventory control systems is the only way for the manufacturer to accurately set internal service targets.

Another benefit for incorporating dealers into the supply chain comes from sharing information. By knowing the dealers' inventory levels, the manufacturer can respond accordingly. It can appropriately reprioritize dealer orders, expedite shipments, and use overtime. Similarly, dealers who have access to the manufacturer's inventory status can respond to market changes more promptly.

Dealers' inventory control systems determine, to a large extent, their reorder patterns, that is, frequency, size, and composition. Hence, understanding their inventory control systems would also improve the distribution network's ability to forecast demand.

Table 1 reiterates the fourteen pitfalls.

## **Opportunities**

The common pitfalls have corresponding strategies for improvement. We will discuss a few key points. However, we have chosen not to describe the specifics of each of them. Readers should be able to deduce the specifics of the opportunities relative to their unique supply chain environments.

**Design for Supply Chain Management.** A lot has been written on design for manufacturability, for assembly, for quality, for producibility, and for serviceability. To this list we would add “design for supply chain management.” Thus product designs should be evaluated not only on functionality and performance but also on the resulting costs and service implications that they would have throughout the product's supply chain. The same applies to process designs.

**Integrate Databases throughout the Supply Chain.** Effective operational control of a supply chain requires centralized coordination of key data from the different entities. Key data would include order forecasts, inventory status at all sites, backlogs, production plans, supplier delivery schedules, and pipeline inventory. The databases should be linked so that managers from any point in the supply chain can retrieve accurate information quickly. With advances in information technology, databases can also be integrated between companies. The trend towards stronger vendor-vendee relationships certainly supports the need for database integration between different companies in an expanded supply chain.

**Integrate Control and Planning Support Systems.** As noted earlier, production planning and inventory control decisions at one site in a supply chain affect decisions at other sites. Decisions at the multiple sites should not be

made independently. A systems approach should be taken. Models for integrated control of multisite manufacturing and distribution systems are just emerging.<sup>6</sup>

**Redesign Organizational Incentives.** Most companies use incentive systems focused on the division, group, or site. These tend to inhibit cooperation. To get multiple sites from different divisions or groups to work together to achieve systemwide effectiveness and efficiency, companies may need to redesign the organization and develop new incentive systems. As we expand our view of the supply chain, we may need to make such changes across company boundaries. This will be more difficult to achieve but should not be ignored.

**Institute Supply Chain Performance Measurement.** New incentives and organizational redesign go hand in hand with new performance metrics. These metrics should take the supply chain perspective; they should consider, for example, inventory measures across the supply chain and total response time instead of individual sites' lead times. Instead of each entity being responsible for its own set of metrics, all entities should take ownership of the supply chain metrics. They should all be held accountable to the overall performance. Operations managers should measure performance regularly and frequently, such as weekly or monthly.

**Expand View of Supply Chain.** As described earlier, manufacturers should understand the needs of stakeholders that affect or are affected by the supply chain. Such an understanding can result in better targets and operating efficiencies. It can also expose opportunities outside the supply chain.

A recent study found that the U.S. companies that stand apart from their peers in terms of their logistics

**Table 1 Pitfalls of Supply Chain Inventory Management and their Symptoms**

Pitfalls	Symptoms
1. No supply chain metrics	<ul style="list-style-type: none"> <li>• Independent and disconnected individual sites</li> <li>• Incomplete metrics</li> <li>• Performance measures not tracked</li> <li>• No attention to measures tracked</li> </ul>
2. Inadequate definition of customer service	<ul style="list-style-type: none"> <li>• Inadequacy of line-item fill rate measure</li> <li>• No measures for response times</li> <li>• No measures for lateness</li> <li>• No measures for backorder profile</li> </ul>
3. Inaccurate delivery status data	<ul style="list-style-type: none"> <li>• Delays in providing delivery information</li> <li>• Inaccurate delivery information</li> </ul>
4. Inefficient information systems	<ul style="list-style-type: none"> <li>• Inadequate linkage among databases at different sites</li> <li>• Proliferation of operating systems for the same function at different sites</li> <li>• Delays and inaccuracies of data transfer</li> </ul>
5. Ignoring the impact of uncertainties	<ul style="list-style-type: none"> <li>• No documentation or tracking of key sources of uncertainties</li> <li>• Partial information on sources of uncertainties</li> </ul>
6. Simplistic inventory stocking policies	<ul style="list-style-type: none"> <li>• Stocking policies independent of magnitudes of uncertainties</li> <li>• Static stocking policies</li> <li>• Generic and subjective stocking policies</li> </ul>
7. Discrimination against internal customers	<ul style="list-style-type: none"> <li>• No service measures of internal customers</li> <li>• Low priority for internal orders</li> <li>• Inappropriate incentive systems</li> <li>• Jockeying for priority among different internal divisions</li> </ul>
8. Poor coordination	<ul style="list-style-type: none"> <li>• No coordination among supplying divisions to complete an order</li> <li>• No system information among multiple supplying divisions</li> <li>• Independent shipment plans</li> </ul>
9. Incomplete shipment methods analysis	<ul style="list-style-type: none"> <li>• No consideration of inventory and response time effects</li> </ul>
10. Incorrect assessment of inventory costs	<ul style="list-style-type: none"> <li>• Omission of obsolescence and cost of rework</li> <li>• No quantitative basis for inventory holding cost assessments</li> </ul>
11. Organizational barriers	<ul style="list-style-type: none"> <li>• Independent performance measures and incentive systems at different sites</li> <li>• Barriers between manufacturing and distribution</li> </ul>
12. Product-process design without supply chain consideration	<ul style="list-style-type: none"> <li>• No consideration of manufacturing and distribution in product-process design</li> <li>• No consideration in design for customization and localization</li> <li>• Organizational barriers between design and the supply chain</li> </ul>
13. Separation of supply chain design from operational decisions	<ul style="list-style-type: none"> <li>• Chain decisions without consideration of inventory and response time efficiencies</li> </ul>
14. Incomplete supply chain	<ul style="list-style-type: none"> <li>• Focus on internal operations only</li> <li>• Inadequate understanding of operational environment and needs of immediate and ultimate customers</li> </ul>



operations typically use more data-processing technology and have a higher level of information system support so that they have more electronic data interchange with their suppliers and customers.<sup>7</sup> This reduces or eliminates many of the administrative delays in the supply chain.

## Conclusion

Supply chains are very complex. Many firms are vulnerable to the pitfalls described in this paper. By delineating these pitfalls, we hope more supply chain managers will be able to avoid them and that they will make use of the abundant opportunities that are open to them. ♦

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