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INTRODUCTION TO SUPPLY CHAIN MANAGEMENT

Supply chain management is now considered to be a key to competitiveness for global companies. Integrating supply with demand is a fundamental challenge for managers today. Mastering supply chain management can enable companies to increase market share, reduce costs, improve customer service, and increase market value through improvements in return on assets.

In the 1970s, companies competed by excelling in quality, and in the 1980s, the focus turned to efficiency in manufacturing. Since the 1990s, quality is no longer a source of competitiveness but has become a basic requirement, and many companies have reduced inefficiencies in manufacturing to a minimum. The biggest opportunity, these days, seems to lie outside the four walls of manufacturing. The field of competition has now shifted to the management of the global supply chain. The success of companies such as Procter & Gamble (P&G), Seven-Eleven Japan (SEJ), Dell Computers (Dell), Zara, and Wal-Mart is testimony that a well-orchestrated supply chain is crucial to the competitiveness of an enterprise.

Dell is one of the largest PC manufacturers in the world, and one of the main reasons for Dell's success is the way it manages its supply chain. Dell's supply chain model is based on direct sales to customers. This model enables Dell to exert much more control over its supply chain than many other companies, and in addition, get direct information about its customers. Based on this information, Dell can make educated decisions that will affect the entire supply chain. Dell also provides its suppliers real-time information to ensure that they keep the right levels of inventory of the right components. Dell's close contact with customers as well as its understanding of customers' needs allows it to develop better forecasts and thus keep lower inventories. This gives Dell several advantages over the competition, including lower cost of capital invested in inventories, the ability to go faster to market with new components (such as Intel chips), and ensuring that defects are not introduced into a large quantity of products.

Zara, the fastest-growing fashion company in the world—located in La Coruna, Spain—has achieved more than 20% annual growth in the years 2001 to 2006.[1] The key to Zara's success is its supply chain management approach. Zara designed a fast-response supply chain for its

[1] http://www.inditex.com (accessed December 22, 2008).

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products that incorporates all the different stages in its supply chain, from design and manufacturing to distribution and retailing. Due to high demand uncertainty in the fashion industry and the high cost of mistakes, Zara's supply chain approach enables it to make its design and production decisions within a fashion season instead of well in advance of a season, resulting in better response to demand.

SEJ posted record profits during the Asian economic crisis, and it did this by being one of the most innovative companies in the world in the management of its supply chain. SEJ focused on the demand side of the business and the smart use of information to achieve efficient use of scarce shelf space. This was strategically important because of the high cost of real estate in Japan. The company introduced systems to analyze hourly sales trends each day and make the results available to all stores and suppliers by early the following day. This supported efficient product replenishment: giving stores a high level of stock availability by determining the right quantity of the right products.

By recognizing data as the key to success, and developing elaborate information systems in tandem with agile logistics, SEJ achieved significantly higher sales per store than its competitors. Its systems delivered dividends: low operational costs, low inventories, short cycle times, and high customer service, which resulted in increased sales, better market penetration, higher profits, and superior shareholder returns.

SEJ demonstrates the importance of sharing information, but in this case, information-sharing is not that difficult to achieve because the information remains within the boundaries of one organization. More difficult problems arise when it is necessary to share information among different organizations.

Some companies have taken information-sharing to sophisticated levels of information-coordination and knowledge-exchange among supply chain partners. Such knowledge-sharing can include capacity plans, production schedules, promotion plans, demand forecasts, and shipment schedules. But seeking a deeper level of information- or knowledge-exchange demands a greater degree of trust. So the business conditions and supply chain partners will need to support that approach.

A good example of how this can work is the introduction of a program called Collaborative Planning, Forecasting, and Replenishment (CPFR) by U.S. pharmaceutical and health-care products manufacturer Warner-Lambert (now Pfizer) in the mid-1990s. The program's goal was to streamline product flow by sharing its strategic plans, performance data, and market insights with key retailer Wal-Mart. The program also recognized that the manufacturer could benefit from the retailer's market knowledge, which was incorporated into the CPFR model. As a result of this demand forecast collaboration, Warner-Lambert increased its products' shelf-fill rate from 87% to 98%, earning the company about $8 million a year in additional sales.[2]

These examples of large companies such as SEJ, Dell, Zara, and Wal-Mart illustrate two of the key issues for supply chain success: first, coordination and collaboration, and second, the value of information-sharing. Coordination and collaboration mean that the whole supply chain operates as one entity. Instead of each party trying to operate in its own interest, the parties will work together in the interests of the whole supply chain. The crucial requirements are the ability to share information among supply chain partners, as well as aligning the parties' incentives. Next, we provide some definitions for supply chain management. We discuss the issue of supply and demand uncertainty and how to align the supply chain strategy with the product demand and supply characteristics.

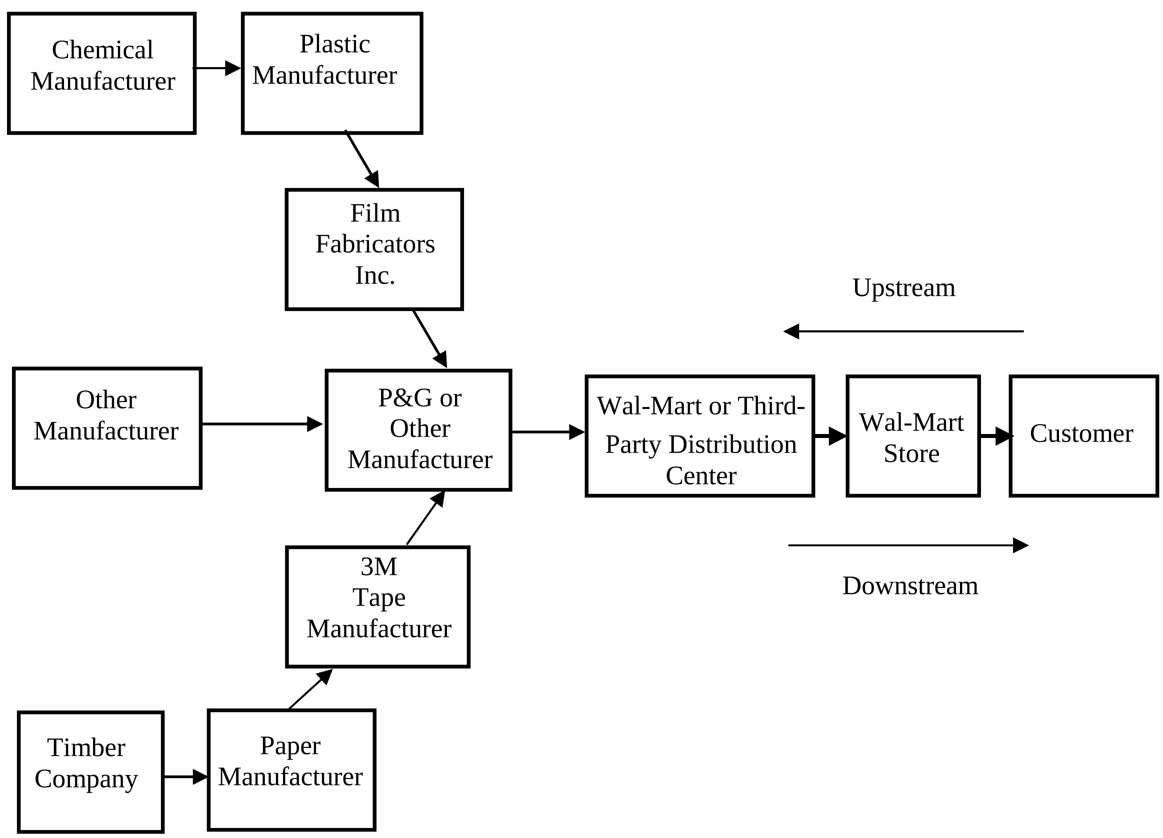
Supply Chain Management Definitions

A *supply chain* consists of all the parties involved directly or indirectly in fulfilling a customer request. (This definition doesn't reveal whether a customer request is for a product or a service. But when discussing services, sometimes the supply chain is referred to as a value chain.) In this note, we will focus mainly on supply chains for products, although some of the analysis would be equally appropriate for services.

Consider a customer walking into a Wal-Mart to purchase diapers. The supply chain begins with the customer's order of diapers. The next stage is the Wal-Mart store that the customer visits. Wal-Mart will have an inventory of diapers supplied from a finished-goods distribution center (warehouse) managed by Wal-Mart or by a third-party distributor. That distributor receives its stock from the manufacturer, for example, P&G, which produces Pampers. The P&G Pampers production line receives raw materials from a variety of suppliers, including tape from 3M and plastic wrap from Film Fabricators Inc. Those suppliers' raw materials may be supplied by lower-tier suppliers. The Pampers' supply chain is shown in **Figure 1**.

[2] H. L. Lee, "Creating Value Through Supply Chain Integration," *Supply Chain Management Review*, (September–October 2000), 40–6.

Figure 1. Supply chain for Pampers diapers.



Supply chain management involves answering a number of questions about the supply chain:

- Where are materials sourced? Where are they built?
- What channels of distribution are used?
- How are strong relationships built with suppliers and customers?
- How is direct information from end consumers gathered and accessed?
- What logistics structure is used?
- How are information flows and systems coordinated globally?
- How can incentive systems for all partners in the supply chain be set up so that the overall performance of the chain can be optimized?

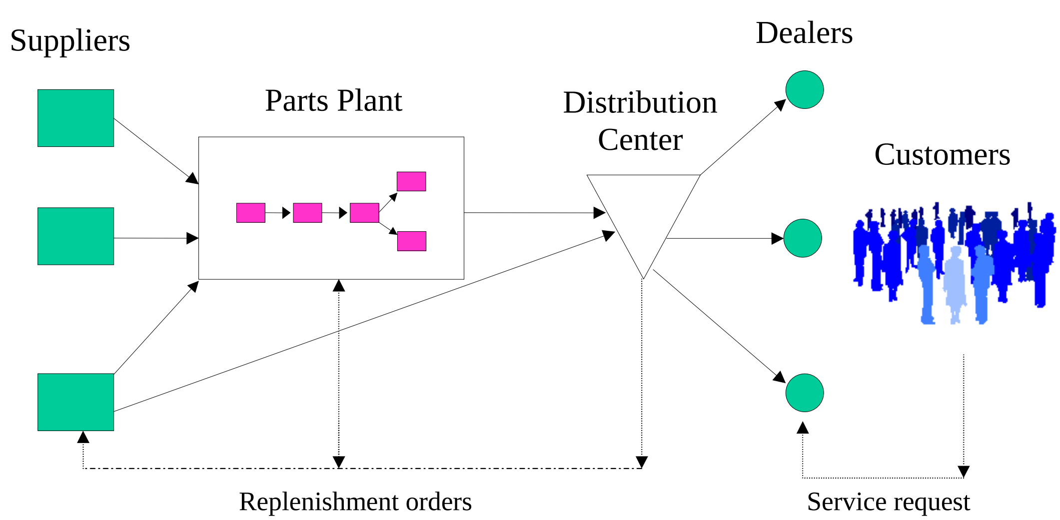
Supply chain management can be defined as the effective control of the flows of material, information, and finance in a network consisting of suppliers, manufacturers, distributors, and customers. **Table 1** describes the different flows in the supply chain. Material flows include both physical product flows from the suppliers to the end customers (which we call *downstream*) and the reverse flows (which we call *upstream*) such as returns, repairs, and servicing.

Table 1. Classification of supply chain flows.[3]

	Upstream	Downstream
Information	Sales, orders, inventory, quality, promotion plans	Capacity, promotion plans, delivery schedules
Material	Returns, repairs, servicing, recycling, disposal	Raw materials, intermediate products, finished goods
Finance	Payments, consignments	Credits, consignment, payment terms, invoice

In order to discuss the flows in **Table 1**, consider the supply chain for the General Motors Service Parts Organization (GMSPO) illustrated in **Figure 2**. GMSPO manages more than 4 million SKUs (stock-keeping units). GM procurement managers purchase raw materials and subassemblies. The parts production plants (PPP) produce some of these SKUs. The parts distribution centers (PDCs) replenish their inventories by ordering both from GM suppliers and PPPs. The 8,000 dealers located across North America also carry inventory ultimately to satisfy consumer demand on time when needed. GMSPO was formed to coordinate and to create visibility across this extended supply chain.

Figure 2. GM parts distribution network.



A key to delivering this service to GM customers is the information flow. This involves information about parts' orders and sales to be shared with the upstream parties as well as the

[3] Lee, 2000.

sharing of capacity and delivery schedules information with the downstream parties. As we mentioned above, information flow is critical to supply chain success. For example, if Wal-Mart runs a special promotion for Pampers, it is crucial that Wal-Mart informs P&G about it given that the promotion will increase the sales of Pampers. This means that P&G should build more inventory, but it also means that when making forecasts for the next period, P&G should not take that increase in sales as an increasing trend in purchasing diapers, but rather be aware of the connection between those sales and the promotion.

The financial flow includes all the different payments and credits in the supply chain, including payment terms agreed upon by the different parties in the supply chain.

The objective of every supply chain is to maximize the overall value generated by the chain. The value generated by a supply chain is the difference between what the final product is worth to the customer and the total costs across the supply chain.

For example, if a customer purchases a GM car for $20,000 (which represents the revenue the supply chain receives from the product), the value generated by the supply chain is equal to the difference between $20,000 and the total costs the supply chain spent on production, inventory, transportation, and so on. This value represents the *supply chain profitability* from this car that will be shared by all the different parties within the supply chain.

We measure the success of the supply chain by looking at the total supply chain profitability instead of the local profits of the individual supply chain stages. In order to be successful, a supply chain should try to work as one entity to maximize supply chain profitability. Thus it is clear that when a customer purchases Pampers in a Wal-Mart store, only the customer purchase provides a positive financial flow—all the other financial flows described in **Table 1** are simply fund exchanges between the different parties in the supply chain. In order to maximize the supply chain value, we need to manage the different flows described in **Table 1** in the most efficient way.

Making the Supply Chain Fit Your Product

Managing supply chains effectively is a difficult and challenging task caused by the current business trends of shortening product life cycles, increased product variety, globalization of business, and the growing advances in information technology. A recent survey conducted by Booz Allen and Hamilton[4] showed that one of the key reasons for the failure of companies to benefit from their supply chain is a lack of fit of the overall strategy with the supply chain strategy. A common mistake that numerous companies make is to choose a supply chain strategy that does not match the company's product characteristics. Many companies believe that the role of a supply chain strategy is to reduce costs and be efficient. This might be true when your

[4] P. Heckmann, D. Shorten, and H. Engel, "Supply Chain Management at 21—The Hard Road to Adulthood," Booz Allen and Hamilton publications, 2003.

product is a low-margin one with low demand uncertainty; however, it could be a devastating mistake to use this kind of strategy for high-margin fashion products. Zara's phenomenal growth and success is due to its ability to choose a supply chain strategy that fits its product and its overall business strategy. This means that when designing a supply chain strategy, managers need to ensure it is aligned with the product it is supporting and more specifically with the uncertainties related to this product. We can divide the product uncertainties into two main types: demand uncertainties and supply uncertainties.

Demand-side uncertainty

When considering the demand uncertainty, products can be classified into two major categories: primarily *functional* or primarily *innovative* based on their product life cycle, demand predictability, product variety, and market standards for lead time.[5]

Functional products have long product life cycles and therefore more stable demand, while innovative products have short life cycles with high innovation and fashion contents that result in highly unpredictable demand. Examples of functional products include groceries, basic clothing, food, and oil and gas, whereas examples of innovative products might be fashion apparel, computers, and telecom products.

Table 2 summarizes the differences between functional and innovative products. As can be seen, functional products have less product variety than innovative products due to the fashion-based nature of those products and the advances in technology that result in frequent introduction of new products. Due to long product life cycles and less product variety, demand for functional products is much easier to forecast than that of innovative products. But the simplicity of forecasting and the stability of the product lure many competitors to enter the market for functional products, and thus their profit margins are smaller than those of innovative products and their cost of obsolescence is lower.

Table 2. Characteristics of functional and innovative products.[6]

	Functional	**Innovative**
Product life cycle	More than 2 years	2 months to 1 year
Contribution margin	5%–20%	20%–60%
Product variety	Low (10–20 variants per category)	High (Hundreds of variants per category)
Margin of error in demand forecast at time of production commitment	10%	40%–100%
Average stock-out rate	1%–2%	10%–40%
Forced end of the season markdowns as % of full price	0%	10%–25%
Lead time required for made-to-order products	6 months to 1 year	1 day to 2 weeks

[5] M. L. Fisher, "What is the Right Supply Chain for Your Product?" *Harvard Business Review* (March–April 1997), 105–16.
[6] Fisher, "What is the Right Supply Chain for Your Product?"

Supply-side uncertainty

It is not enough to consider demand uncertainties alone when devising a supply chain strategy. We also need to consider the supply side. Supply processes can be categorized into two main categories: *stable* supply processes and *evolving* supply processes.

A stable supply process is one where the manufacturing process and the underlying technology are mature, and the supply base is well established. An evolving supply process is one where the manufacturing process and the underlying technology are still under development and are changing rapidly; as a result, the supply base may be limited in both size and experience. **Table 3** describes the differences between stable and evolving supply processes.

Table 3. Characteristics of stable and evolving supply processes.[7]

	Stable	**Evolving**
Breakdowns	Fewer breakdowns	Vulnerable to breakdowns
Process stability and yield	Stable and higher yields	Variable and lower yields
Quality	Fewer quality problems	Potential quality problems
Supply sources	More supply sources	Fewer supply sources
Reliability of suppliers	Reliable suppliers	Unreliable suppliers
Process changes	Fewer	More
Capacity constraints	Fewer capacity constraints	Potential capacity constraints
Changeover	Easier to change over	Difficult to change over
Flexibility	Flexible	Inflexible
Lead time	Dependable lead time	Variable lead time

As can be seen in **Table 3**, in a stable supply process, the manufacturing complexity tends to be low or manageable and the manufacturing processes are usually highly automated with long-term supply contracts. In an evolving supply process, conversely, the manufacturing process will require much more attention and is subject to breakdowns and uncertain yields. In addition, in this case, because the suppliers themselves might be going through process innovations, the supply base will be less reliable than in the case of stable supply processes.

Although functional products tend to have more mature and stable supply processes, that is not always the case. **Table 4** provides examples of functional products that have high supply uncertainties. One example would be some food products—especially fruits and vegetables. Even if demand for those products is stable and predictable, the supply might be uncertain both with respect to its quantity and with respect to its quality due to weather conditions.

[7] H. L. Lee, "Aligning Supply Chain Strategies with Product Uncertainty," *California Management Review* (Spring 2002), 105–19.

Table 4. Uncertainty framework examples.[8]

Supply Uncertainty	Demand Uncertainty: **Low (Functional products)**	Demand Uncertainty: **High (Innovative products)**
Low (Stable process)	Grocery, basic apparel, food, oil and gas	Fashion apparel, computers, pop music
High (Evolving process)	Hydroelectric power, some food products	Telecom, high-end computers, semiconductor

Supply Chain Strategies

From the uncertainty framework in **Table 4**, it is clear that products can be divided into four groups based on their supply and demand uncertainties. Thus, when we try to devise the supply chain strategy to match the product uncertainties, we have four types of strategies that correspond to those four product types:

1. Efficient supply chains
2. Risk-hedging supply chains
3. Responsive supply chains
4. Agile supply chains

Table 5 provides the uncertainty framework that matches each of the product types with the right supply chain strategy.

Table 5. The uncertainty framework with matched strategies.[9]

Supply Uncertainty	Demand Uncertainty: **Low (Functional products)**	Demand Uncertainty: **High (Innovative products)**
Low (Stable process)	Efficient supply chains	Responsive supply chains
High (Evolving process)	Risk-hedging supply chains	Agile supply chains

[8] Lee, 2002, 108.
[9] Lee, 2002.

Efficient supply chains

Efficient supply chains focus on producing the highest cost efficiencies in the supply chain. When products have both low demand and low supply uncertainties, the basis for competition is efficiency. In order to gain such efficiencies, the company should try to eliminate non-value-added activities and focus on getting the best capacity utilization in production and distribution. In addition, the firm should utilize the advances in information technology to link all the activities to increase efficiency.

A company could achieve cost efficiency in two major ways: productivity improvements and effective logistics and distribution. Using lean operations, automation, facility layout, or workflow streamlining could help companies realize productivity improvements. Many Japanese manufacturers focus on these types of improvements to cut cost and gain efficiency. For products that have stable demand and supply processes, it might be possible to ship them directly from the manufacturing facility to the stores utilizing an effective logistics system.

One of the biggest drug-store chains in the United States, Longs Drugs, uses state-of-the-art scientific replenishment optimization software to plan replenishments to its warehouses and stores, which has resulted in inventory savings of 40%. This enabled Longs Drugs to use the savings to purchase 20 new stores.[10]

Risk-hedging supply chains

Risk-hedging supply chains focus on pooling and sharing resources in a supply chain in order to share the risks of supply disruption. When supply processes are still evolving, they are faced with uncertainties regarding yield, process reliability, supply source, and lead time. In this case, companies need to find ways to prevent those uncertainties from affecting the demand fulfillment. This can be achieved using strategies such as inventory pooling among different facilities (stores or warehouses) so that the order fulfillment process will not be disrupted due to component shortages. Companies that use risk-hedging strategies may also need to develop multiple supply bases in order to have backup sources for their products. Although the cost of having those multiple sources might be high, it will reduce the risk of supply shortages that can be even more costly.

The Internet is a tool that companies can use in order to transfer supply and demand information and increase the efficiency of risk pooling. One example of the use of the Internet is e-marketplaces such as Covisint that was established by the big three car manufacturers in the United States and later joined by Nissan and Renault. Through this public e-marketplace the companies can locate many supply sources, which reduces the risk of supply shortages as well as lead times for the components.

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[10] Hau L. Lee and Seungjin Whang, "Demand Chain Excellence: A Tale of Two Retailers," *Supply Chain Management Review* (January 2001).

Responsive supply chains

Responsive supply chains aim to be responsive and flexible to changing and diverse customer needs. These strategies are suitable for cases when demand is highly unpredictable with a short selling season, which could result in excessive inventory, which in turn, might be very costly for innovative products. Rather than focusing on accurate forecasting and inventory planning, companies with stable supply processes and product technology should focus on building a responsive and flexible supply chain using concepts such as postponement and build-to-order strategies.

One of the best examples for the use of responsive supply chain strategies is the fashion industry. Due to the innovative nature of the product and the stability of the supply processes, companies use responsive supply chain strategies to deal with the fashion gamble, which can result in having too much stock at the end of the season and having to discount steeply to sell it. Fashion companies such as Benetton, Sport Obermeyer, and Zara use the concept of responsiveness in order to cope with this fashion gamble.

Benetton used the idea of postponement by redesigning its sweater manufacturing process from dye first, knit second, to knit first, dye second, thereby postponing the color decision until more information about the demand for different colors arrived.

Sport Obermeyer, a skiwear manufacturer based in Aspen, Colorado, developed a concept of accurate response whereby the company first produces the products with more predictable demand before the season and makes the unpredictable products within the season, after more demand information becomes available.[11]

Similarly, Zara designed a fast-response supply chain for its fashion products incorporating all the different stages in its supply chain, from design and manufacturing to distribution and retailing. Zara's fast-response supply chain involves designing and manufacturing more than 10,000 designs per year, although in small batches. This enables Zara to avoid the fashion gamble because designs that do not sell can be transferred to other stores and Zara can decide not produce more of them. Like Sport Obermeyer, Zara purposely keeps its manufacturing facilities at low utilization within the season to give the company the flexibility to react to the more accurate demand information available in those times. In addition, in order to be able to respond quickly and not hold too much inventory, Zara uses planes and trucks instead of trains and ships. This high cost of transportation is balanced by the reduced cost of maintaining more inventory and the avoided losses of discounting products at the end of the fashion season. Zara's fast-response system means that it takes only 15 to 30 days to deliver new styles anywhere in the world (from design and production through to store delivery). The big advantage for Zara was that it could make its design and production decisions within a fashion season instead of well in advance of a season, resulting in a better response to demand. For the

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[11] M. L. Fisher, J. H. Hammond, W. R. Obermeyer, and A. Raman, "Making Supply Meet Demand in an Uncertain World," *Harvard Business Review* (May–June 1994), 83–93.

retailers, Zara's system allowed them to receive product soon after they ordered it and provided something new to sell every two weeks without having to hold much inventory.[12]

Agile supply chains

Agile supply chains are responsive and flexible to customers' needs, while hedging for the risks of supply shortages and disruptions by pooling inventories or other capacity resources.

An example of a company that utilizes this type of strategy is Xilinx Inc., a "fabless" semiconductor company. (Fabless—without fabrication—refers to outsourcing the manufacturing of silicon wafers while keeping the function of design, development, and marketing.) Xilinx specializes in highly innovative high-end integrated circuits that often represent the first generation of the most powerful integrated circuits. Based on the nature of the product, the technology processes used are very challenging and demanding, with a need for a highly sophisticated fabrication facility. Thus, Xilinx created a close partnership with two foundries, United Microelectronics Corporation in Taiwan and Seiko in Japan. Fabricated wafers are stocked by the foundries, forming a decoupling point known as die banks. Then, as demand for specific chips is revealed through orders from customers such as Dell, Motorola, and HP, other supply partners in Taiwan and the Philippines carry out the final assembly and testing. Using this decoupling point strategy, Xilinx is therefore able to be responsive to its customer needs despite its evolving supply process.[13]

Another example is Cisco, which embarked on a very ambitious project to create an e-hub that will link multiple tiers of suppliers via the Internet in order to coordinate supply and demand planning across the supply chain. This e-hub also provides an opportunity to discover potential supply and demand problems early so that supply chain partners can take appropriate actions.

[12] K. Ferdows, M. A. Lewis, and J. A. D. Machuca, "Rapid-Fire Fulfillment," *Harvard Business Review* (November 2004), 104–10.

[13] Lee, 2002.