

Chapter 9 SCM

Supply Chain Management at The Moscow McDonald's

Around the world, McDonald's operates more than 11,000 restaurants in 51 countries, 4,000 outside the United States. One of the most unique is the 700-seat McDonald's in Moscow. McDonald's insists that a Big Mac must taste the same in Moscow as it does in New York, Paris, or Sydney, yet all food products used to supply its restaurant in Russia must be secured locally. McDonald's prepared for this challenge by planning the supply chain for the Moscow restaurant six years in advance, when McDonald's experts began to work with Russians to upgrade their production standards to supply the desired quality of meat, wheat, potatoes, milk, and other necessary basic ingredients.

Supplier location is an important part of the supply chain at McDonald's, and past experience has shown that what works best is to combine a number of independently owned food-processing plants dedicated solely to supplying McDonald's restaurants. This type of centralized system, called a *food town*, reduces both transportation and material handling costs. A \$60 million food town was established in Russia that combines a bakery, meat plant, chicken plant, lettuce plant, fish plant, and distribution center. Each of these processing facilities is independently managed, but all share cooling and freezing facilities with the distribution center. Locating dedicated processing facilities together is the only way McDonald's could ensure the standards of quality and customer service required in its Moscow restaurant. The system also reduces capital setup costs, inventory and material handling costs, and distribution costs.¹



McDonald's in Pushkin Square in Moscow adheres to founder Ray Kroc's creed of QSC&V (quality, service, cleanliness, and value) as any other McDonald's in the United States or around the world does. To achieve its expected level of quality and service in Moscow, McDonald's



developed an entire supply chain for growing, processing, and distributing food, part of which is the \$60 million food plant shown here. This follows McDonald's overall approach to supply chain management, which is to construct a strong logistical chain from suppliers to customers with no weak links, especially among suppliers. McDonald's makes sure everyone along the supply chain understands its expectations for performance and closely monitors this performance.

¹ P. Ritchie, "McDonald's: A Winner Through Logistics," *International Journal of Physical Distribution and Logistics Management* 20, no. 3 (1990): 21-24.

A **supply chain** is made up of the interrelated organizations, resources, and processes that create and deliver products and services to end customers. A supply chain encompasses all the facilities, functions, and activities involved in producing and delivering a product or service, from suppliers (and their suppliers) to customers (and their customers). It includes planning and managing supply and demand; acquiring materials; producing and scheduling the product or service; warehousing, inventory control, and distribution; and delivery and customer service. Supply chain management coordinates all these activities so that customers can be provided with prompt and reliable service of high-quality products at the least cost. Successful supply chain management in turn can provide the company with a competitive advantage.

Facilities along the supply chain include plants, warehouses, distribution centers, service centers, and retail operations. Products and services can be distributed by rail, truck, water, air, pipeline, computer, mail, telephone, or in person. Processes within the supply chain include forecasting of product or service demand, selecting suppliers (sourcing) and ordering materials (procurement), inventory control, scheduling production, shipping and delivery, information management, quality management, and customer service. Most of the topics in this text fall somewhere within the supply chain. Managing the supply chain is tantamount to coordinating all the operations of a company with the operations of its suppliers and customers.

The delivery of a product or service to a customer is a complex process encompassing many different interrelated facilities, processes, and activities. First, demand for a product or service is forecast, and plans and schedules are made to meet demand within a time frame. The product or service can require multiple suppliers (who have their own suppliers) who prepare and then ship parts and materials to manufacturing or service sites. One of the largest producers, General Motors, has more than 2,500 suppliers that serve its 120 parts plants and 30 auto and truck assembly plants. Parts and materials are transformed through complex processes into final products or services. Finally, these products are shipped to external or internal customers. However, this may not be the final step at all as these customers may transform the product or service further and ship it on to their customers. All of this is part of the supply chain; that is, the flow of goods and services from the materials stage to the end user.

What makes this process so complicated, and the management of the supply chain so complex, is the uncertainty all along the supply chain at every stage. Uncertainty in the form of wrong forecasts, late deliveries, poor-quality materials or parts, machine breakdowns in the manufacturing process, canceled orders, erroneous information, slow information, transportation breakdowns, and the like cause "breaks" in the supply chain that can result in poor customer service; that is, not having the product or service available to customers when and where they want it. Companies cope with this uncertainty with their own form of "insurance," *inventory*. All companies carry inventory to minimize the negative effects of uncertainty and to keep the productive process flowing smoothly from suppliers to the customer. However, inventory is very costly so companies--both suppliers and their customers--would like to minimize it. Thus, one important objective of supply chain management is to coordinate all the different activities, or "links" of the chain, so that goods can move smoothly and on time from suppliers to customers to distribution to suppliers to customers, while keeping inventories low and costs down.

Unfortunately, the different companies that depend on each other to produce a product or service do not always work together and that is a dilemma of supply chain management. Customers do not want to have to keep large, costly inventories so they demand that their suppliers keep them instead so their service will not suffer, and these suppliers pressure their suppliers to do the same, and so on, all the way down the supply chain.

Effective supply chain management requires that suppliers and customers work together in a coordinated manner by sharing and communicating information by talking to one another. It is the rapid flow of information among customers, suppliers, distribution centers, and transportation systems that has enabled some companies to develop very efficient supply chains. Suppliers and customers must also have the same goals; that is, that they be on the same page. Suppliers and customers need to be able to trust each other: Customers need to be able to count on the quality and timeliness of the products and services of their suppliers. Further, suppliers and customers must participate together in the design of the supply chain to achieve their shared goals and to facilitate communication and the flow of information.



Some companies attempt to gain control of their supply chains by *vertically integrating*--by owning and controlling all the different components along the supply chain from materials and parts procurement to delivery of the final product and customer service--like the McDonald's in Moscow described at the beginning of this chapter. However, even with this type of organizational structure, the different functions and operating units can be uncoordinated. For example, at a computer manufacturer one facility producing chips responded to demand pressure from another company facility producing motherboards by increasing capacity at considerable cost, only to learn later that the chips were never a source of delay in the delivery of motherboards further down the supply chain. At Nabisco purchasing figured that they would save more than a half-million dollars by reducing the tensile strength of a box, but as a result of the weakened boxes they suffered more than a million dollars in product returns further downstream in the supply chain.

No matter what type of organizational structure exists within a company, it still must focus on coordinating its different activities to achieve overall company goals.

As this brief discussion illustrates, supply chain management encompasses so many different interrelated topics that it is not possible to cover all of them in a single chapter. Thus, we must devote separate chapters to some of them including forecasting, production and scheduling, inventory control, and quality. In this chapter we will focus on several key elements of the supply chain including the supplier-customer relationship and purchasing (also known as sourcing and procurement), type and location of facilities, transportation, and distribution.

Supply Chain Design: A Strategic Issue

Since a company's supply chain encompasses virtually all of its operating functions and facilities, its design is necessarily an integral part of its strategic planning process. For most companies the goals of their strategic plan are often the same as the objective of supply chain management--the prompt and reliable delivery of high-quality products and services at the

least cost. To accomplish this requires strategic design decisions that effectively coordinate all of the supply chain functions. It is not surprising that many of the same strategic design considerations for a quality management program can be applied to supply chain design.

The central component of the strategic planning process is a goal or set of goals. In supply chain management before goals can be established, it is necessary to know what current performance is and what is possible after improvement or reengineering. In total quality management (TQM), this is referred to as **benchmarking**, measuring where the company (and/or a competitor) is now and using that as a guideline as to where the company wants to be in the future. However, a company must measure performance and set goals in terms of the supply chain as a whole, not just itself. A company may set high goals for itself for minimizing inventory, but if the inventory levels of its suppliers are required to be excessively high just so the company can achieve its own local goals without regard to the suppliers' costs, then the cost of the high inventory will eventually be passed on to the company as higher delivery, material and, parts costs anyway. If a company achieves its own quality goals and ignores the quality programs of its suppliers, then its quality will be adversely affected. Thus, the supply chain must be designed to minimize inventory and achieve high quality among both suppliers and customers.

This level of interdependence and goal sharing makes the selection of suppliers, also called **sourcing**, and the purchasing process, also called **procurement**, important strategic decisions for a company. Suppliers must be reliable in terms of quantity, timeliness, and quality. McDonald's expects delivery of its food ingredients from suppliers within two days of placing an order--always. Changing suppliers frequently can lead to interruption and delays in the flow of materials to the production process; too many suppliers can be difficult to coordinate and control; and too many suppliers can be risky, if they are not reliable, and can cut down on competition and the incentive to keep prices low. Suppliers must be perceived as a virtual extension of the customer, operating with the same goals and quality expectations.

For a company to achieve its strategic goals, it must control the bane of supply chain management we mentioned earlier--uncertainty. This requires identifying and understanding the causes of the uncertainty, determining how it affects other activities up and down the supply chain, and then formulating ways to reduce or eliminate it. An effective means for identifying and reducing uncertainty is to strategically apply the principles of TQM, including statistical process control, all along the supply chain. This means that suppliers use TQM to ensure quality products are delivered on time to customers; distribution centers employ TQM to make sure that products are packaged, handled, and shipped on time with no damage or processing errors; and shippers deliver products undamaged to the right place on time.

Another important aspect of supply chain design is communication and information flow. Advances in computer technology and the Internet have made it possible for suppliers, customers, distribution centers, and shippers to communicate almost instantaneously, thus enhancing the ability to coordinate these different supply chain processes. Computerized point-of-sale information can be transmitted instantaneously via communication networks to distribution centers and shippers enabling quick delivery to customers and quick replenishment of warehouse stocks by suppliers. If everyone along the supply chain has access to the same information at the same time, it enables them all to coordinate closely and thus reduce uncertainty, which in turn allows them to reduce inventory levels.

The types and number of facilities to construct (or acquire) and where to locate them are strategic design issues since transportation and distribution costs can be a significant part of supply chain costs. Facility and location decisions are costly, long-term commitments. They also dictate other design decisions including which suppliers to use, modes of transportation, distribution centers, and customer markets. For example, 75 percent of Honda's suppliers are within 150 miles of its Marysville, Ohio, plant, and it uses locally based trucking companies to ship its parts and materials.

Wal-Mart is an example of a company that has incorporated these various design characteristics into an effective and successful supply chain. Wal-Mart's competitive strategy is to provide quality goods to its customers when and where they want them at a competitive price. The key to achieving these strategic goals has been a feature of its supply chain design known as "cross-docking." In its cross-docking system, products are delivered to Wal-Mart's warehouses on a continual basis where they are sorted, repackaged, and distributed to stores without sitting in inventory. Goods "cross" from one loading dock to another in forty-eight hours or less. This system allows Wal-Mart to purchase full truckloads of goods while avoiding the inventory and handling costs, in the process reducing its costs of sales to 2 to 3 percent less than the industry average. Wal-Mart then passes these cost savings on to its customers as lower prices. Low prices enable them to forego frequent discount promotions which stabilizes prices, which in turn make sales more predictable, thus reducing stockouts and the need for excess inventory.

THE COMPETITIVE EDGE

Daimler-Chrysler Excels at Outsourcing

Two thirds of the components used to make Chrysler cars--more than 60,000 different items--come from outside sources. Chrysler shares its 150 major suppliers with Ford and GM. Being the smallest of the U.S. automakers, and thus lacking as much clout, it is surprising that Chrysler is the recognized pro at supplier relations. "None of the other car companies we work with are as accessible or as willing to take advice from suppliers," says Alcoa. Chrysler involves suppliers early in the design process and solicits their ideas on cost savings and technological innovation.

Most companies do not understand the full extent of their supply chains. In mapping out its supply chains, Chrysler discovered that even a simple \$3 engine part can involve 35 separate suppliers. To coordinate supplier activities, Chrysler assigns a particular supplier to act as a team leader. Its job is to oversee other suppliers in the design and manufacture of a component such as an engine or a seat. The Plymouth Prowler, the first U.S. car with an all-aluminum body, was built with cutting-edge supply chain management techniques--so say AT&T, Harley Davidson, and the Department of Energy, who have all benchmarked Chrysler's outsourcing practices

Source: Justin Martin, "Are You as Good as You Think You Are?" *Fortune* (September 30, 1996): 145-46.

Retailers do not all use cross-docking because it is difficult to coordinate and manage. To make it work Wal-Mart has invested heavily in an integrated support system that provides continuous contact between all of Wal-Mart's suppliers, distribution centers, and every *point-of-sale* in every store via its own satellite communication system. This information system sends out point-of-sale (bar code) data directly to Wal-Mart's 4,000 suppliers. In addition, Wal-Mart owns 2,000 trucks to service its 19 distribution centers; this allows the company to ship goods from warehouses to stores within forty-eight hours and restock store shelves an average of twice a week, compared to the industry average of once every two weeks. Cross-docking also requires close management cooperation at all levels. Store managers are connected to each other and to corporate headquarters via a video link that allows for frequent information exchanges about products, pricing, sales, and promotions.² Figure 9.1 illustrates the relationship between facilities and functions along the Wal-Mart supply chain.

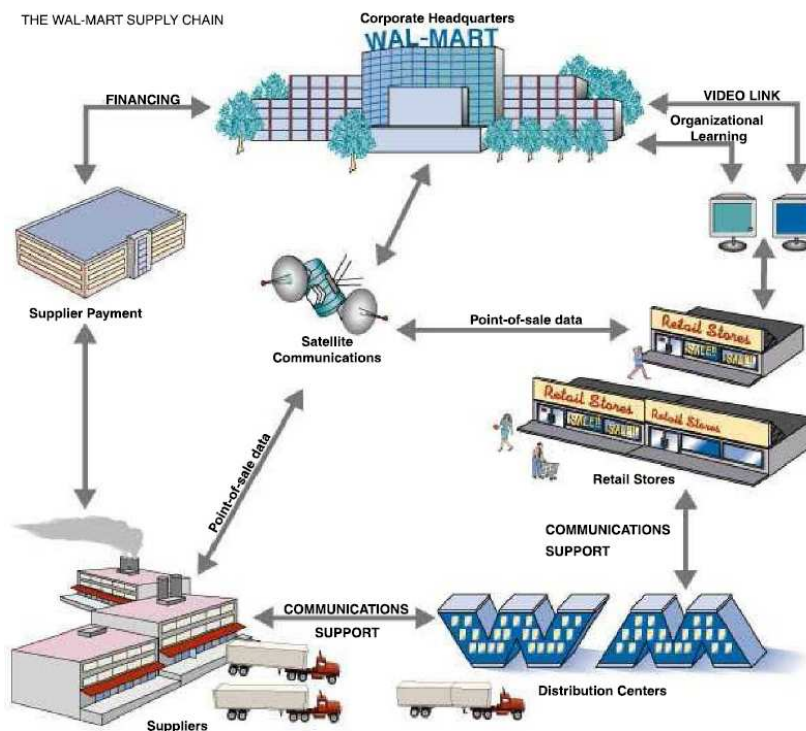


FIGURE 9.1 The Relationship Between Facilities and Functions Along the Wal-Mart Supply Chain

Source: Adapted from Garrison Wieland for "Wal-Mart's Supply Chain," *Harvard Business Review*, vol. 70, no. 2, (March–April 1992) p. 60–61.

In one instance Wal-Mart found it to be more cost-effective to bypass distribution centers and warehouses altogether. Wal-Mart used to hold inventories of Pampers diapers in its warehouse before shipping them to stores. However, after looking at its whole supply chain, Wal-Mart realized that Pampers take up so much space and have such a low profit margin that the company was losing about 20 cents per case just handling the inventory. It found it was more profitable to have diapers shipped directly from the supplier to the store more frequently even though the cost of transportation and store labor would both be higher. By looking at the relationship between components of the supply chain (including inventory, warehousing, transportation and the retail operation) instead of just inventory, Wal-Mart was able to reduce supply chain costs.

Another type of relationship Wal-Mart has developed with some of its suppliers is to have them take over warehousing and shipping. For example, to sell at some Wal-Mart stores Johnson Wax must forecast demand for its own products (shaving gel and air fresheners) using Wal-Mart's weekly sales data and then place its own products on the store shelves.

Supply Chain Linkages

From our preceding discussion about supply chains we are able to identify three primary elements that supply chains consist of: structures, processes, and the linkages between these structures and processes. *Structures* include the organizational units that interact within the supply chain such as the company, its suppliers, its customers, distribution channels, design and engineering centers, and manufacturing and service centers. *Processes* include demand planning and supply planning, forecasting, sourcing and purchasing, manufacturing and service operations, logistics (shipping), order entry, materials management, and new product and service development. The key elements in the overall management of a supply chain are the *linkages* between structures and processes. These linkages are usually in the form of shared information and continuous communication.

In some companies management teams are established to coordinate and manage this information flow. These teams are often in the form of *cross-functional teams*--for example, a team consisting of members from human resources, purchasing and manufacturing who work together to coordinate the interaction among these functions. *Cross-enterprise teams* coordinate processes between different organizations in the supply chain--for example, purchasing, suppliers and distributors. Another important linkage between structures and processes are common measures of performance by which the effectiveness and economy of the supply chain as a whole can be judged. For example, if inventory level is an important company measure of supply chain performance and marketing has no responsibility for inventory, it will seek to maximize inventory in order not to lose any sales. Sometimes linkages are created by establishing co-locations--for example, joining a warehouse and a manufacturing facility or combining a supplier and manufacturing facility at one location.

As mentioned, shared information and communication are critical linkages in successful supply chain management. The flow of materials and activity through a supply chain should be matched by the flow of information. Processes need to be closely linked so that information can flow smoothly between them and they can be effectively coordinated. All the structures and organizational units in the supply chain need to be able to "see" the current status of customer orders and the schedules established to meet those orders quickly and simultaneously. If information is transmitted quickly, accurately, and clearly between the different structures and processes then the entire chain is effectively moving in unison to meet customer needs swiftly. If this is successfully achieved, the need for inventory to compensate for time lags and errors within the supply chain is eliminated; in effect, information can replace inventory.

For many companies the flow of information is still conducted within paper-based systems or ineffective information systems that are uncoordinated, slow, and subject to error. Customers fax handwritten orders to suppliers, who in turn manually enter these orders in their own computer information system, which then generate paper orders that are sent to manufacturing. Materials and parts may be at a factory ready to be put to use, but if there is a significant time lag until the information about an order is processed, then those materials just sit, increasing inventory costs. A company may phone or fax its shipper to schedule the order shipment, and the shipper may process these transaction requests by hand. Inventory stocks are often counted by hand. Alternatively, many companies are now adopting sophisticated new software systems like SAP that create the information linkages that will integrate the processes and structures within a supply chain.

Enterprise Resource Planning Systems: SAP

Enterprise resource planning (ERP) systems are a relatively new type of software that gives companies extensive control over (and provides information about) their business processes, including most of the supply chain functions. This type of software generally includes separate integrated modules for controlling and coordinating business processes like forecasting, inventory, manufacturing, purchasing, logistics, human resources, and sales. These software modules provide the linkages for most of the supply chain functions in a company. ERP systems software has become extremely popular. In 1997 corporations paid more than \$10 billion to ERP companies for applications software, installation, training, and maintenance. The leading ERP software firms are SAP, Oracle, J. D. Edwards, PeopleSoft and Bann. Of these firms SAP is by far the largest, so much so that it has become synonymous with ERP applications software.

SAP AG, a German-based company founded in 1972 by five former IBM engineers is a German acronym for Systeme, Anwendungen, Produkte in der Datenverarbeitung (Systems, Applications, and Products in Data Processing). It has offices in more than fifty countries around the world with more than 15,000 employees and more than 15,000 installations of SAP worldwide. In 1996 it sold more than 9,000 units of its software product, called R/3, and had sales of \$2.4 billion. In 1997, with sales of \$3.5 billion, it had one third of the world's \$10 billion ERP applications software market.

R/3 software includes powerful programs for accounting and controlling, production and materials management, quality management and plant maintenance, sales and distribution, human resources management, and project management. Within these main programs there are more than 1,000 business process modules. R/3 is designed as an integrated system, but the modules can be used individually. R/3 links all of a company's business processes with those of its customers and suppliers to create a complete supply chain covering the entire route from supply to delivery. It acts as a virtual network of shared information that links supply chain structures and processes together so that companies can make quick, coordinated decisions, thereby cutting supply chain costs and reducing uncertainties.

SAP's R/3 software was introduced in 1992. Prior to that SAP's moderately successful R/2 software was designed to link every part of a company's operation while other software firms focused on individual business areas like personnel or manufacturing. It was also able to handle different currencies, languages, and regulations. However, it ran on large mainframe computers, and in the 1980s firms began to abandon mainframes in favor of PCs. The almost instant success of R/3 was because SAP was able to adapt its older generation, powerful mainframe software to work in client-server systems with networks of PCs linked to servers. R/3 was a powerful and attractive tool that could also accommodate many users at the same time in the newly emerging client-server environment. More than 7,000 companies around the world and nearly half of the world's 500 largest companies, including General Electric, Coca-Cola, Intel, IBM, Chevron, Colgate-Palmolive, and Microsoft, now use R/3. R/3 is especially beneficial for large companies involved in global markets. When a customer makes an order and a salesperson enters it in R/3, that transaction ripples throughout the company, adjusting inventory, parts supplies, accounting entries, production schedules, shipping schedules, and balance sheets. Different nations' laws, currencies, and business practices are embedded in R/3, which enables it to translate sales transactions smoothly between business units in different countries--for example, a company in Taiwan and its customer in Brazil.

Figure 9.2 provides an illustrative example of how SAP's R/3 software works. In this example a Japanese retailer of cellular phones places an order with the sales representative of a manufacturer in the United States for 1,000 model A (handheld) cell phones. The sales rep (in step 2) accesses the R/3 sales module from his portable PC and checks the current price of the phones, any discounts the customer may be eligible for, and the customer's credit history. Simultaneously (in step 3) R/3's inventory software checks the available inventory stock of the phones and notifies the sales rep that 500 phones are available in the company's Hong Kong warehouse and can be shipped immediately. The other 500 phones can be delivered from the company's factory in Mexico in one week. R/3's manufacturing software (in step 4) schedules the production of the 500 phones in Mexico while instructing the warehouse in Hong Kong to ship its 500 phones to the customer. R/3 simultaneously schedules the shipment of the phones from the warehouse (in step 5) with the company's shipper. When the production schedule is set R/3's human resource module (in step 6) immediately identifies a labor force shortage at the factory and alerts the personnel manager to hire more workers. At the same time R/3's materials-planning module (in step 7) notifies the purchasing manager to order more cell phone components from suppliers in Brazil and Taiwan. During the week the customer in Japan logs onto the company's R/3 system via the Internet (in step 8) to check on the progress of its order in Mexico. It also learns of the availability of 200 units of a different model colored cell phone, which the customer orders. This transaction data plus all others in the company are automatically entered in the R/3 forecasting and financial modules (in step 9), which the company uses for planning.³

Chevron adopted SAP R/3 in 1992 in an effort to cut purchasing costs and by 1997 reduced these costs by 15 percent. Purchase orders, which used to involve faxes of handwritten forms, now are done much more quickly since transactions are done electronically. IBM adopted SAP as part of its restructuring and reengineering program in the early 1990s. It contracted for twenty-one SAP projects covering 80 percent of its business functions, eight of which were running by 1997

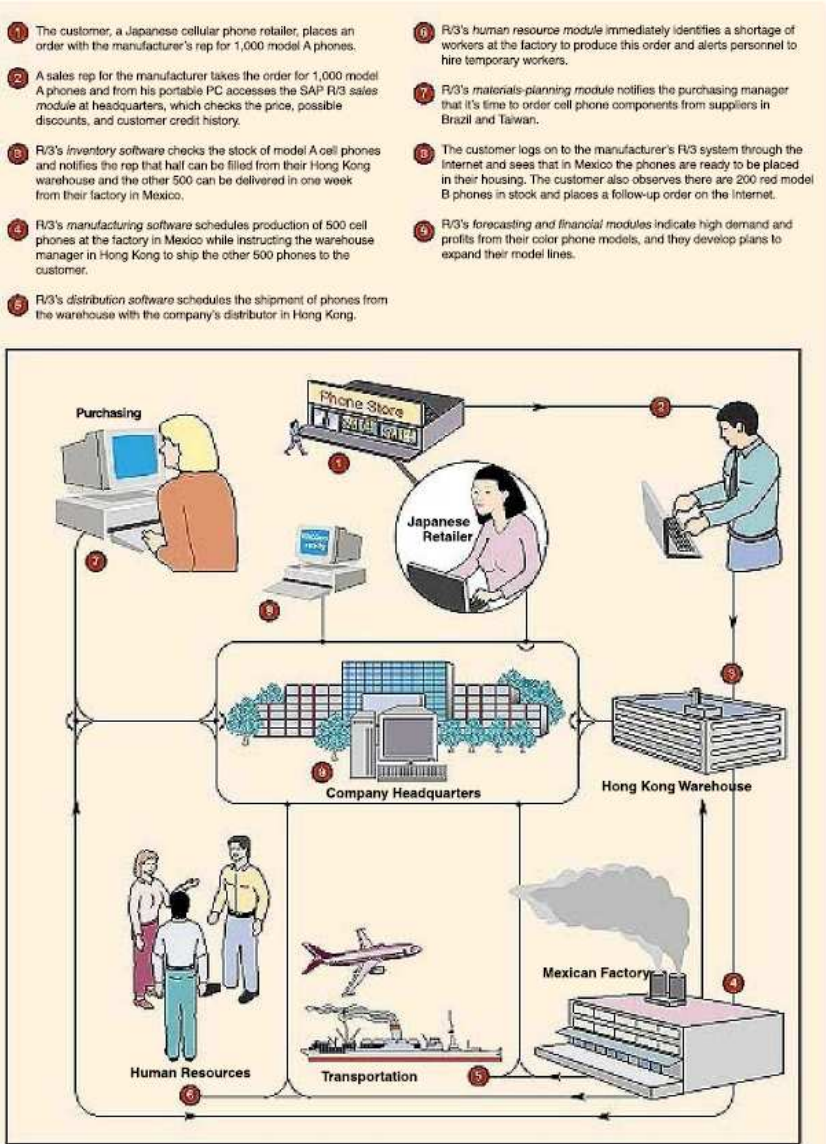


FIGURE 9.2 Linking the Supply Chain with SAP

with positive results. For example, when a customer wanted credit for a returned disk drive it used to take up to three weeks; now the credit is issued while the customer is on the phone. Where IBM staff members used to spend thousands of hours at the end of each month gathering data from many systems and reconciling it for management, it is now done automatically by SAP. The development of a worldwide procurement system with SAP enabled Microsoft to save \$12 million annually just in early-payment discounts from vendors. R/3 enabled Monsanto to cut its production planning from six weeks to three, reduce working capital, and enhance its bargaining position with suppliers, saving the company an estimated \$200 million a year.

However, SAP is not for everyone. It is very costly and complex, costing clients millions of dollars for implementation, thus making its use practical for only larger firms. Companies annually spend almost \$10 billion in computer and networking equipment to run SAP, and a \$20 billion support industry of consultants, trainers, and software firms have grown up around SAP and the other ERP software companies. SAP is very difficult to install and can cost hundreds of millions of dollars. It took five years and \$160 million for Chevron to install SAP. Consulting firms have made a fortune helping companies install SAP.

The Impact of the Internet on the Supply Chain

In our illustrative example of SAP in Figure 9.2, the customer was able to check on the status of their order in step 8 using the Internet. The Internet is beginning to have a major impact on supply chain design and management and in fact appears to be on the verge of revolutionizing the supply chain for many companies. More than 400,000 companies sell goods and services on the Internet, resulting in sales of more than \$5.1 billion in 1998, more than double the 1997 total. However, 80 percent of the business on the Internet is conducted between companies rather than direct consumer sales. That is, the major business use of the Internet is by companies conducting supply chain transactions over the Internet with their suppliers, distributors, and customers.⁴

More than anything else the Internet adds speed and accessibility to the supply chain. Companies are able to reduce or eliminate traditional time-consuming activities associated with ordering and purchasing transactions by using the Internet to link directly to suppliers, factories, distributors, and customers. It enables companies to reduce the time for product design, speed up ordering and delivery of component parts and materials, track orders and sales by the minute, and get instant feedback from customers and suppliers. This combination of reliable information and speed allows companies to minimize inventory. Adaptec, Inc., a California manufacturer of computer storage products, used the Internet to speed up communication with its Taiwanese chip suppliers. It was able to send parts orders to its suppliers, as well as engineering drawings and manufacturing instructions, in seconds. Their time from order to delivery was reduced from as long as sixteen weeks to just fifty-five days, saving more than \$1 million. Adaptec's time for processing purchase orders dropped from six days to just minutes, and work-in-process inventory was reduced by \$9 million. Ernst & Young estimates that inventories could eventually be reduced by \$350 billion if companies use the Internet to share promotional plans, sales forecasts, and point-of-sale data.⁵

Dell Computer's popular "build-to-order" models were initially based on telephone orders by customers. Dell created an efficient supply chain based on a huge number of weekly purchase orders faxed to parts suppliers. However, Dell now sends out orders to suppliers every two hours over the Internet and sells \$5 million worth of PCs daily on the Internet. Dell's suppliers

are able to access the company's inventories and production plans, and they receive constant feedback on how well they are meeting shipping schedules. Dell's speed in customizing and delivering computers is unmatched in the industry. Its inventory on hand is down to eight days (versus twenty-six days at Compaq), and its revenue growth is approximately 55 percent.⁶

The Internet is changing the fundamental nature of doing business within the supply chain. It creates new forms of linkages, blurring the traditional roles of manufacturers, distributors, and suppliers and frequently cutting out intermediaries altogether. It tears down geographic barriers, allowing companies to tap markets and suppliers around the world they could not have reached before. As a result, the Internet has shifted the advantage in the transaction process from the seller to the buyer since it makes it easier for companies to deal with many suppliers in order to get lower prices and better service. General Electric purchased \$1 billion worth of supplies over the Internet in 1997, saving the company 20 percent on material costs because it was able to reach a broader base of suppliers and negotiate better deals. By 2000 GE expects to make \$5 billion in purchases over the Internet, and it expects to save more than \$500 million in purchasing costs from 1999 to 2002.

Extranets allow select business partners of a company (i.e., their suppliers and distributors) access to a company's internal network via the Internet. Hewlett-Packard and Procter & Gamble use extranet links with their ad agencies to exchange marketing plans and accelerate the development of advertising campaigns. The winemaker Robert Mondavi Corporation purchases satellite images from NASA to spot problems with vineyards. It uses an extranet to send these images to independent growers it purchases grapes from to improve their grapes.⁷

Many companies, especially large manufacturers, have already been using an older form of electronic commerce technology, Electronic Data Interchange (EDI), to transmit purchase orders and invoices. EDI provides a secure means for transmitting standardized business forms over private networks. The value of EDI transactions is currently fourteen times higher than business-to-business Internet transactions, although that ratio is expected to change dramatically in the next few years. EDI is expensive and complex to set up, effectively shutting out many companies. However, companies can run their EDI data over the Internet (or convert it to a form that will), which reduces the cost.

◆ Pause and Reflect ◆

***9-1.** Supply chain management is a very important topic in operations. Give some indication of the scope of a typical supply chain by reviewing the Supply Chain Council's Frequently Asked Questions. What does The Supply Chain Council do? What issues is it currently addressing?

9-2. Describe the supply chain, in general terms, for McDonald's and for Ford.

***9-3.** Explore Toronto's Integrated Supply Chain Management Project. What type of research is being conducted? Link to at least one of the project's publications and summarize their findings.

9-4. Define the strategic goals of supply chain management, and indicate how each element of a supply chain (purchasing, facility selection, location, production, inventory, and transportation and distribution) impacts on these goals.

***9-5.** Numerous companies offer supply chain management "solutions." Visit Numetrix, CAPS Logistics, Menlo, Silicon Graphics, Roadway Express, and Federal Express. How do these companies help manage supply chains? Do all five have the same approach? What are the strengths of each?

***9-6.** Describe how industry initiatives such as quick response, agile manufacturing, and flexible ensemble manufacturing relate to supply chain management.

***9-7.** How have advances in communication technology affected the supply chain? Access Electronic Reporting, the Electronic Commerce World Institute, and EDI on Gap-Net for up-to-date information.

These exercises require a direct link to a specific Web site. Click **Internet Exercises for the list of internet links for these exercises.*

² G. Stalk, P. Evans, and L. E. Shulman, "Competing on Capabilities: The New Rules of Corporate Strategy," *Harvard Business Review* 70, no. 2 (March-April 1992): 57-69.

³ G. Edmundson and A. Reinhardt, "Silicon Valley on the Rhine," *Business Week* (November 3, 1997): 162-166.

⁴ R. D. Hof, G. Williams, and G. Saveri, "The 'Click Here' Economy," *Business Week* (June 22, 1998): 122-128.

⁵ A. Reinhardt, "Log On, Link Up, Save Big," *Business Week* (June 22, 1998): 132-138.

⁶ R. D. Hof, G. Williams, and G. Saveri, "The 'Click Here' Economy," *Business Week* (June 22, 1998): 122-128.

⁷ A. Reinhardt, "Log On, Link Up, Save Big," *Business Week* (June 22, 1998): 132-138.

The Global Supply Chain

International trade barriers have fallen, and global markets are changing so that the supply chain of many companies extends around the world. The dissolution of communism opened up new markets in Middle and Eastern Europe, and the creation of the European Community (EC) in 1992 resulted in the world's largest potential economic market of nearly 400 million people. Europe, with a total population of 850 million, is the largest, best-educated, and wealthiest economic group in the world. Asia has experienced dramatic growth in its export-driven economies since trade barriers began falling in the late 1980s and 1990s.

For many U.S. companies eager to enter growing global markets, extending their supply chains to foreign countries represents a strategic challenge. Trading in foreign countries is not "business as usual." Transportation and distribution systems vary significantly among countries in availability, capability, and quality. Few countries have the transportation choices that are available in the United States. Governments frequently play a significant role in international trade by establishing duties or tariffs, import quotas to protect their local businesses, and regulations unique to their own countries. Foreign markets are not

homogeneous and often require customized service in terms of packaging and labeling. These factors and others only increase the amount of uncertainty involved in the flow of goods through the supply chain and result in the need for even higher inventory levels to protect against breaks in the supply chain than might be required domestically. In this section we will discuss some of the opportunities and problems along the global supply chain.

Free Trade and Global Opportunities

The proliferation of trade agreements has changed global markets and has accelerated global trade activity. Nations have joined together to form trading groups, or **nation groups**, and within these groups products move freely with no import tax, called **tariffs** or **duties**, charged on member products. The members of a group charge uniform import duties to nations outside their group, thus removing tariff trade barriers within the group and raising barriers for outsiders. The group adopts rules and regulations for freely transporting goods across borders that, combined with reduced tariffs, gives member nations a competitive advantage over nonmembers. These trade advantages among member nations lower supply chain costs and reduce cycle time--that is, the time required for products to move through the supply chain.

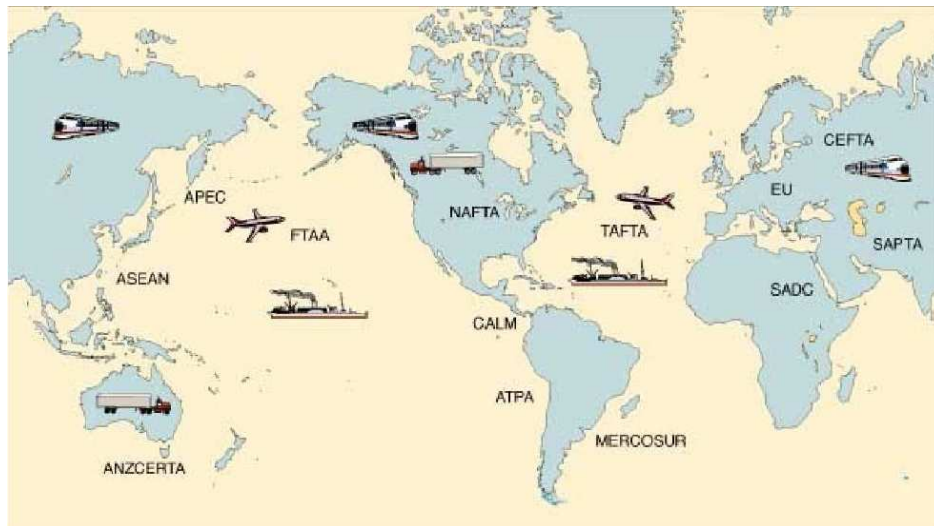


FIGURE 9.3 Global Trading Groups

(See Figure 1.b, page 13 for an explanation of these trade group abbreviations.)

Figure 9.3 shows the international trade groups the United States trades with. NAFTA is the North American Free Trade Agreement, and EU is the European Community trade group, which includes many of the countries of Western Europe. NAFTA has given U.S. auto parts suppliers, for example, an advantage over Japanese competitors with Canadian and Mexican automakers. Kodak has moved some of its production back to North America from Europe to accommodate increased demand for film exports as a result of NAFTA-driven market changes. Caterpillar has indicated that if Chile joins MERCOSUR, the South American trade group, it will shift some of its U.S. production to Brazil to serve customers in Chile. Global trade agreements have also given U.S. companies opportunities in markets previously unaccustomed to cross-border trade. From 1992 to 1994 U.S. exports to most of the emerging market regions (in Middle and Eastern Europe and Asia) participating in free trade agreements increased by more than 20 percent.⁸

Global Supply Chain Problems and Solutions

While new markets and lowered trade barriers have provided U.S. companies with opportunities around the world, they have also created challenges to supply chain management. Trade agreements that benefit member nations create obstacles for nonmembers. Import duties that typically average 5 to 10 percent of product value plus various transport and product regulations can significantly increase supply chain costs and transit times, inhibiting customer service.

To avoid or "drawback" (e.g., get back) duties, many companies have duty specialists, something akin to an international tax lawyer. These specialists advise how duties affect supply chain decisions and how to avoid duties. Digital Equipment Corporation in Europe imports LCD displays from Taiwan to use in the assembly of laptop PCs that it exports back to Taiwan. The import duty on LCDs is 4.9 percent; however, it can be avoided because of a trade regulation that allows a firm to import a product, add value to it, and then reexport it in a different condition.⁹ This and similar duty drawbacks can reduce supply chain costs significantly. However, duty specialists do not always communicate their advice early enough in the process of designing the supply chain so that the company can take advantage of duty drawbacks.

Besides duty specialists, companies often use other international **trade specialists** to help manage transportation and distribution operations in foreign countries. For example, *international freight forwarders* handle the details of air and ship freight shipments and obtain the legal documents necessary for goods to cross foreign borders. This includes booking space on carriers, preparing export declarations, obtaining consular documents (which give permission for goods to enter a country and are used to determine duties), arranging for insurance, and preparing shipping notices that coordinate the physical movement of goods with their payment. *Customs house brokers* manage the movement of imported goods through a country's customs procedures. *Export packers* perform customized packaging and labeling. *Export management companies* handle overseas sales for companies and help them identify foreign companies that can be licensed to manufacture their products. *Export trading companies* combine all the services of international trade in one firm, handling transportation, documentation, and sales.

Inefficient and undersized transportation and distribution systems can be obstacles in newly emerging markets. Ports, roads, and railroads are stretched to the limit across Asia. In China, where rail is the most common and inexpensive mode of transportation, investment in rail transport increased only 3 percent in 1993 compared with 13 percent growth in GNP and 23 percent growth in industrial output. From 1992 to 1993 Asian ports in Singapore, Hong Kong, and Kaohsiung had the highest gains in container traffic in the world, and China's container traffic increased 36 percent from 1993 to 1994, straining capacities to their limit in all of these ports.¹⁰ Suppliers importing raw materials into Mexico face transportation equipment shortages, long and uncertain overland shipment times, and high inventory levels to offset delays. Companies exporting out of Central and Latin America are plagued by ship seizures and truck hijackings that drive transportation costs up and delay customer delivery. Levi Strauss and Co. has suggested these problems can raise costs by as much as 20 percent per year.¹¹

Market instability also creates supply chain problems. Foreign markets tend to be fragmented, unlike homogeneous U.S. markets, forcing companies to customize their operations for each

country in which it does business. Countries in Asia have been compared to islands, each with their own language, customers, and trade regulations. Many newly emerging markets have experienced political turmoil, trade imbalances, and currency fluctuations. For example, since the NAFTA agreement, Mexico has experienced a major devaluation of the peso, political instability, and export surges and recessions. Such problems make it difficult to manage the supply chain in order to maintain inventory levels and delivery times to satisfy customers and minimize costs.

Despite problems the economic opportunities are great among newly emerging global markets. U.S. companies must be innovative and strategically perceptive in their design and management of global supply chains. They must carefully research potential problems and develop strategic plans. Supply chain management must be flexible enough to react to sudden market changes or changes in the transportation and distribution systems and to provide effective customer service anywhere in the world. Companies need to take advantage of new information systems and technologies to help them manage and coordinate the movement of parts and products between countries.

THE COMPETITIVE EDGE

Global Supply Chain Management at Digital Equipment Corporation

Digital Equipment Corporation is one of the world's largest computer manufacturers, with customers in the United States and 81 countries. In the 1970s and 1980s, Digital focused on minicomputers and mainframes, producing most of its own components at 33 plants in 13 different countries. It distributed components, products, and service through 30 distribution and repair centers.

From 1987 to 1991 poor economic conditions plus changes in the computer market brought about by rapid advances in computer technology decreased the demand for large computers and increased demand for networks of smaller, less expensive computers. Faced with the need to produce and distribute many more PCs, which required less space and resources, Digital redesigned its supply chain, including its logistics systems and distribution practices, to deliver a huge number of desktop PCs and workstations instead of a smaller number of large computer systems. Digital's strategy for restructuring was contained in its Global Supply Chain Model (GSCM), which recommends a worldwide production, distribution, and supplier network to determine the fastest, least-costly delivery system. The GSCM was applied to several large sectors within Digital. Digital reduced its plants from 33 to 12 located in three self-contained major customer regions in the Pacific Rim, the Americas, and Europe. Manufacturing costs decreased by \$500 million and logistics costs decreased by more than \$300 million even though the number of units manufactured and shipped increased dramatically. Digital reduced its service facilities from 34 to 17 with associated annual cost reductions of more than \$80 million. In addition, physical assets were reduced by \$34 million, and inventory was reduced by \$74 million. Since 1991 Digital has reduced related costs by \$1 billion and assets by \$400 million while increasing unit production by 500 percent and increasing company revenues.

Source: B. C. Arntzen, G. G. Brawn, T. P. Harrison, and L. L. Trafton, "Global Supply Chain Management at Digital Equipment Corporation," *Interfaces* 25, no. 1 (January-February 1995): 69-93.

Some companies have addressed their supply problems by vertically integrating; for example, investing in their own trucking fleets and distribution systems to control their own product delivery. Companies have also banded together to form consortiums for consolidating shipping, warehousing, and distribution, although problems inevitably arise when competing products travel through the same distribution channels.

Countries are also making infrastructure improvements to sustain and accelerate market growth. The Mexican government is privatizing its railroads and container terminals and is paving its major roads. Foreign investors are actively developing port and container facilities in China. Foreign trucking carriers are being invited to countries to establish transport systems and provide expertise for improving existing ones. Western models for retail distribution with large outlets instead of traditionally small stores are being implemented. Such improvements among the South American countries of MERCOSUR resulted in an increase in U.S. imports in excess of 40 percent from 1992 to 1994.

◆ Pause and Reflect ◆

***9-8.** Describe the current state of the global supply chain. What issues are pressing in international shipping? Inter-American trade? Worldwide trade agreements?

These exercises require a direct link to a specific Web site. Click **Internet Exercises for the list of internet links for these exercises.*

⁸ J. F. Zubrod, Jr., and M. B. Barron, "Trade Pacts Fuel a Transformation in the Rules of Global Logistics," *Transportation and Distribution* 37, no. 4 (April 1996): 60-67.

⁹ B. C. Arntzen, G. G. Brown, T. P. Harrison, and L. L. Trafton, "Global Supply Chain Management at Digital Equipment Corporation," *Interfaces* 25, no. 1 (January-February 1995): 69-93.

¹⁰ J. F. Zubrod, R. Tasiaux, and A. Beebo, "The Challenges of Logistics Within Asia," *Transportation and Distribution* 37, no. 3 (March 1996): 83-86.

¹¹ Zubrod and Barron, "Trade Pacts Fuel a Transformation in the Rules of Global Logistics." *Transportation and Distribution* 37, no. 4 (April 1996): 60-67.

Purchasing and Suppliers

Purchased materials have historically accounted for about half of U.S. manufacturing costs, and many manufacturers purchase more than half of their parts. The purchasing or

procurement function plays a crucial role in supply chain management. Purchasing must make sure that the parts and materials required by the product specifications are of the desired quality and are delivered on time. If poor-quality parts and materials are used, the final product will be of poor quality. If deliveries are late from suppliers, final products will likely be late to the customer.

Purchasing must select suppliers that share the company's commitment to quality and scheduling and that maintain their own quality assurance program for providing good-quality materials and parts. A partnership exists between the supplier and the company. In this partnership the company expects and demands that the supplier monitor its own quality so that it is unnecessary for the company to inspect incoming parts and materials or worry that they will be delivered on time. The supplier, in effect, is an integral part of the company's quality management program and supply chain, and is subject to the same goals and responsibilities as other functional areas. More and more suppliers are recognizing they must adopt TQM to do business with companies that have become quality conscious. In a very competitive global economy, this means that American suppliers often must adopt TQM principles and practices to do business with countries around the world.

Single-Sourcing

In the past many manufacturing companies purposefully purchased a part or material from different suppliers, and it was not unusual for a company to limit its purchases of a part from any single supplier to a maximum percentage (for example, 10 or 15 percent) so the company would not be dependent on the uncertain performance of any one supplier. If a supplier was unable to meet delivery schedules, delivered a poor-quality batch, or even went out of business, the effect on the customer would be dampened by the other suppliers. However, TQM practices have resulted in a new approach called **single-sourcing**.

With single-sourcing, a company purchases a part or material from very few suppliers, sometimes only one. With single-sourcing, a company has more direct influence and control over the quality and delivery performance of a supplier if the company has a major portion of that supplier's volume of business. The company and supplier enter into a partnership, referred to as *partnering*, in which the supplier agrees to meet the quality standards of the customer in terms of parts, materials, service, and delivery. Suppliers become part of the supply chain of the customer. In return, the company enters into a long-term purchasing agreement with the supplier that includes a stable order and delivery schedule. Every part except the engine block in General Motor's Quad 4 engine (its first new engine in several decades) is single-sourced, resulting in only 69 total suppliers, which is half the normal number for a production engine. In return for the suppliers' assurance of top quality and low cost, GM guaranteed the suppliers their jobs for the life of the engine. In the development of its LH cars, the Chrysler Concorde, the Dodge Intrepid, and the Eagle Vision, Chrysler trimmed its supplier base from 3,000 to a few more than 750.¹² Single-sourcing obviously creates an intensely competitive environment among suppliers, with quality and service being factors in the selection process.

An additional aspect of the partnering relationship is the involvement of the supplier in the product design process. In many cases the supplier is given the responsibility of designing a new part or component to meet the quality standards and features outlined by the company. When Guardian Industries of Northville, Michigan, developed an oversized solar glass windshield for Chrysler's LH cars, its engineers met on an almost daily basis with the

Chrysler design team to make sure the quality, features, and cost of the windshield met Chrysler standards. To produce the windshields, Guardian opened a new \$35 million plant in Ligonier, Indiana.¹³

The Supplier-Customer Relationship

Acquiring quality parts and materials is a fundamental principle of TQM and is essential in supply chain management. However, the quality of parts and materials does not completely define the supplier-customer relationship. Another important aspect of this relationship is customer service, which to the customer often means prompt, on-time delivery. Customers insist not only that quality items be supplied but also that they be provided on time and in the right amount. As a result, location and transportation can be important parts of the supply chain.

The impact of the supplier-customer relationship on location is pronounced for those companies that require **on-demand** (also known as *direct-response*) shipments or use the just-in-time (JIT) inventory system. For the supplier, JIT means contracting to deliver small quantities of items to their customers "just in time" for production. This can result in deliveries on a daily basis or even several deliveries per day. For example, every part used on the production line at the Honda Marysville, Ohio, plant is delivered on a daily basis.¹⁴ When deliveries must be made this frequently and on-time delivery is so crucial to the customer's production process, a supplier's proximity to its customer can be a critical factor. Location of the supplier is one of the most important criteria used by JIT companies for selecting and evaluating suppliers.^{15,16,17} Another criterion is on-time delivery performance. Local suppliers are usually preferred, and if that is not possible, suppliers that are close are often given preference.

THE COMPETITIVE EDGE

Supplier Quality and Reliability

Perdue Farms exercises a demanding set of controls over supplier operating procedures, which it closely monitors. As an example, approximately 2,000 farmers receive about 5,000 one-day-old chicks into 5,000 Perdue-built chicken houses. To make sure the Perdue quality process is implemented properly, a team of 100 service agents visits the chicken flocks daily.

In Monsanto Chemical Company's supplier quality-upgrading program called Total Quality/Total Partnership, suppliers are rated according to specific sites, products, and services. In this program, suppliers climb four quality rating levels in the following order: supplier, approved, preferred, and, at the top, partner. Suppliers at the bottom level either move up or out.

Bethlehem Steel Corporation's Supplier excellence certification process evaluated and certified more than 1,250 suppliers and carriers. The certification process includes an evaluation of the supplier's quality system with levels of certification, qualified and preferred, depending on the numerical rating attained from the

evaluation and a positive merit assessment. Suppliers must be certified or risk losing Bethlehem's business.

Union Camp Corporation looks favorably on suppliers who achieve ISO 9000 registration, a "third-party" quality certification process administered by the International Organization of Standards. An outside firm evaluates a supplier's quality management program using international standards.

Honda America's quality and purchasing departments work together to ensure supplier quality. The quality department reviews every supplier of Honda parts and suppliers are certified. Teams of three purchasing engineers are sent to Honda suppliers selected for their Best Position program and work with a three-person team from the supplier to brainstorm on new ways to improve product quality and productivity.

Source: Based on J. P. Morgan and S. Cayer, "Quality: Up and Running," *Purchasing* 112, no. 1 (1992): 69-83.

Cost savings can also be obtained with **continuous replenishment**. Continuous replenishment is by the continuous updating of data shared between suppliers and customers such that replenishment, as managed by the supplier, may occur daily or even more frequently. The customer pays a premium for regular daily deliveries instead of weekly deliveries; however, continuous replenishment reduces the need for warehouse space and inventories, thus saving costs. Express courier service for daily deliveries may increase transportation costs for a company by \$20 million, but it may reduce working capital requirements for warehousing and inventory by \$200 million, thereby reducing overall supply chain costs significantly. However, a successful continuous replenishment system requires accurate product demand forecasting and an information system that includes up-to-date warehouse withdrawal data, shipping data, and point-of-sale data (i.e., computer record of a sale at the retail site) so that the inventory and distribution process can be managed with pinpoint control.

Companies often suggest that potential suppliers relocate nearby if they want to be considered for business. Some larger manufacturing companies, such as in the automobile industry, have informed their suppliers that if they wish to continue supplying the company, they must relocate closer to provide the quality delivery performance and customer service expected. For example, more than 75 percent of the U.S. suppliers for Honda are within a 150-mile radius of their Marysville, Ohio, assembly plant. All the suppliers for Buick City in Flint, Michigan, are within 300 miles or eight hours. Similarly, 75 percent of the suppliers for Ford's Lincoln Continental plant in Wixom, Michigan, are within this same radius. Most suppliers of seats are within 20 miles of the automobile plants they serve. Kasle Steel built a new mill within the gates of Buick City.

In the past GM bought steel in coils from all the major steel producers and shipped it directly to its six metal stamping plants in Michigan. However, two steel processors and a logistics provider are constructing a new \$80 million distribution center in Lansing, Michigan that will

combine manufacturing, warehousing and distribution to process the steel coils on a JIT basis for each of GMs metal stamping plants' needs and streamline deliveries.

Sometimes locating the supplier close to the customer is a quality-driven decision rather than a cost-effective one, especially in service companies. When McDonald's opened a new restaurant in Perth in Western Australia it would have been more cost-effective to supply food and supplies from a central distribution center in Sydney, 4,000 kilometers away. However, this distance would have made it impossible to meet McDonald's normal standards of customer service, which include delivering food products twice a week to each restaurant 98 percent of the time within fifteen minutes of the scheduled order receipt time, and within two days of the order being placed. As a result McDonald's opened a separate warehouse facility in western Australia at the same time it opened the restaurant. Although McDonald's concentrates on minimizing inventory at its distribution warehouses just as GM does, it has not gone to a JIT system because of its standards for delivery and quality customer service. Stockouts are absolutely prohibited at distribution centers, and no expense is spared to make sure that every menu item is always available at every restaurant.¹⁸

◆ Pause and Reflect ◆

***9-9.** Outsourcing is increasingly popular in today's competitive environment. Visit the Outsourcing Institute and summarize the trends and concerns facing companies that elect to "buy" rather than "make."

These exercises require a direct link to a specific Web site. Click **Internet Exercises for the list of internet links for these exercises.*

¹² E. Raia, "The Extended Enterprise," *Purchasing* 114, no. 3 (March 4, 1993), 48-51.

¹³ E. Raia, "The LH Story," *Purchasing* 114, no. 2 (February 18, 1993): 55-57.

¹⁴ E. Raia, "JIT in Detroit," *Purchasing* (1988): 68-77.

¹⁵ A. Ansari and B. Modarress, *Just-In-Time Purchasing* (New York: Free Press, 1990).

¹⁶ R. J. Schonberger and J. P. Gilbert, "Just-In-Time Purchasing: A Challenge for U.S. Industry," *California Management Review* (1983): 58.

¹⁷ S. Dowst, "Quality Suppliers: The Search Goes On," *Purchasing* (September 15, 1988): 94A4-94A12.

¹⁸ P. Ritchie, "McDonald's: A Winner Through Logistics," *International Journal of Physical Distribution and Logistics Management* 20, no. 3 (1990): 21-24.

Types of Facilities

The type of facility is a major determinant of its location. The factors that are important for determining the location of a manufacturing plant are usually different from those that are important in locating a service facility or a warehouse. In this section we discuss the major categories of facilities and the different factors that are important in the location decision.

Heavy Manufacturing

Heavy-manufacturing facilities are plants that are large, require a lot of space, and are expensive to construct, such as automobile plants, steel mills, and oil refineries. The cost of Chrysler's truck transmission plant in Kokomo, Indiana, was \$1 billion, and its engine plant expansion in Detroit cost \$750 million. The cost of Nucor Corporation's new steel mill in Berkeley County, South Carolina, was \$500 million. Ford's transaxle plant in Sterling Heights, Michigan, encompasses 2.7 million square feet of floor space.



A key objective of Honda's corporate philosophy is to manufacture products in markets in which they are sold. Following this objective Honda opened its Marysville, Ohio plant in 1982, the first Japanese auto plant in America. The clean and bright 3.1 million square feet Marysville plant builds 380,000 Honda Accords annually for the U.S. market and for export. The Marysville plant has 5,200 employees, called associates, some of which are shown here eating lunch in the plant cafeteria. All plant employees including managers eat together in the plant cafeteria so that they can "brainstorm" problems together. In 1989 Honda built a plant in nearby East Liberty, Ohio to manufacture Civics, and their engine and transmission plant is located in Anna, Ohio, just north of Dayton. Parts and materials for these plants are purchased from suppliers in 33 states. Five out of every seven Hondas sold in the United States are built here. A virtual tour of the Marysville, Ohio Honda plant can be accessed from the Honda home page on the internet at <http://www.honda.com>.

Factors in the location decision for plants include construction costs, land costs, modes of transportation for shipping heavy manufactured items and receiving bulk shipments of raw materials, proximity to raw materials, utilities, means of waste disposal, and labor availability. Sites for manufacturing plants are normally selected where construction and land costs can be kept at a minimum and raw material sources are nearby in order to reduce transportation costs. Access to railroads is frequently a factor in locating a plant. Environmental issues have increasingly become a factor in plant location decisions. Plants can create pollution, including raw material wastes, burning and air pollution, noise pollution, and traffic pollution. These plants must be located where the harm to the environment is minimized. Although proximity to customers is a factor for some facility types, it is less so for manufacturing plants.

Light Industry

Light-industry facilities are perceived as cleaner plants that produce electronic equipment and components, computer products, or assembled products like TVs; breweries; or pharmaceutical firms.

Some of the largest and most expensive new plants in the United States are being constructed for manufacturing semiconductors and computer chips. Motorola's new \$3 billion semiconductor facility in Goochland County, Virginia, includes fifteen to twenty campus-like buildings, and Intel constructed a new \$2.2 billion semiconductor plant in Hillsboro, Oregon. Land and construction costs tend to be high for these facilities because they make use of the most advanced technology and equipment, and must provide a clean and climate-controlled manufacturing environment. They also depend on a skilled workforce, so they need to be located in attractive, easily accessible geographic areas with good education and training capabilities. Although close proximity to raw materials is not a requirement for light industry, a good transportation system for supply and distribution is required. The environment tends to be a less important factor in light industry since burning raw materials is not part of the production process and there are no large quantities of toxic or hazardous waste.

Warehouses and Distribution Centers

Warehouses are an intermediate point in the supply chain where products are held for distribution. Normally a warehouse is a building that is used to receive, handle, store, and then ship products; however, some of the largest business facilities in the United States are warehouse/distribution centers. Light assembly and packaging may sometimes be done in a warehouse, and some warehouse operators will provide sales support and personnel.

Retail companies that have begun to operate on the Internet sometimes function almost exclusively out of a warehouse-type environment. For example, Amazon.com Books sold trade books online out of a group of offices furnished with desks and computers on the fourth floor of an old building in Seattle, supplemented by a 46,000 square-foot warehouse. The company went online in 1995, and in 1996 its annual sales revenue was estimated to be \$17 million.

Distribution centers for The Gap in Gallatin, Tennessee, Target in Augusta City, Virginia, and Home Depot in Savannah, Georgia, each encompass more than 1.4 million square feet of space--about 30 times bigger than the area of a football field! The UPS Worldwide Logistics warehouse in Louisville, Kentucky, includes 1.3 million square feet of floor space. These centers generally require moderate environmental conditions, although some specialized warehouses require a controlled environment, such as refrigeration or security. Because of their role as intermediate points in the supply chain, transportation costs are often an important factor in the location decision for warehouses. The proximity to markets is also a consideration, depending on the delivery requirements, including frequency of delivery required by the customer. Construction and land costs, labor availability, little proximity to raw materials, and waste disposal are less important.

THE COMPETITIVE EDGE

Restructuring the Supply Chain at Procter & Gamble

Procter & Gamble (P&G) is a worldwide market leader in laundry detergent, diapers, feminine protection pads, shampoos, facial moisturizers, teen acne skin care products, and fabric softener. It produces more than 300 brands of consumer goods at 58 operating unit locations (i.e., plants, divisions, and facilities) around the world with sales (in 1995) of \$33.5 billion. To maintain its 159-year history of continual growth it recently conducted a major restructuring of its North American supply chain encompassing the United States, Canada, and Mexico. This supply chain consisted of hundreds of suppliers, more than 60 plants, 15 distribution centers and more than 50 product categories.

P&G believed it needed to reduce manufacturing expenses and working capital while increasing the speed of moving products to market and avoiding capital investment resulting from the introduction of new product lines at an increasingly faster pace. In addition P&G wanted to reduce costs and provide better customer value by reducing customer inventories, which required the creation of more efficient linkages with their customers.

P&G believed it could save money by restructuring its supply chain for the following reasons. First, deregulation of the trucking industry had lowered transportation costs and product shipping. Product compaction (for example, detergents in concentrated form) allowed for more product to be shipped per truckload. These factors allowed for the elimination of some plants and distribution centers. P&G's quality management initiatives had resulted in higher levels of reliability and increased productivity at every plant, which would also allow for fewer plants. Product life cycles had decreased from three to five years a few decades ago to 18 to 24 months. Since this would require more frequent changes in equipment, fewer plants would be more cost-effective. Finally, P&G had acquired excess plant capacity through several corporate acquisitions. For these reasons P&G developed a restructuring strategy that focused on product sourcing--that is, selecting the best location and scale of operation for making each product and developing an efficient distribution system that complemented this system of facilities.

The supply chain restructuring project at P&G was completed within approximately one year. Twelve facilities were closed, a 20 percent reduction in P&G's North American plants. Fewer plants resulted in higher delivery costs but lower manufacturing expenses and less staff and a more efficient supply chain, plus reductions in the cost of packing materials and ingredients, resulting in overall annual (before tax) savings of more than \$250 million.

Source: J. Camm, T. Chorman, F. Dill, J. Evans, D. Sweeney, and G. Wegryn, "Blending OR/MS, Judgement, and GIS: Restructuring P&G's Supply Chain," *Interfaces*, 27, no. 1 (January-February 1997): 128-142.

Retail and Service

Retail and service operations usually require the smallest and least costly facilities. Examples include retail facilities like groceries and department stores, among many others, and such service facilities as restaurants, banks, hotels, cleaners, clinics, and law offices. However, there are always exceptions, and some service facilities like a hospital, a company headquarters, a resort hotel, or a university academic building can be large and expensive. One of the most important factors for locating a service or retail facility is proximity to customers. It is often critical that a service facility be near the customers it serves, and a retail facility must be near the customers who buy from it. Construction costs tend to be less important, although land or leasing costs can be high. For retail operations, for which the saying "location is everything" is meaningful, site costs can be very high. Factors like zoning, utilities, transportation, environmental constraints, and labor tend to be less important for service operations, and closeness to suppliers is not usually as important as it is to manufacturing firms that must be close to materials and parts suppliers.

◆ Pause and Reflect ◆

9-10. How are the location decisions for service operations and manufacturing operations similar and how are they different?

9-11. Indicate what you perceive to be general location trends for service operations and manufacturing operations.

Site Selection: Where to Locate

When we see in the news that a company has selected a site for a new plant, or a new store is opening, the announcement can appear trivial. Usually it is reported that a particular site was selected from among two or three alternatives, and a few reasons are provided, such as good community, heavy customer traffic, or available land. However, such media reports do not reveal the long, detailed process for selecting a site for a business facility. It usually culminates a selection process that can take several years and the evaluation of dozens or hundreds of potential sites.

Decisions regarding where to locate a business facility or plant are not made often but they tend to be crucial in terms of a firm's profitability and long-term survival. A mistake in location is not easily overcome. Business success often is being "in the right place at the right time." For a service operation such as a restaurant, hotel, or retail store, being in the right place usually means in a location that is convenient and easily accessible to customers.

Location decisions for services tend to be an important part of the overall market strategy for the delivery of their products or services to customers. However, a business cannot simply survey the demographic characteristics of a geographic area and build a facility at the location with the greatest potential for customer traffic; other factors, particularly financial considerations, must be part of the location decision. Obviously, a site on Fifth Avenue in

New York City would be attractive for a McDonald's restaurant, but can enough hamburgers and French fries be sold to pay the rent? In this case, the answer is yes.

Location decisions are usually made more frequently for service operations than manufacturing facilities. Facilities for service-related businesses tend to be smaller and less costly, although a hospital can require a huge investment and be very large. Services depend upon a certain degree of market saturation; the location is actually part of their product. Where to locate a manufacturing facility is also important, but for different reasons, not the least of which is the very high expense of building a plant or factory. Although the primary location criteria for a service-related business is usually access to customers, a different set of criteria is important for a manufacturing facility. These include the nature of the labor force, and labor costs, proximity to suppliers and markets, distribution and transportation costs, energy availability and cost, the community infrastructure of roads, sewers, and utilities, quality of life in a community, and government regulations and taxes.

When the site selection process is initiated, the pool of potential locations for a manufacturing or service facility is, literally, global. In today's international marketplace, countries around the world become potential sites. The site selection process is one of gradually and methodically narrowing down the pool of alternatives until the final location is determined. In the following discussion, we identify some of the factors that companies consider when determining the country, region, community, and site at which to locate a facility.

Global Location Factors

Until the last decade of the twentieth century companies tended to locate within their national borders. This has changed in recent years as companies have begun to locate in foreign countries to be closer to newly emerging markets and to take advantage of lower labor costs. New trade agreements between countries have knocked down trade barriers around the world and created new markets like the European Community (EC). The fall of communism has opened up new markets in Eastern Europe and Asia. The trendy retail clothing store The Gap has opened more than fifty-five stores in the United Kingdom and over seventy in Europe in recent years.

Foreign firms have also begun to locate in the United States to be closer to their customers. Mercedes Benz, BMW, and Honda have all located new facilities in the United States. For both U.S. and foreign companies, the motivation is the same--to reduce supply chain costs and better serve their customers. Relatively slow overseas transportation requires multinational companies to maintain large, costly inventories to serve their foreign customers in a timely manner. This drives up supply chain costs and makes it economical for companies to relocate closer to their markets. In a survey of corporate executives conducted by the International Development Research Council in 1995, one fourth said more than half of their company's revenue came from international operations. Half of the companies surveyed said their growth in the future would come from Asia, and 20 percent said their growth would come from Latin America or Europe.¹⁹

While foreign markets offer great opportunities, the problems with locating in a foreign country can be substantial, making site location a very important part of supply chain design. For example, although China offers an extremely attractive potential market because of its huge population, growing economy, and cheap labor force, it has probably the most inefficient transportation and distribution systems in Asia, and a morass of government

regulations. Nevertheless, U.S. companies' investments in China grew by 500 percent from 1990 to 1994, and total direct foreign investment in China in 1995 totaled \$37 billion, second in the world only to the United States. General Motors in a partnership with Shanghai Automotive Industry is building a new \$1 billion auto plant in Shanghai; Motorola constructed a new \$700 million semiconductor plant in Tianjin; Intel built a new microchip plant in Shanghai; and Avon Products built a new cosmetics plant in Conghua.²⁰

Emerging markets in Russia and the former Soviet states are attractive; however they can also be risky since the free market economy is new to these states. Lack of familiarity with standard business practices and corruption can threaten success for foreign companies. Finland provides a unique site for entering these markets. It is the only member of the European Union to share a border with Russia. Many Finnish citizens speak Russian, Finland's railroads use the same wide-gauge track as Russia's, its ports already handle 80 percent of all goods going to the former Soviet republics, it has a high concentration of skilled and educated workers, and it is a global leader in telecommunications technology.

Quebec, an attractive market for U.S. companies with a population of 7.3 million and a \$125 billion (US) economy, is the ninth largest trading partner of the United States. However, Quebec's separatist movement makes it a questionable location for some foreign companies. An independent Quebec would have to reapply to join the North American Free Trade Agreement (NAFTA), and if it were unsuccessful it could be at a disadvantage as a location site. Despite the possibility of separatism, Bristol-Myers Squibb, Goodyear, Hyundai, IBM, and Kraft Foods are all undertaking multi-million-dollar expansions in the last few years.²¹

Some of the factors that multinational firms must consider when locating in a foreign country include the following:

- Government stability
- Government regulations
- Political and economic systems
- Economic stability and growth
- Exchange rates
- Culture
- Climate
- Export and import regulations, duties, and tariffs
- Raw material availability
- Number and proximity of suppliers
- Transportation and distribution systems
- Labor force cost and education
- Available technology
- Commercial travel
- Technical expertise
- Cross-border trade regulations
- Group trade agreements

Regional and Community Location Factors in the United States

Manufacturing facilities in the United States were historically located in the Midwest, especially in the Great Lakes region. Industry migrated to the sunbelt areas, the Southeast and Southwest, during the 1960s and 1970s, where labor was cheaper (and not unionized), the

climate was better, and the economy was growing. However, in the late 1980s and 1990s, there has been a perceptible shift in new plants and plant expansion back to the nation's agricultural heartland.

From 1995 to 1997 the North Central region, consisting of Illinois, Michigan, and Ohio, attracted more than 6,200 new and expanded facilities--more than any other region in the country. The South Atlantic region was second during this period. Ohio was the top state for new and expanded business facilities with more than 2,900; Texas was second with approximately 2,500. Ohio was also the top state in attracting foreign firms.

Certain states are successful in attracting new manufacturing facilities for a variety of reasons. Ohio, for example, is well located to serve the auto industry along the Interstate-75 corridor, and it is within one-day truck delivery of 60 percent of the U.S. population and two thirds of its purchasing power. It has a good base of skilled and educated labor, a large mass of industry which spawns other businesses, and it has established good incentive programs to attract new businesses. Ohio also benefits from a number of towns and cities with populations less than 50,000 that have a rich agricultural heritage. The residents of these communities have a strong work ethic and are self-reliant and neighborly. These communities typically have quality health services; low crime rates; solid infrastructures of roads, water and sewer systems; open spaces to expand; and quality education.²²

Labor is one of the most important factors in a location decision, including the cost of labor, availability, work ethic, the presence of organized labor and labor conflict, and skill and educational level. Traditionally labor costs have been lower and organized labor less visible across the South and Southwest. While labor conflict is anathema to many companies, in some cases labor unions have assisted in attracting new plants or in keeping existing plants from relocating by making attractive concessions.

The proximity of suppliers and markets are important location factors. Manufacturing companies need to be close to materials, and service companies like fast-food restaurants, retail stores, groceries, and service stations need to be close to customers and distribution centers. Transportation costs can be significant if frequent deliveries over long distances are required. The closeness of suppliers can determine the amount of inventory a company must keep on hand and how quickly it can serve its own customers. Uncertainty in delivery schedules from suppliers can require excessive inventories.

It is important for service-related businesses to be located near their customers. Many businesses simply look for a high volume of customer traffic as the main determinant of location, regardless of the competition. An interstate highway exit onto a major thoroughfare always has a number of competing service stations and fast-food restaurants. Shopping malls are an example of a location in which a critical mass of customer traffic is sought to support a variety of similar and dissimilar businesses. For example, a shopping mall typically has numerous restaurants (sometimes grouped into food courts), several large department stores, and a variety of small specialty stores that sell similar products. In fact, a large department store in a mall will stock almost every product (not brand) that every one of the smaller stores around it also stocks. Instead of seeking a location away from large competitors, these small retail stores cluster together to feed off the customer traffic created by the larger anchor stores. Businesses that rely on a steady customer clientele, such as doctors, dentists, lawyers, barber shops and hair salons, and health clubs often tend to seek locations with limited competition.



Fashion Island Mall in Newport Beach, California is one of the approximately 38,000 shopping centers that operated in the United States during the first part of this decade. These shopping centers accounted for over \$717 billion in annual sales and more than 4 1/2 billion square feet, or 19 square feet for every person in the United States. Three hundred sixty-five of these centers encompassed more than a million square feet each and included an average of 155 stores and businesses, which is more stores than many small towns and communities have. In fact, some of these mega-malls seem like small cities. Shopping centers and malls attract a mass of customers that will support a multitude of different stores and businesses, that on their own could not attract a sufficiently profitable number of customers to a single location. Many retail business chains now locate almost exclusively in shopping centers and malls; thus their location decision becomes one of center selection and where within a center they want to be located. Demographic and geographic considerations are left to the center developers.

Although it is important to be located where customers are in order to make sales, it is also important to be near enough to customers to provide a high level of customer service. This is especially true given the current emphasis and expectations regarding quality service. As international markets have opened up, a number of major manufacturing companies have located plants overseas to minimize transportation costs and be closer to their customers.

Environmental regulations are a factor in many companies' site selection process. An incentive to attract new businesses has been a recent trend to liberalize regulations in many localities. Despite this trend, companies must carefully consider environmental regulations when making their location decision. For example, a new warehouse, considered to be an environmentally "clean" type of facility, may have no difficulty qualifying as an industrial park occupant even under stringent environmental covenants. However, it may later discover it cannot obtain a permit to store products classified as toxic or hazardous. Companies should do their environmental homework before selecting a site.

A company moving into an existing facility should learn about the activities of the previous occupants, or neighbors. They may have left hazardous materials or created conditions which adversely affected the soil or groundwater which the new occupant would have to clean up at considerable expense. Companies should also avoid the following sites: those near landfill areas; sites with underground storage tanks; buildings with asbestos; sites with inadequate sewage treatment, toxic waste discharges by prior occupants, oil and grease leaks from railroads, ships, or highways, runoffs of chemicals (e.g., fertilizers and pesticides) from golf courses and farms; and sites with inadequate storm water drainage.

Another important factor, **infrastructure**, is the collection of physical support systems of a location including the roads, water and sewer, and utilities. If a community does not have a good infrastructure, it must make improvements if it hopes to attract new business facilities. From a company's perspective an inadequate infrastructure will add to its supply chain costs and inhibit its customer service.

As an example of an inadequate infrastructure, consider Martha's Vineyard, an island off the Massachusetts coast. Tourism is virtually the island's sole industry, and in recent years it has been successful in attracting increasing numbers of tourists. Its products are lodging, sightseeing, and food services, and its supply chain includes the road system and ferry that brings tourists to the island. However, visitors have increased so much in recent years that the road system can no longer accommodate the traffic. On the Fourth of July 1995, traffic lined up for three miles on the two-lane road leading to the ferry, angering residents and visitors. The solution was to require ferry reservations sixteen days in advance. However, all ferry space for 1996 was booked by February, leaving many residents without reservations to get on and off the island. Lodging reservations dropped significantly in some parts of the island because visitors were not sure they could make it onto the island.

Factors that are considered when selecting the part of the country and community for a facility are summarized as follows:

- Labor (availability, education, cost, and unions)
- Proximity of customers
- Number of customers
- Construction/leasing costs
- Land cost
- Modes and quality of transportation
- Transportation costs
- Community government
- Local business regulations
- Government services (e.g., Chamber of Commerce)
- Business climate
- Community services
- Incentive packages
- Government regulations
- Environmental regulations
- Raw material availability
- Commercial travel
- Climate
- Infrastructure (e.g., roads, water, sewers)
- Quality of life
- Taxes
- Availability of sites
- Financial services
- Community inducements
- Proximity of suppliers
- Education system

Site Location Factors

When locating at a new site, a business can either purchase or lease an existing building, or select a parcel of land and construct a new facility. Service-related businesses often rent or purchase existing facilities, for example, in shopping malls or office buildings. It is usually more difficult for manufacturing operations to find a building suitable for their specific needs, so construction is required.

If a new facility is built, the factors to consider include the size of the space, potential for expansion, soil stability and content, neighborhood, drainage, direct access to roads, sewer and water connections, utilities, and cost. When evaluating a site for lease or purchase, other considerations (that would be built into a new facility) include structural integrity of the facility, the ability to make alterations to the structure, existing parking and the potential for additional parking, neighborhood, loading-dock facilities, storage, maintenance and utility expenses, the lease rate (or purchase cost), and, if leasing, the length of the lease.

A recent trend in site locations has been industrial and office parks, in which many of the special needs of businesses have been planned for. Industrial parks usually have a combination of available parcels of land and structures that cater to service operations or vendors with storage requirements and light manufacturing. Office parks typically have buildings and office suites that are attractive to white-collar service operations such as insurance companies, lawyers, doctors, real estate, and financial institutions.

Location Incentives

Besides physical and societal characteristics, local incentives have increasingly become a major important factor in attracting companies to specific locations. Incentive packages typically include job tax credits, relaxed government regulations, job training, road and sewage infrastructure improvements, and sometimes just plain cash. These incentives plus the advantages of a superior location can significantly reduce a company's supply chain costs while helping it achieve its strategic goal for customer service.

Toyota selected Princeton, Indiana, a small town 20 miles north of Evansville, as the site for a new \$700 million factory to manufacture its T100 midsize pickup trucks. The factory employs 1,300 and produces about 100,000 trucks per year. State and local government officials provided a \$72 million incentive package that included \$12 million to construct a new interchange and other improvements on US-41, \$2.8 million to help train workers, and a maximum of \$15 million in job tax credits for workers hired at the plant. However, this package was small compared with some offered by other states to attract automakers. Alabama offered an incentive package worth approximately \$252 million to attract a Mercedes plant in 1993, and South Carolina provided BMW with a \$130 million package for a plant in 1992.²³

THE COMPETITIVE EDGE

Competing with Attractive, Small-Town Facility Location Sites in
Ohio

From 1993 to 1995 Ohio was selected by Site Selection magazine as the top state in the United States for new and expanded business location sites. Ohio is an attractive location because of its large number of "micropolitan" communities, cities, and towns with a population of less than 50,000, that are economically, politically, and socially self-sustaining. Such small towns in the heartland of America are a favorite location site of industry.

An Ohio micropolitan community that has been successful in attracting new businesses is Bowling Green. Strategically located 20 miles from Toledo on I-75, it is the home of Bowling Green State University, itself an attractive asset to companies. The port of Toledo, one of the top three on Lake Erie, and Toledo Express Airport, hub for two international air freight carriers, are only 30 minutes away, and Detroit is 85 miles away. Bowling Green has inexpensive electricity with a reliable power system; the terrain is flat and inexpensive to develop, and the university provides a versatile student work force.

Another Ohio community that has been successful in attracting businesses is Marysville. Marysville, about 30 miles west of Columbus with a population of 10,000, gained international exposure in the 1980s when it was selected as the site for Honda's first manufacturing facility in America. Honda installed its TQM program, the "Honda Way," at Marysville, which was instrumental in changing American automaking, and Honda was the first Japanese automaker to supply world markets from the United States at Marysville. The city is also the home of the corporate headquarters of the Scotts Co., the world's foremost producer of home lawn-care products, the Nestlé R&D center, and a Goodyear plant. Marysville exhibits many of the attractive location features found in other Ohio small towns including ample development sites, flat terrain, close proximity to transportation and distribution centers, a strong area work ethic, good quality of life, few government restrictions, low cost of living, and little crime.

Source: Ohio Hometown: "The Case for the Micropolitan Community," *Site Selection* 41, no. 1 (February 1996): 2-5; "Bowling Green: Endowed with Education, Rural Work Ethic," *Site Selection* 41, no. 1 (February 1996): 6-7; "Marysville: International Home Town," *Site Selection* 41, no. 1 (February 1996): 18-19.

North Carolina also has an attractive incentive program administered through its Industrial Recruitment Competitive Fund. Inducements available to companies include cash incentives and a strong worker training program through the statewide community college system. Its Job Creation Tax Credit program provides new or expanding businesses a tax credit of \$2,800 per new job created, for a minimum of nine new jobs. An Industrial Development Fund provides up to \$2,400 for each new job created up to a maximum of \$250,000. Also available are industrial development bonds. Locally communities will prepare sites, make infrastructure improvements, and extend rails and utilities to plant sites.²⁴

THE COMPETITIVE EDGE

Using a Site Specialist at Motorola to Locate a New Semiconductor Plant

When Motorola selected Goochland County, Virginia, near Richmond for its new \$3 billion semiconductor manufacturing plant, it ended a two-year search process that started with a list of 300 potential areas around the country. Motorola's first step was to hire a site search specialist from Park One, a real estate and facilities consulting firm in Virginia Beach.

The search specialist first reduced the list of sites to 30, primarily in the Southeast where right-to-work laws prohibit employees from being required to join unions. In May 1994 the specialist met with key representatives from organizations in the Richmond area, including the Greater Richmond Partnership, the Virginia Department of Economic Development, Virginia Power, the engineering school at Virginia Commonwealth University, Richmond International Airport, and other companies in the area such as AT&T. In August 1994 Motorola's vice president for construction was given a tour of the three finalist sites near Raleigh and Durham, North Carolina, Austin, Texas, and in Goochland County, Virginia. The 370-acre site in Goochland County, with wooded seclusion, rolling topography, and good roads and utilities was the best the VP had ever seen for a semiconductor operation. From that point Motorola engaged in serious dialogue with state and local officials about labor force, taxes, utilities, the environment, and education. State officials presented an incentive package to Motorola, and in late November and early December 1994 the president of Motorola's semiconductor products division visited Richmond and the Goochland County site and met with key local leaders and officials. The process ended in April 1995 when Motorola purchased the Goochland site and eventually built a 20-building facility that created 5,000 jobs in the area.

Source: M. Martz, "Motorola Plant Site Sold Itself," *Richmond Times-Dispatch*, April 16, 1995, pp. A1, A12.

States and communities cannot afford to overlook incentives if they hope to attract new companies and jobs. However, they must make sure that the amount of their investment in incentive packages and the costs they incur for infrastructure improvements are balanced against the number of new jobs developed and the expansion of the economy the new plant will provide. Incentives are a good public investment unless they bankrupt the locality. A \$150 million incentive package that Kentucky used to attract Toyota in the 1980s is estimated to have cost \$50,000 per job created.²⁵ While some small communities are successful in attracting new businesses, they are left with little remaining tax base to pay for the infrastructure improvements needed to support the increased population drawn by job demand. Thus, states and communities, much like businesses, need a strategy for economic development that weighs the costs versus the benefits of attracting companies.

Pause and Reflect

***9-12.** Visit Site Selection Magazine's web site. Choose a few articles to read and summarize.

9-13. What factors make the southern region of the United States an attractive location for service and manufacturing businesses?

9-14. What location factors make small cities and towns in the Midwest attractive to companies?

9-15. Select a major (light or heavy) manufacturing facility in your community or immediate geographic area (within a radius of 100 miles), and identify the factors that make it a good or poor site, in your opinion.

These exercises require a direct link to a specific Web site. Click **Internet Exercises for the list of internet links for these exercises.*

¹⁹ A. Pennington, "Global Facilities Go Gangbusters," *Site Selection* 41, no. 1 (February 1996): 156-60.

²⁰ Ibid.

²¹ J. Lyne, "What Next, Quebec?" *Site Selection* 41, no. 1 (February 1996): 58-62.

²² T. Venable, "Triple Crown, Ohio Gallops to Third Straight Win in U.S. Business Location Race," *Site Selection* 41, no. 1 (February 1996): 124-40; and "Ohio Hometown: The Case for the Micropolitan Community," *Site Selection* 41, no. 1 (February 1996): 2-5.

²³ T. Venable, "Toyota Turns into Indiana with \$700 Million Truck Plant," *Site Selection* 41, no. 1 (February 1996): 46-52.

²⁴ L. Liston, "North Carolina's Eastern Eden," *Site Selection* 41, no. 1 (February 1996): 2-12.

²⁵ J. A. Finkle, "Location Incentives Are Unfair and Poorly Justified," *Site Selection* 41, no. 1 (February 1996): 54-55.

Location Analysis Techniques

We will discuss three techniques to help a location decision--the location rating factor, the center-of-gravity technique, and the load-distance technique. The location factor rating mathematically evaluates location factors, such as those identified in the previous section. The center-of-gravity and load-distance techniques are quantitative models that centrally locate a proposed facility among existing facilities.

Location Factor Rating

The decision where to locate is based on many different types of information and inputs. There is no single model or technique that will select the "best" site from a group. However, techniques are available that help to organize site information and that can be used as a starting point for comparing different locations.

In the **location factor rating** system, factors that are important in the location decision are identified. Each factor is weighted from 0 to 1.00 to prioritize the factor and reflect its importance. A subjective score is assigned (usually between 0 and 100) to each factor based on its attractiveness compared with other locations, and the weighted scores are summed. Decisions typically will not be made based solely on these ratings, but they provide a good way to organize and rank factors.

EXAMPLE 9.1	Location Factor Rating
------------------------	-------------------------------

The Dynaco Manufacturing Company is going to build a new plant to manufacture ring bearings (used in automobiles and trucks). The site selection team is evaluating three sites, and they have scored the important factors for each as follows. They want to use these ratings to compare the locations.

<i>Location Factor</i>	<i>Weight</i>	<i>Scores (0 to 100)</i>		
		<i>Site 1</i>	<i>Site 2</i>	<i>Site 3</i>
Labor pool and climate	0.30	80	65	90
Proximity to suppliers	0.20	100	91	75
Wage rates	0.15	60	95	72
Community environment	0.15	75	80	80
Proximity to customers	0.10	65	90	95
Shipping modes	0.05	65	92	65
Air service	0.05	50	65	90

SOLUTION:

The weighted scores for each site are computed by multiplying the factor weights by the score for that factor. For example, the weighted score for "labor pool and climate" for site 1 is

$$(0.30)(80) = 24 \text{ points}$$

The weighted scores for each factor for each site and the total scores are summarized as follows:

<i>Location Factor</i>	<i>Weighted Scores</i>		
	<i>Site 1</i>	<i>Site 2</i>	<i>Site 3</i>
Labor pool and climate	24.00	19.50	27.00
Proximity to suppliers	20.00	18.20	15.00
Wage rates	9.00	14.25	10.80
Community environment	11.25	12.00	12.00
Proximity to customers	6.50	9.00	9.50
Shipping modes	4.25	4.60	3.25
Air service	2.50	3.25	4.50
Total score	77.50	80.80	82.05

Site 3 has the highest factor rating compared with the other locations; however, this evaluation would have to be used with other information, particularly a cost analysis, before making a decision.

Center-of-Gravity Technique

In general, transportation costs are a function of distance, weight, and time. The **center-of-gravity**, or *weight center*, technique is a quantitative method for locating a facility such as a warehouse at the center of movement in a geographic area based on weight and distance. This method identifies a set of coordinates designating a central location on a map relative to all other locations.

The starting point for this method is a grid map set up on a Cartesian plane, as shown in Figure 9.4. There are three locations, 1, 2, and 3, each at a set of coordinates (x_i, y_i) identifying its location in the grid. The value W_i is the annual weight shipped from that location. The objective is to determine a central location for a new facility.

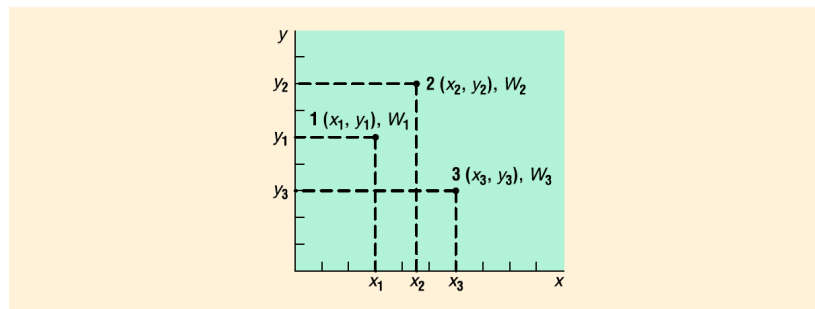


FIGURE 9.4 Grid Map Coordinates

The coordinates for the location of the new facility are computed using the following formulas:

$$x = \frac{\sum_{i=1}^n x_i W_i}{\sum_{i=1}^n W_i}, \quad y = \frac{\sum_{i=1}^n y_i W_i}{\sum_{i=1}^n W_i}$$

where

x, y = coordinates of the new facility at center of gravity

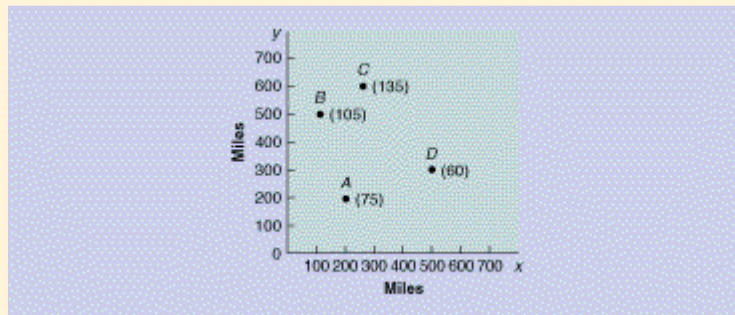
x_i, y_i = coordinates of existing facility i

W_i = annual weight shipped from facility i

EXAMPLE 9.2

The Center-of-Gravity Technique

The Burger Doodle restaurant chain purchases ingredients from four different food suppliers. The company wants to construct a new central distribution center to process and package the ingredients before shipping them to their various restaurants. The suppliers transport ingredient items in 40-foot truck trailers, each with a capacity of 38,000 pounds. The locations of the four suppliers, A, B, C, and D, and the annual number of trailer loads that will be transported to the distribution center are shown in the following figure:



Using the center-of-gravity method, determine a possible location for the distribution center.

SOLUTION:

A	B	C	D
$x_A = 200$	$x_B = 100$	$x_C = 250$	$x_D = 500$
$y_A = 200$	$y_B = 500$	$y_C = 600$	$y_D = 300$
$w_A = 75$	$w_B = 105$	$w_C = 135$	$w_D = 60$

$$x = \frac{\sum_{i=A}^D x_i w_i}{\sum_{i=A}^D w_i}$$

$$= \frac{(200)(75) + (100)(105) + (250)(135) + (500)(60)}{75 + 105 + 135 + 60}$$

$$= 233$$

$$y = \frac{\sum_{i=A}^D y_i w_i}{\sum_{i=A}^D w_i}$$

$$= \frac{(200)(75) + (500)(105) + (600)(135) + (300)(60)}{75 + 105 + 135 + 60}$$

$$= 444$$

Thus, the suggested coordinates for the new distribution center location are $x = 238$ and $y = 444$. However, it should be kept in mind that these coordinates are based on straight-line distances, and in a real situation actual roads might follow more circuitous routes.

Load-Distance Technique

A variation of the center-of-gravity method for determining the coordinates of a facility location is the **load-distance technique**. In this method, a single set of location coordinates is not identified. Instead, various locations are evaluated using a load-distance value that is a measure of weight and distance. For a single potential location, a load-distance value is computed as follows:

$$LD = \sum_{i=1}^n l_i d_i$$

where

LD = the load-distance value

l_i = the load expressed as a weight, number of trips, or units being shipped from the proposed site to location i

d_i = the distance between the proposed site and location i

The distance d_i in this formula can be the travel distance, if that value is known, or can be determined from a map. It can also be computed using the following formula for the straight-line distance between two points, which is also the hypotenuse of a right triangle:

$$d_i = \sqrt{(x_i - x)^2 + (y_i - y)^2}$$

where

(x, y) = coordinates of proposed site

(x_i, y_i) = coordinates of existing facility

The load-distance technique is applied by computing a load-distance value for each potential facility location. The implication is that the location with the lowest value would result in the minimum transportation cost and thus would be preferable.

EXAMPLE 9.3

The Load-Distance Technique

Burger Doodle wants to evaluate three different sites it has identified for its new distribution center relative to the four suppliers identified in Example 9.2. The coordinates of the three sites under consideration are as follows:

Site 1: $x_1 = 360, y_1 = 180$

Site 2: $x_2 = 420, y_2 = 450$

Site 3: $x_3 = 250, y_3 = 400$

SOLUTION:

First, the distances between the proposed sites (1, 2, and 3) and each existing facility (A, B, C, and D), are computed using the straight-line formula for d_i :

$$\begin{aligned}\text{Site 1: } d_A &= \sqrt{(z_A - x_1)^2 + (y_A - y_1)^2} \\ &= \sqrt{(200 - 360)^2 + (200 - 180)^2} \\ &= 161.2\end{aligned}$$

$$\begin{aligned}d_B &= \sqrt{(z_B - x_1)^2 + (y_B - y_1)^2} \\ &= \sqrt{(1000 - 360)^2 + (500 - 180)^2} \\ &= 412.3\end{aligned}$$

$$\begin{aligned}d_C &= \sqrt{(z_C - x_1)^2 + (y_C - y_1)^2} \\ &= \sqrt{(250 - 360)^2 + (600 - 180)^2} \\ &= 434.2\end{aligned}$$

$$\begin{aligned}d_D &= \sqrt{(z_D - x_1)^2 + (y_D - y_1)^2} \\ &= \sqrt{(500 - 360)^2 + (300 - 180)^2} \\ &= 184.4\end{aligned}$$

$$\text{Site 2: } d_A = 333, d_B = 323.9, d_C = 226.7, d_D = 170$$

$$\text{Site 3: } d_A = 206.2, d_B = 180.3, d_C = 200, d_D = 269.3$$

Next, the formula for load distance is computed for each proposed site:

$$\begin{aligned}\text{LD}(\text{site 1}) &= \sum_{i=1}^n k_i d_i \\ &= (75)(161.2) + (135)(412.3) + (135)(434.2) + (60)(184.4) \\ &= 125,063\end{aligned}$$

$$\begin{aligned}\text{LD}(\text{site 2}) &= (75)(333) + (105)(323.9) + (135)(226.7) + (60)(170) \\ &= 99,789\end{aligned}$$

$$\begin{aligned}\text{LD}(\text{site 3}) &= (75)(206.2) + (105)(180.3) + (135)(200) + (60)(269.3) \\ &= 77,555\end{aligned}$$

Since site 3 has the lowest load-distance value, it would be assumed that this location would also minimize transportation costs. Notice that site 3 is very close to the location determined using the center-of-gravity method in Example 9.2.

Computerized Location Analysis with Excel, POM for Windows, and Excel OM

Location factor ratings can be done with Microsoft Excel. Exhibit 9.1 shows the Excel spreadsheet for Example 9.1. Notice that the active cell is E12 with the formula (shown on the formula bar at the top of the spreadsheet) for computing the weighted score for site 1.

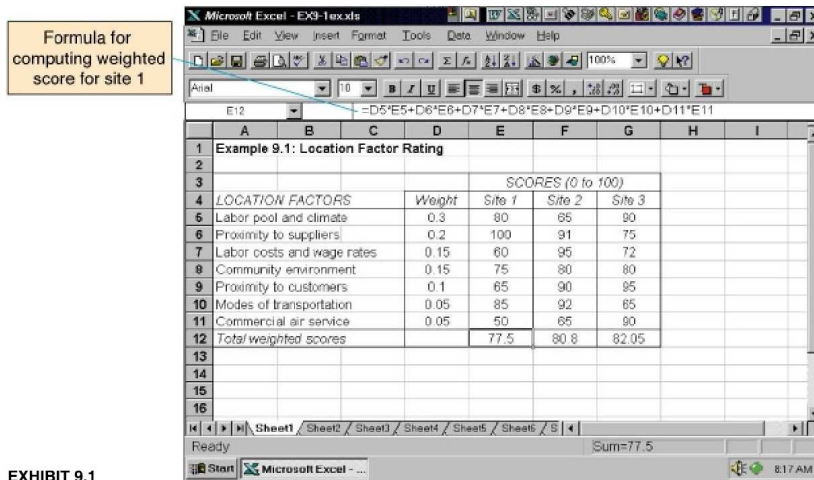


EXHIBIT 9.1

POM for Windows also has a module for computing location factor ratings as well as the center-of-gravity technique. The solution screen for the application of the center-of-gravity technique in Example 9.2 is shown in Exhibit 9.2.

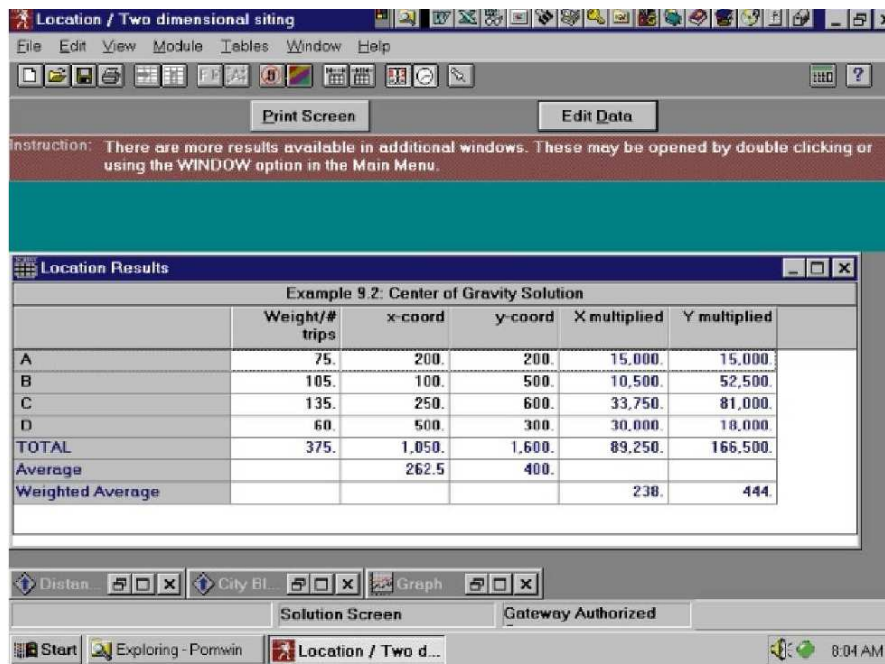


EXHIBIT 9.2

Excel OM also has modules for location factor ratings and the center-of-gravity technique. Exhibit 9.3 and Exhibit 9.4 show the solution screens for Examples 9.1 and 9.2, respectively.

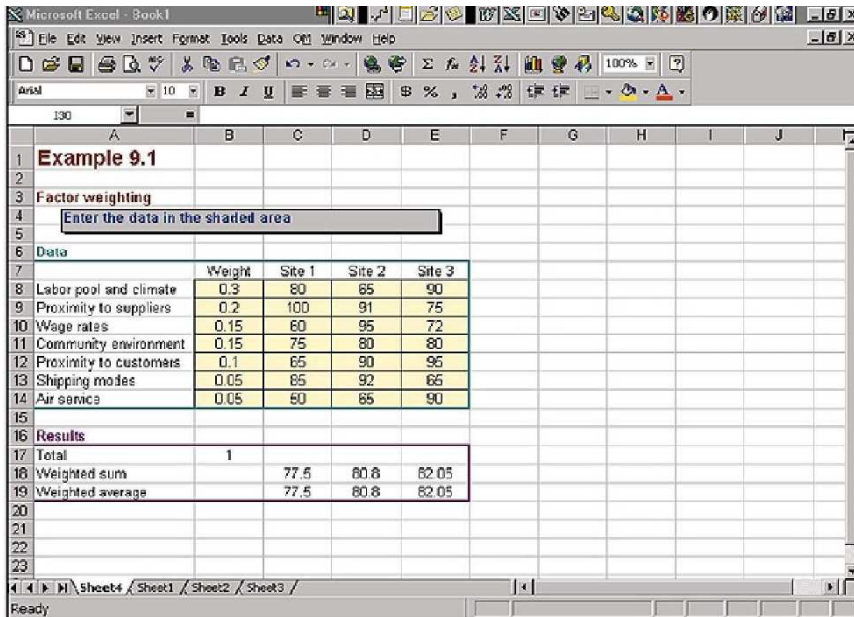


EXHIBIT 9.3

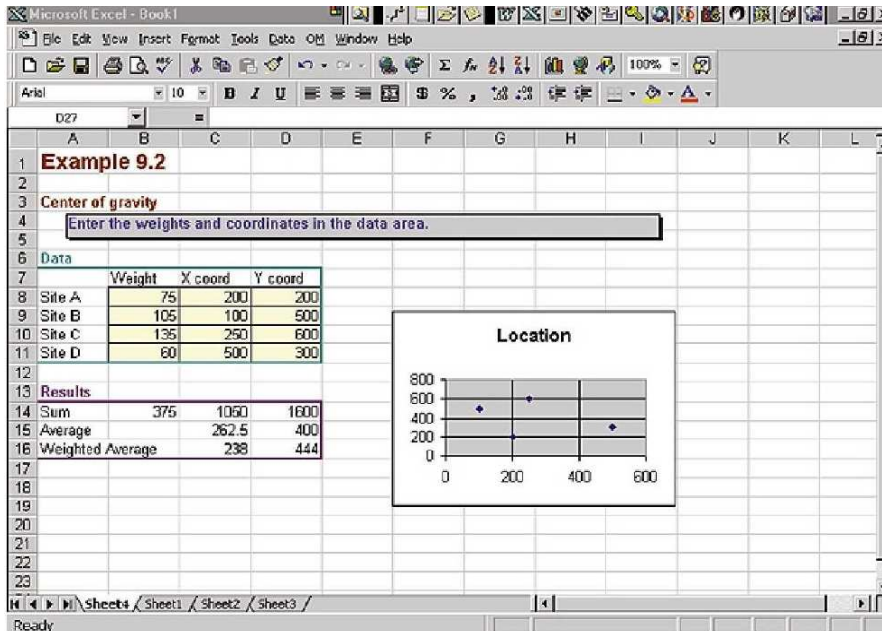


EXHIBIT 9.4

◆ Pause and Reflect ◆

9-16. What would be the important location factors that McDonald's might consider before opening up a new restaurant?

9-17. The following businesses are considering locating in your community:

- A pizza delivery service
- A sporting good store
- A small brewery
- A plant making aluminum cans

Describe the positive and negative location factors for each of these businesses.

9-18. Assume that you are going to open a fast-food restaurant in your community. Select three sites. Perform a location factor analysis for each and select the best site.

9-19. Suppose your college or university were planning to develop a new student center and athletic complex with a bookstore, theaters, meeting areas, pool, gymnasium, and weight and exercise rooms. Identify three potential sites on your campus for this facility and rank them according to location factors you can identify.

Transportation and Distribution Systems

Transportation is a key element in successful supply chain management. For some manufacturing firms, transportation costs can be as much as 20 percent of total production costs. For service companies involved in the distribution of retail items such as catalog sales, it can be even higher. In one year L. L. Bean ships approximately 11 million packages, 650,000 in a week, which is about 19 tractor-trailer loads. During the Christmas season, it will fill a 40-foot UPS trailer every 20 minutes.

Transportation costs depend largely on where a company is located relative to its suppliers, warehouses, distribution centers, and customers. The level of customer service--speed and frequency of delivery--required by a company's customers can determine the mode of transportation and costs. Inventory levels within a company's supply chain are affected by the mode of transportation used and how close it is to the company's physical facilities. The transportation mode selected by a company can dictate the type of material handling, packaging, loading, and order processing systems used.

The five principal modes of transportation within the United States and between countries are railroads, highways (trucking), water, air, and pipelines. In the United States the greatest volume of freight is shipped by railroads (approximately one third of the total), followed by trucking, pipeline, and inland waterways. By far the smallest volume is carried by air. The cheapest modes of transportation are pipelines and water, each averaging less than 2 cents per ton-mile (one ton of freight carried one mile), with rail costs slightly higher at 3 cents per ton-mile. Truck costs are a little less than 40 cents per ton-mile and air freight over twice as high as trucking at about 90 cents per ton-mile. Air is obviously the fastest form of transportation, and water and pipeline are the slowest. Trucks are faster than railroads for short distances, and they are about even over longer distances. However, because of different shipping requirements and the availability of different modes of transportation as goods move between regions of the country and between countries around the world, different modes of transportation are often combined. This is referred to as *intermodal transportation*.

Railroads

There are more than 150,000 miles of railroad lines in the United States, most concentrated in the East and Midwest. Railroads are particularly good for transporting low-value, high-density, bulk products such as raw materials over long distances between major distribution centers. Such products generally require little sorting or classification. Of the total annual rail freight tonnage, a little more than half comprises coal, minerals, and ores, with coal accounting for more than 40 percent. In fact, 90 percent of all coal transport is by train.

In general, railroads have not been as economical for shipping small loads over short distances because of the high cost of terminal handling and the inflexibility of rail lines. Railroads also operate on less flexible schedules than trucks, and they usually cannot go directly from one business location or plant to another as trucks can; trains operate from railyard to railyard. Rail transportation is also usually slower than trucking, since shipments spend some amount of time being put together as trains at terminals. Rail freight service has the worst record of quality performance of all modes of freight transport--almost ten times more late deliveries than trucking.²⁶



In one form of intermodal transportation, goods are loaded into truck trailers or containers, driven to a rail intermodal yard, and loaded on rail cars such as the double stack cars shown here. The railway hauls the cars to other terminals or ports, where the trailers or containers may be transferred to ships or be delivered by truck to their final destinations. This combines the flexibility of trucking for pickup and delivery with the low cost of long haul rail service. Through the 1980s and into the 1990s more than 4 million intermodal trailer loads were moved annually in the United States. Norfolk Southern uses cars (such as the double stack cars shown here) extensively to meet JIT manufacturing demands of automotive industry customers in the Detroit area. On the west coast the Southern Pacific Railroad originates thirty-five eastbound double stack trains per week from Southern California alone.

Railroads have made several innovations to help overcome some of these disadvantages and to compete more effectively with trucking for smaller loads. *Intermodal rail service* hauls truck trailers or containers on railroad flatcars or specially designed "well cars," which feature a well-like lower section in which the trailer or container rides. They combine the low-cost, long-distance travel of trains with the flexible delivery and pickup capabilities of trucking.

Double-stacking, stacking one container on top of another on a railcar, as pioneered by American President Lines (APL) in 1984, can be as much as 40 percent cheaper than long-haul trucking. APL operates a long-haul container network of fifty-nine terminals in the United States, Mexico, and Canada. Triple-stacking was introduced by Mark VII, an intermodal carrier, in 1994.

Another recent innovation is the Road-Railer--a truck trailer with steel wheels for rail travel and rubber tires for road travel. These trailers can swiftly change from highway to rails and back again, allowing for more scheduling flexibility, faster deliveries, and smaller loads.

Intermodal shipping that combines rails and trucking grew faster than any other segment of the freight shipping industry from 1993 to 1995, averaging 5.7 percent compound annual growth since 1988. By 1997 intermodal transportation is expected to carry 35 percent of all freight shipments of 500 miles or more. Procter and Gamble ships between 7 and 10 percent of its freight intermodally, about 50,000 to 60,000 containers per year. However, P&G still adds a safety stock to loads to offset late rail deliveries. For example, if the Chicago to Los Angeles transit time is three days, P&G allows four days to make sure of on-time delivery to their customers.²⁷ However, these forms of intermodal shipping have demonstrated a much higher level of quality performance than traditional rail freight service, comparing more favorably with trucking.

Trucking

Trucking is the most used mode of freight transportation in the United States. Trucks provide flexible point-to-point service, delivering small loads over short to long distances over widely dispersed geographic areas. The trucking system is extensive, with thousands of firms in the United States, and service is typically fast, reliable, and less damage-prone than rail shipping. However, although the ability to handle small loads efficiently is an advantage, the inability to carry large loads economically is trucking's most serious disadvantage. Trucks also lose their cost advantage over railroads over long distances when terminal handling costs are proportionally less of the total transport bill and labor costs are proportionally more.

Companies that have adopted TQM programs and JIT systems or require on-demand delivery have put increased pressure on truck carriers to improve performance. This means picking up and delivering orders complete and free from damage, on time, with the paperwork in order, at a low cost. Carriers are now being looked at as a critical part of the supply chain from the supplier to the purchaser/processor to the eventual customer. An effective relationship between suppliers and their customers/purchasers can be disrupted by a carrier that is unable to meet tight delivery schedules and damages loads during transit. As a result many companies have reduced the number of truck carriers they employed to select a few, or single-sourcing their transportation needs.

Single-sourcing in transportation means reducing the number of transportation carriers to relatively few, although not usually one. From 1993 to 1996 DuPont reduced its truck carrier base from twenty to about five. Over a five-year period, Monsanto cut its carriers from ten to several.²⁸ For the shipper and the carrier the advantages of single-sourcing include economies of scale, more volume per carrier, and the shipper becomes a more important customer. Single-sourcing results in a stronger relationship between shippers and carriers such that they become more dependent on each other and more willing to help each other. Some companies, as part of the strategic design of their supply chain, are selling their private carrier fleets and single-sourcing their transportation needs to focus more closely on their core businesses. Other companies use only one carrier but allow that carrier to outsource to other carriers from a group acceptable to the shipper. In this type of relationship the carrier is usually obligated to take 100 percent of a customer's loads; it cannot turn down anything. Others like Wal-Mart have their own private truck fleet in order to gain more direct control over their supply chain.

Single-sourcing is also becoming a factor in rail transportation, but not necessarily by design from the shipper's perspective. Railroads have been consolidating through mergers, leaving many shippers with only one rail source. These may leave some U.S. locations in a noncompetitive situation for rail transport, which may ultimately result in shippers seeking

alternatives with truck carriers. This will be especially true if the trend toward smaller, more frequent deliveries with less inventory continues.

Airfreight

In recent years there has been a proliferation of airfreight carriers that carry relatively small packages, including UPS, DHL, Federal Express, and Puralator, domestically and overseas. However, the majority of this type of air cargo moves on passenger flights. Even though air transport is the least utilized of all shipping modes, it is the fastest growing. In 1995 total domestic and internal airfreight emanating from the United States grew by 4.5 percent while total international airfreight increased by almost 8 percent.



The Federal Express Superhub in Memphis, Tennessee, is the headquarters of Federal Express. Federal Express, the industry leader in overnight mail service, began to see its market share and profitability erode during the mid-1980s from fierce competition, a burgeoning fax business, and electronic mail. In reaction Federal Express strategically shifted its focus from overnight letter service to the higher margin package delivery business. Federal Express has always been a leader in the use of technology. Handheld Cosmos trackers and computer terminals in their vans allow drivers to track customer packages and quickly access customer data. Federal Express is using the same technology to manage customer inventories for high-priced goods in warehouses at its hubs. With an expanded truck fleet and second-day package delivery, Federal Express has become a JIT deliverer for companies like IBM who want to get out of warehousing.

The type of products shipped by airfreight tend to be lightweight or small, such as electronic components, medical supplies, perishable products such as flowers or fruit, or emergency items for which quick delivery outweighs cost. However, chartered aircraft are sometimes used for large all-freight shipments as well. For example, livestock are sometimes transported by chartered aircraft instead of ships because a short flight of less than a day is much less harmful to animals and quicker than transoceanic ship transport lasting twenty days or longer. Large aircraft like the Boeing 747 and the Airbus can be configured to carry freight containers only or a combination of passengers on an upper deck and containers or pallets beneath the passenger compartment in a lower deck.

THE COMPETITIVE EDGE

The Federal Express Superhub

The central component in Federal Express's global airfreight system is the terminal it constructed in Memphis, Tennessee. Called the *superhub*, this facility is the nerve center of Federal Express's vast distribution network. Packages from around the world are routed to the superhub to be sorted and sent on to their destinations. The support network includes sorting operations in Los Angeles, Oakland, Chicago, Indianapolis, Newark, London, Brussels, and the Far East. Each night, in less than three hours, the superhub sorts and transfers more than a million packages between connecting flights encompassing more than 100 planes. The superhub, pioneered by Federal Express, has been copied by all other airfreight express services.

Source: Based on *The Allyn and Bacon Plant Tour Video*, Program 1: "Federal Express: Setting the Pace for the 90s," copyright 1988 by Federal Express, distributed by Allyn and Bacon.

The advantages of airfreight are quickness and reliability. It is an efficient and economical means of transport for high-value, lightweight products that need to be shipped over long distances. It can be advantageous for overseas transit, where the alternative is slower water transport. However, air transport is so much more expensive than other transport systems that it is cost-prohibitive for most types of products. In addition, airfreight is part of a terminal-to-terminal logistics system that requires handling, loading, and unloading at the origin and destination, combined with truck pickup and delivery. Airfreight companies have become very adept at combining air and trucking systems, resulting in reliable and rapid delivery in diverse geographic areas and over short distances. However, it is still very costly, and for short distances of less than 500 miles, or a single day's road travel, it may not be much quicker than a point-to-point truck carrier.

Water

Shipping by water is one of the oldest means of freight transport in the United States, beginning with the construction of the Erie Canal between 1817 and 1825. Over the years an intricate system of waterways, canals, and lock systems has been developed in the United States and abroad. Water transport is still a significant means for transporting certain types of products between specific locations, although it is less visible and publicized than other transport modes. The three primary water transport systems for the United States are inland waterways, consisting of river systems, canals, and the Great Lakes; the nation's coastlines; and the oceans that connect the United States with the rest of the world.

Water transport is a very low-cost form of shipping; however, it is also slow. It is tied to a fixed system of river and coastal ports that serve as terminals and distribution points. It is limited to heavy, bulk items such as raw materials, minerals, ores, grains, chemicals, and petroleum products. If delivery speed is not a factor, water transport is cost competitive with railroads for shipping these kinds of bulk products.



More than 80 percent of the seaborne cargo handled by the Port of Singapore Authority is containerized. The Port of Singapore handles over 10 million TEUs (twenty-foot container equivalent units) annually at three container terminals. The Brani terminal shown here has nine berths, thirty-one Quay cranes, and a capacity of 5.5 million TEUs. Since its first container ship in 1972, the Port of Singapore has grown from 130,000 TEUs annually to more than 10 million TEUs annually and has been the world's busiest port in terms of shipping tonnage since 1986.

Water transport is the only means of international shipping between countries separated by oceans for most products, since air transport is limited to a very narrow range of freight items. Transoceanic shipping companies have been effective in developing intermodal transport systems. They combine trucks, railroads, and ships to connect markets, customers, and suppliers around the world. The most successful and visible example is container systems and container ships. Standardized containers that fit on rail flat cars and can be reloaded onto truck trailers are an effective and economical means of transporting products across long distances that encompass land and water.

Pipelines

In the United States, pipelines are used primarily for transporting crude oil from oil fields to refineries and petroleum products such as gasoline from refineries to tank farms. There are about 150,000 miles of crude oil pipelines in the United States. Pipelines called slurry lines carry other products that have been pulverized and transformed into liquid form like coal and kaolin. Once the product arrives at its destination, water is removed leaving the solid material. Although pipelines require a high initial capital investment to construct, they are economical because they can carry materials over terrain that would be difficult for trucks or trains to travel across, for example, the Trans-Alaska pipeline. Once in place pipelines have a long life and are low-cost in terms of operation, maintenance, and labor.

Distribution

A major goal of a distribution operation is speed--to reduce the time to get products to customers as much as possible. A key factor in reducing delivery time is location. Many companies, especially in the retail service industries, are building regional distribution centers

within next-day or second-day truck delivery. This makes distribution more compatible with quick-response or on-demand delivery requirements of customers. The trend is to locate distribution centers in outlying areas of large markets where construction and other costs are lower. For example, distribution centers on Long Island serve the New York area; Springfield, Massachusetts is strategically located to serve New England; Indianapolis and Dayton can serve the Midwest; Raleigh is a popular site in the South Atlantic; Tulsa, Shreveport, and Fort Worth are becoming distribution centers in the southwest; and Orange County and Medford are popular locations in the Pacific region.

Companies are also making full use of information technology to speed distribution. Many companies use electronic data interchange (EDI) combined with bar codes to provide quick response to customers. EDI is a specialized network (sometimes on the Internet) that companies use to exchange orders and status with their suppliers and customers. This system allows companies to conduct secure business transactions with customers on the Internet. Levi Strauss uses EDI and regionalized distribution centers to deliver its jeans and related products within seventy-two hours. Levi Strauss's goal is a system of weekly store orders based on sales patterns that come directly from point-of-sale information captured at the store. Sales pass directly from the store register up the supply chain via EDI to Levi Strauss, and new shipping notices come quickly back down to the store. Manufacturing and distribution also receive this information, and they configure production and delivery processing and schedules accordingly. Distribution does not just include sending jeans on their way to the store. Some retailers may want jeans folded once, ready for the shelf, while another retailer may want jeans double-folded for shelving, or a store may require hanging jeans on their own hanger.²⁹ This type of electronic-based distribution reduces inventories and replenishes store stock quickly, which enables stores to have a better selection of products with the same space, accomplishing the strategic goal of quality customer service.

THE COMPETITIVE EDGE

Direct-Response Catalog Shipping at Donnelley Logistics Services and Mailfast

When direct marketers and retailers mail seasonal catalogs, delivery timing affects the entire supply chain. Additional telephone customer service representatives must be hired, inventories of merchandise must be available in warehouses, and employees to fill and package orders must be on hand. If a catalog reaches a customer too soon, it puts pressure on an unprepared supply chain; if it arrives too late, the resources sit idle.

Donnelley Logistics Services serves direct marketers by transporting catalogs to the post office. Donnelley is the second largest user of the U.S. Postal Service. It delivers approximately 3.5 billion pounds of printed material to more than 230 sectional post office centers each year. It is able to lower supply chain costs for customers in two ways. First, Donnelley penetrates the postal service as far into the mail stream as possible, thus reducing postal rates. Second, it delivers within the narrow time frame specified by direct-marketing customers, usually a range of one or two days. Donnelley is a service company whose own supply chain is almost completely vertically integrated, including autonomous divisions for printing all the

way through to its own distribution centers.

Mailfast, part of TNT Express Worldwide, was established to provide global mail, distribution, and delivery services. Approximately 30 percent of its business is with direct-marketing firms. Mailfast helps direct-marketing companies who are expanding internationally to develop their own supply chains. For example, a U.S. direct marketer might want to have catalogs delivered in the United Kingdom. Mailfast would advise the company as to what data in what form are needed to assist with customs clearance and delivery systems in the United Kingdom before picking up the catalog packages. Careful research in advance results in on-time delivery at the end.

Source: R. Morton, "Direct Response Shipping," *Transportation and Distribution* 37, no. 4 (April 1996): 32-36.

Global distribution presents companies in the international marketplace with special problems. It is not easy for a U.S. company to select a distribution site and construct a facility in another country since areas are unfamiliar, building codes and construction methods are different, and methods of distribution can be unique to countries. One way to deal with these problems is for companies to outsource their distribution process; that is, let an international distribution specialist handle distribution. An example is Roadway Logistics Services (ROLS) which took over 3M's 300,000-square-foot distribution facility in Breda, the Netherlands, and brought in other clients to fill up unused space. This lowered 3M's supply chain costs. As other products flowed through the facility, transportation efficiency improved as well, further reducing costs.³⁰

◆ Pause and Reflect ◆

***9-20.** Compare transportation by truck, sea, and rail. What are the advantages and disadvantages of each mode of transportation? What types of decisions have to be made for each mode?

9-21. Discuss the negative aspects of each of the five major modes of transportation: rails, Truck, air, water, and pipeline.

***9-22.** How do logistics executives view the future? Visit Ohio State's Logistics Department and access their research reports. You'll find a survey of logistics execs. Summarize the trends in the industry.

These exercises require a direct link to a specific Web site. Click **Internet Exercises for the list of internet links for these exercises.*

²⁶ P. Bradley, "Carriers Pursue Great Leaps Along Road to Better Service," *Purchasing* (January 4, 1993): 83-87.

²⁷ H. L. Richardson, "Partnerships for Intermodal Excellence," *Transportation and Distribution* 37, no. 3 (March 1996): 34-38.

²⁸ H. Richardson, "Bulk Shipping: Single Source Wise Favor," *Transportation and Distribution* 37, no. 4 (April 1996): 40-44.

²⁹ P. A. Trunick, "Build for Speed," *Transportation and Distribution* 37, no. 3 (March 1996): 67-70.

³⁰ T. Andel, "Forge a New Role in the Supply Chain," *Transportation and Distribution* 37, no. 3 (March 1996): 107-12.

Summary

Supply chain management is one of the most important, strategic aspects of operations management because it encompasses so many related functions. Whom to buy materials from, where to locate facilities, how to transport goods and services, and how to distribute them in the most cost-effective, timely manner constitutes much of an organization's strategic planning. Contracting with the wrong supplier can result in poor-quality materials and late deliveries. A location decision is not easily reversed if it is a bad one. For a service operation, the wrong location can mean not enough customers to be profitable, whereas for a manufacturing operation, a wrong location can mean excessive costs, especially for transportation and distribution. Selecting the wrong mode of transportation or carrier can mean late customer deliveries that will require high, costly inventories to offset. All of these critical functional supply chain decisions are complicated by the fact that they often occur in a global environment within cultures and markets at a distance and much different from those in the United States.

Key Formulas

Center-of-Gravity Coordinates

$$x = \frac{\sum_{i=1}^n x_i W_i}{\sum_{i=1}^n W_i}, \quad y = \frac{\sum_{i=1}^n y_i W_i}{\sum_{i=1}^n W_i}$$

Load-Distance Technique

$$LD = \sum_{i=1}^n W_i d_i$$
$$d_i = \sqrt{(x_i - x)^2 + (y_i - y)^2}$$

Case Problem

CASE PROBLEM 9.1

Selecting a European Distribution Center Site for American International Automotive Industries

American International Automotive Industries (AIAI) manufactures auto and truck engine, transmission, and chassis parts for manufacturers and repair companies in the United States, South America, Canada, Mexico, Asia and Europe. The company transports to its foreign markets by container ships. To serve its customers in South America and Asia, AIAI has large warehouse/distribution centers. In Europe it ships into Hamburg and Gdansk, where it has contracted with independent distribution companies to deliver its products to customers throughout Europe. However, AIAI has been displeased with a recent history of late deliveries and rough handling of its products. For a time AIAI was not overly concerned since its European market wasn't too big and its European customers didn't complain. Plus, it had more pressing supply chain problems elsewhere. In the last three years, since trade barriers have fallen in Europe and Eastern European markets have opened up, its European business has expanded, as has new competition, and its customers have become more demanding and quality conscious. As a result, AIAI has initiated the process to select a site for a new European warehouse/distribution center. Although it provides parts to a number of smaller truck and auto maintenance and service centers in Europe, it has seven major customers--auto and truck manufacturers in Vienna, Leipzig, Budapest, Prague, Krakow, Munich, and Frankfurt. Its customers in Vienna and Budapest have adopted manufacturing processes requiring continuous replenishment of parts and materials.

AIAI's European headquarters is in Hamburg. The vice-president for construction and development in Dayton, Ohio, has asked the Hamburg office to do a preliminary site search based on location, geography, transportation, proximity to customers, and costs. The Hamburg office has identified five potential sites in Dresden, Lodz, Hamburg, Gdansk, and Frankfurt. The Hamburg office has forwarded information about each of these sites to corporate headquarters, including forecasts of the number of containers shipped annually to each customer as follows: Vienna, 160; Leipzig, 100; Budapest, 180; Prague, 210; Krakow, 90; Munich, 120; and Frankfurt, 50. When the vice-president of construction in Dayton received this information, he pulled out his map of Europe and began to study the sites.

Assist AIAI with its site selection process in Europe. Recommend a site from the five possibilities, and indicate what other location factors you might consider in the selection process.

References

Bowersox, D. J. *Logistics Management*, 2d ed. New York: Macmillan, 1978.

Francis, R. L., and J. A. White. *Facilities Layout and Location: An Analytical Approach*. Upper Saddle River, N.J.: Prentice Hall, 1987.

Fulton, M. "New Factors in Plant Location." *Harvard Business Review* (May-June 1971): 4-17, 166-68.

Hitchcock, F. L. "The Distribution of a Product from Several Sources to Numerous Localities." *Journal of Mathematics and Physics* 20 (1941): 224, 230.

Johnson, J. C., and D. F. Wood. *Contemporary Logistics*, 6th ed. Upper Saddle River, N.J.: Prentice Hall, 1996.

Moore, Laurence, J., Sang M. Lee, and Bernard W. Taylor. *Management Science*, 4th ed. Boston: Allyn and Bacon, 1993.

Schmenner, R. W. *Making Business Location Decisions*. Upper Saddle River, N.J.: Prentice Hall, 1982.

Taylor, B. W. *Introduction to Management Science*, 5th ed. Upper Saddle River, N.J.: Prentice