Introduction to supply chain

A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. The supply chain includes not only the manufacturer and suppliers, but also transporters, warehouses, retailers, and even customers themselves. Within each organization, such as a manufacturer, the supply chain includes all functions involved in receiving and filling a customer request.

The primary purpose of any supply chain is to satisfy customer needs and, in the process, generate profit for itself. The term supply chain conjures up images of product or supply moving from suppliers to manufacturers to distributors to retailers to customers along a chain. This is certainly part of the supply chain, but it is also important to visualize information, funds, and product flows along both directions of this chain. The term supply chain may also imply that only one player is involved at each stage. A manufacturer may receive material from several suppliers and then supply several distributors. Thus, most supply chains are networks. It may be more accurate to use the term supply network or supply web to describe the structure of most supply chains, as shown in Figure 1

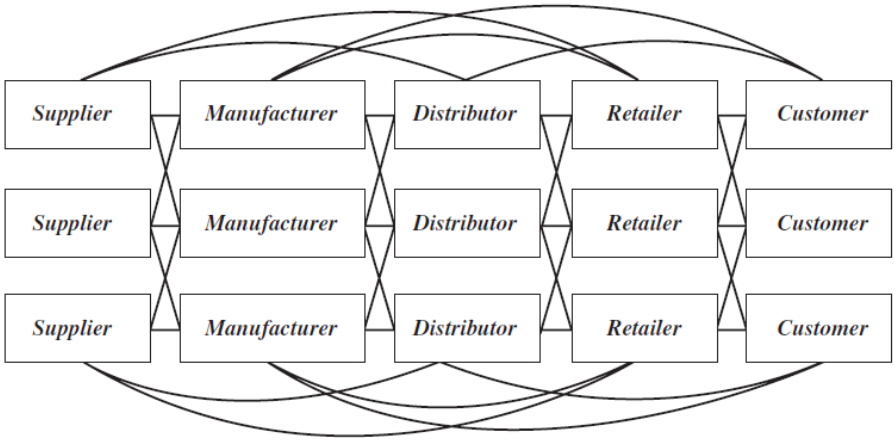


Figure 1

A typical supply chain may involve a variety of stages, including the following:

- Customers
- Retailers
- Wholesalers/distributors
- Manufacturers
- Component/raw material suppliers

Each stage in a supply chain is connected through the flow of products, information, and funds. These flows often occur in both directions and may be managed by one of the stages or an intermediary. Each stage in Figure 1 need not be present in a supply chain. The appropriate design of the supply chain depends on both the customer's needs and the roles played by the stages involved.

The Objective of a Supply Chain

The objective of every supply chain should be to maximize the overall value generated. The value (also known as supply chain surplus) a supply chain generates is the difference between what the value of the final product is to the customer and the costs the entire supply chain incurs in filling the customer's request.

Supply Chain Surplus = Customer Value - Supply Chain Cost

The value of the final product may vary for each customer and can be estimated by the maximum amount the customer is willing to pay for it. The difference between the value of the product and its price remains with the customer as consumer surplus. The rest of the supply chain surplus becomes supply chain profitability, the difference between the revenue generated from the customer and the overall cost across the supply chain. Supply chain success should be measured in terms of supply chain surplus and not in terms of the profits at an individual stage. Effective supply chain management involves the management of supply chain assets and product, information, and fund flows to grow the total supply chain surplus. A growth in supply chain surplus increases the size of the total pie, allowing contributing members of the supply chain to benefit.

Decision Phases in a Supply Chain

Successful supply chain management requires many decisions relating to the flow of information, product, and funds. Each decision should be made to raise the supply chain surplus. These decisions fall into three categories or phases, depending on the frequency of each decision and the time frame during which a decision phase has an impact.

1. Supply chain strategy or design: During this phase, a company decides how to structure the supply chain over the next several years. It decides what the chain's configuration will be, how resources will be allocated, and what processes each stage will perform. Strategic decisions made by companies include whether to outsource or perform a supply chain function in-house, the location and capacities of production and warehousing facilities, the products to be manufactured or stored at various locations, the modes of transportation to be made available along different shipping legs, and the type of information system to be used. A firm must ensure that the supply chain configuration supports its strategic objectives and increases the supply chain surplus during this phase.

2. Supply chain planning: For decisions made during this phase, the time frame considered is a quarter to a year. Therefore, the supply chain's configuration determined in the strategic phase is fixed. This configuration establishes constraints within which planning must be done. The goal of planning is to maximize the supply chain surplus that can be generated over the planning horizon given the constraints established during the strategic or design phase. Companies start the planning phase with a forecast for the coming year (or a comparable time frame) of demand and other factors, such as costs and prices in different markets. Planning includes making decisions regarding which markets will be supplied from which locations, the subcontracting of manufacturing, the inventory policies to be followed, and the timing and size of marketing and price promotions. As

a result of the planning phase, companies define a set of operating policies that govern short-term operations.

3. Supply chain operation: The time horizon here is weekly or daily. During this phase, companies make decisions regarding individual customer orders. At the operational level, supply chain configuration is considered fixed and planning policies are already defined. The goal of supply chain operations is to handle incoming customer orders in the best possible manner. During this phase, firms allocate inventory or production to individual orders, set a date by which an order is to be filled, generate pick lists at a warehouse, allocate an order to a particular shipping mode and shipment, set delivery schedules of trucks, and place replenishment orders. Because operational decisions are being made in the short term (minutes, hours, or days), there is less uncertainty about demand information.

Process Views of a Supply Chain

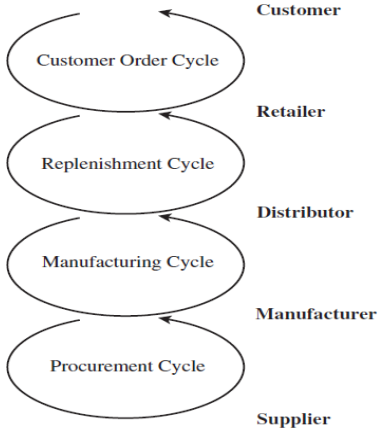
A supply chain is a sequence of processes and flows that take place within and between different stages and combine to fill a customer need for a product. There are two ways to view the processes performed in a supply chain.

1. Cycle view: The processes in a supply chain are divided into a series of cycles, each performed at the interface between two successive stages of the supply chain.

2. Push/pull view: The processes in a supply chain are divided into two categories, depending on whether they are executed in response to a customer order or in anticipation of customer orders. Pull processes are initiated by a customer order, whereas push processes are initiated and performed in anticipation of customer orders.

Cycle View of Supply Chain Processes

Cycle view clearly defines processes involved and the owners of each process. Specifies the roles and responsibilities of each member and the desired outcome of each process. Given the five stages of a supply chain as shown in Figure 1, all supply chain processes can be broken down into the following four process cycles, as shown in Figure 2:



- Customer order cycle
- Replenishment cycle
- Manufacturing cycle
- Procurement cycle

Each cycle occurs at the interface between two successive stages of the supply chain. Not every supply chain will have all four cycles clearly separated. For example, a grocery supply chain in which a retailer stocks finished-goods inventories and places replenishment orders with a distributor is likely to have all four cycles separated. Dell, in contrast, bypasses the retailer and distributor when it sells servers directly to customers.

Figure 2

Within each cycle, the goal of the buyer is to ensure product availability and to achieve economies of scale in ordering. The supplier attempts to forecast customer orders and reduce the cost of receiving the order. The supplier then works to fill the order on time and improve efficiency and accuracy of the order fulfillment process. The buyer then works to reduce the cost of the receiving process. Reverse flows are managed to reduce cost and meet environmental objectives.

Even though each cycle has the same basic subprocesses, there are a few important differences among the cycles. In the customer order cycle, demand is external to the supply chain and thus, is uncertain. In all other cycles, order placement is uncertain but can be projected based on policies followed by the supply chain stage. The detailed process description of a supply chain in the cycle view is useful when considering operational decisions because it clearly specifies the roles of each member of the supply chain. The cycle view is used by enterprise resource planning (ERP) systems to support supply chain operations.

Push/Pull View of Supply Chain Processes

All processes in a supply chain fall into one of two categories, depending on the timing of their execution relative to end customer demand. With pull processes, execution is initiated in response to a customer order. With push processes, execution is initiated in anticipation of customer orders based on a forecast. Pull processes may also be referred to as reactive processes because they react to customer demand. Push processes may also be referred to as speculative processes because they respond to speculated (or forecasted), rather than actual, demand. The push/pull boundary in a supply chain separates push processes from pull processes, as shown in Figure 3. Push processes operate in an uncertain environment because customer demand is not yet known. Pull processes operate in an environment in which customer demand is known. They are, however, often constrained by inventory and capacity decisions that were made in the push phase.

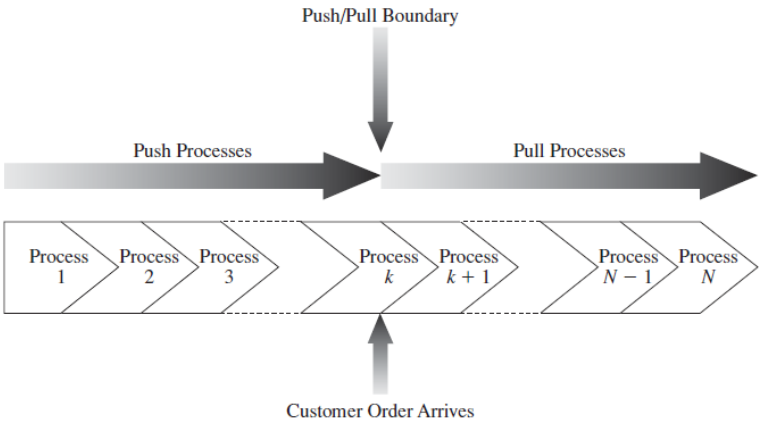


Figure-3

Let us compare a make-to-stock environment like that of L. L. Bean and a build-to-order environment like that of Ethan Allen to compare the push/pull view and the cycle view.

L. L. Bean executes all processes in the customer order cycle after the customer order arrives. All processes that are part of the customer order cycle are thus pull processes. Order fulfillment takes place from product in inventory that is built up in anticipation of customer orders. The goal of the replenishment cycle is to ensure product availability when a customer order arrives. All processes in the replenishment cycle are performed in anticipation of demand and are thus push processes. The same holds true for processes in the manufacturing and procurement cycles. In fact, raw material such as fabric is often purchased six to nine months before customer demand is expected. Manufacturing itself begins three to six months before the point of sale. The processes in the L. L. Bean supply chain break up into pull and push processes, as shown in Figure 4.

Ethan Allen makes customized furniture, such as sofas and chairs, for which customers select the fabric and finish. In this case, the arrival of a customer order triggers production of the product. The manufacturing cycle is thus part of the customer order fulfillment process in the customer order cycle. There are effectively only two cycles in the Ethan Allen supply chain for customized furniture: (1) a customer order and manufacturing cycle and (2) a procurement cycle, as shown in Figure 5.

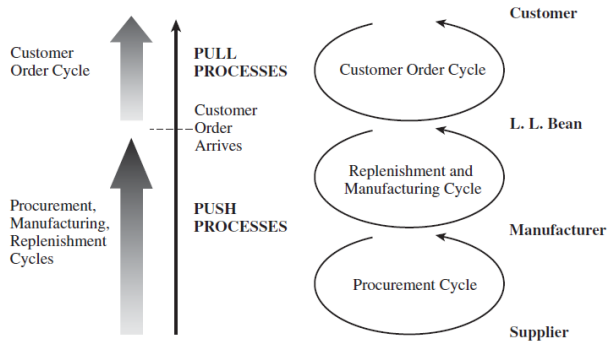


Figure 4 -Push/Pull Processes for the L. L. Bean Supply Chain

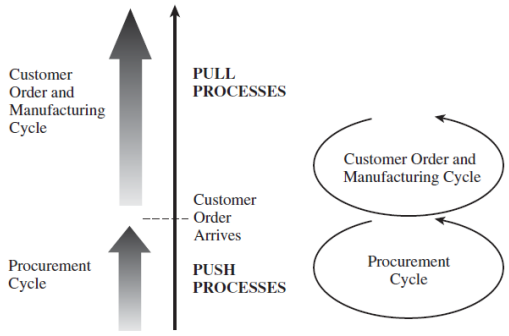


Figure 5- Push/Pull Processes for Ethan Allen Supply Chain for Customized Furniture

A push/pull view of the supply chain is very useful when considering strategic decisions relating to supply chain design. The goal is to identify an appropriate push/pull boundary such that the supply chain can match supply and demand effectively.

DRIVERS AND METRICS IN SUPPLY CHAIN

Drivers and Metrics may link key financial measures of firm performance to supply chain performance. The three logistical drivers—facilities, inventory, and transportation—and the three cross-functional drivers—information, sourcing, and pricing—that determine the performance of any supply chain. How these drivers are used in the design, planning, and operation of the supply chain. Define several metrics that can be used to gauge the performance of each driver and its impact on financial performance.

Drivers of Supply Chain Performance

A supply chain's performance in terms of responsiveness and efficiency is based on the interaction between the following logistical and cross-functional drivers of supply chain performance.

Let's define each driver and discuss its impact on the performance of the supply chain.

1. Facilities are the actual physical locations in the supply chain network where product is stored, assembled, or fabricated. The two major types of facilities are production sites and storage sites. Decisions regarding the role, location, capacity, and flexibility of facilities have a significant impact on the supply chain's performance.

2. Inventory covers all raw materials, work in process, and finished goods within a supply chain. The inventory belonging to a firm is reported under assets. Changing inventory policies can dramatically alter the supply chain's efficiency and responsiveness.

3. Transportation entails moving inventory from point to point in the supply chain. Transportation can take the form of many combinations of modes and routes, each with its own performance characteristics. Transportation choices have a large impact on supply chain responsiveness and efficiency

4. Information consists of data and analysis concerning facilities, inventory, transportation, costs, prices, and customers throughout the supply chain. Information is potentially the biggest driver of performance in the supply chain because it directly affects each of the other drivers. Information presents management with the opportunity to make supply chains more responsive and more efficient.

5. Sourcing is the choice of who will perform a supply chain activity, such as production, storage, transportation, or the management of information. At the strategic level, these decisions determine what functions a firm performs and what functions the firm outsources. Sourcing decisions affect both the responsiveness and efficiency of a supply chain.

6. Pricing determines how much a firm will charge for the goods and services that it makes available in the supply chain. Pricing affects the behavior of the buyer of the good or service, thus affecting demand and supply chain performance. For example, if a transportation company varies its charges based on the lead time provided by the customers, it is likely that customers who value efficiency will order early and customers who value responsiveness will be willing to wait and order just before they need a product transported. Any change in pricing affects revenues directly but could also affect costs based on the impact of this change on the other drivers.

Framework for Structuring Drivers

a visual framework for supply chain decision making in Figure 6. Most companies begin with a competitive strategy and then decide what their supply chain strategy ought to be. The supply chain strategy determines how the supply chain should perform with respect to efficiency and responsiveness. The supply chain must then use the three logistical and three cross functional drivers to reach the performance level the supply chain strategy dictates and maximize the supply

chain profits. Although this framework is generally viewed from the top down, in many instances a study of the six drivers may indicate the need to change the supply chain strategy and, potentially, even the competitive strategy.

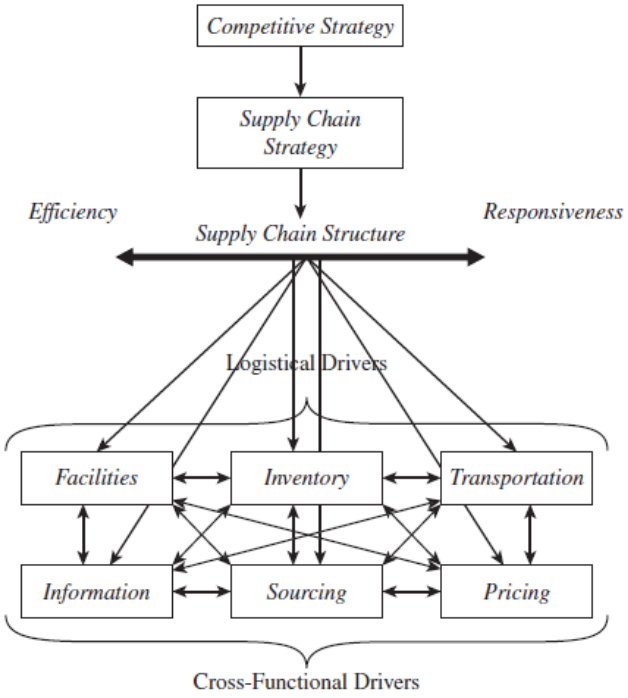


Figure 6 - Supply Chain Decision-Making Framework

A detailed discussion of each of the three logistical and three cross-functional drivers, their roles in the supply chain, and their impact on financial performance given below

FACILITIES

Firms can increase responsiveness by increasing the number of facilities, making them more flexible, or increasing capacity. Each of these actions, however, comes at a cost. Increasing the number of facilities increases facility and inventory costs but decreases transportation costs and reduces response time. Increasing the flexibility or capacity of a facility increases facility costs but decreases inventory costs and response time.

Components of Facilities Decisions

Decisions regarding facilities are a crucial part of supply chain design. We now identify components of facilities decisions that companies must analyze.

Role Firms must decide whether production facilities will be flexible, dedicated, or a combination of the two. Flexible capacity can be used for many types of products but is often less efficient, whereas dedicated capacity can be used for only a limited number of products but is more efficient. Firms must also decide whether to design a facility with a product focus or a functional focus. A product-focused facility performs all functions (e.g., fabrication and assembly) needed for producing a single type of product. A functional-focused facility performs a given set of

functions (e.g., fabrication or assembly) on many types of products. A product focus tends to result in more expertise about a product at the expense of the functional expertise that comes from a functional methodology.

Location Deciding where a company will locate its facilities constitutes a large part of the design of a supply chain. A basic trade-off here is whether to centralize to gain economies of scale or to decentralize to become more responsive by being closer to the customer. Companies must also consider a host of issues related to the various characteristics of the local area in which the facility is situated. These include macroeconomic factors, quality of workers, cost of workers, cost of facility, availability of infrastructure, proximity to customers, the location of that firm's other facilities, tax effects, and other strategic factors.

Capacity Companies must also determine a facility's capacity to perform its intended function or functions. A large amount of excess capacity allows the facility to respond to wide swings in the demands placed on it. Excess capacity, however, costs money and therefore can decrease efficiency. A facility with little excess capacity will likely be more efficient per unit of product it produces than one with a lot of unused capacity. The high-utilization facility, however, will have difficulty responding to demand fluctuations. Therefore, a company must make a trade-off to determine the right amount of capacity to have at each of its facilities.

Facility-Related Metrics

Facility-related decisions affect both the financial performance of the firm and the supply chain's responsiveness to customers. On the financial side, facilities decisions have an impact on the cost of goods sold, assets in PP&E (if facilities are owned), and selling, general, and administrative expense (if facilities are leased). A manager should track the following facility-related metrics that influence supply chain performance:

- **Capacity** measures the maximum amount a facility can process.
- **Utilization** measures the fraction of capacity that is currently being used in the facility. Utilization affects both the unit cost of processing and the associated delays. Unit costs tend to decline (PPET increases) and delays increase with increasing utilization.
- **Processing/setup/down/idle time** measures the fraction of time that the facility was processing units, being set up to process units, unavailable because it was down, or idle because it had no units to process. Ideally, utilization should be limited by demand and not setup or downtime.
- **Production cost per unit** measures the average cost to produce a unit of output. These costs may be measured per unit, per case, or per pound, depending on the product.
- **Quality losses** measure the fraction of production lost as a result of defects. Quality losses hurt both financial performance and responsiveness.
- **Theoretical flow/cycle time of production** measures the time required to process a unit if there are absolutely no delays at any stage.

• **Actual average flow/cycle time** measures the average actual time taken for all units processed over a specified duration, such as a week or a month. The actual flow/cycle time includes the theoretical time and any delays. This metric should be used when setting due dates for orders.

• **Flow time efficiency** is the ratio of the theoretical flow time to the actual average flow time. Low values for flow time efficiency indicate that a large fraction of time is spent waiting.

• **Product variety** measures the number of products or product families processed in a facility. Processing costs and flow times are likely to increase with product variety.

• **Average production batch size** measures the average amount produced in each production batch. Large batch sizes will decrease production cost but increase inventories.

• **Production service level** measures the fraction of production orders completed on time and in full.

INVENTORY

Inventory exists in the supply chain because of a mismatch between supply and demand. This mismatch is Intentional at a steel manufacturer, where it is economical to manufacture in large lots that are then stored for future sales. The mismatch is also intentional at a retail store where inventory is held in anticipation of future demand or when the retail store builds up inventory to prepare for a surge in sales during the holiday season. In these instances, inventory is held to reduce cost or increase the level of product availability.

Inventory affects the assets held, the costs incurred, and responsiveness provided in the supply chain. High levels of inventory in an apparel supply chain improve responsiveness but also leave the supply chain vulnerable to the need for markdowns, lowering profit margins. A higher level of inventory also facilitates a reduction in production and transportation costs because of improved economies of scale in both functions. This choice, however, increases inventory holding cost. Low levels of inventory improve inventory turns but may result in lost sales if customers are unable to find products, they are ready to buy. In general, managers should aim to reduce inventory in ways that do not increase cost or reduce responsiveness.

Components of Inventory Decisions

Cycle inventory is the average amount of inventory used to satisfy demand between receipts of supplier shipments. The size of the cycle inventory is a result of the production, transportation, or purchase of material in large lots. Companies produce or purchase in large lots to exploit economies of scale in the production, transportation, or purchasing process. With the increase in lot size, however, comes an increase in carrying costs. The cycle inventory decisions the retailer must make are how much to order for replenishment and how often to place these orders.

Safety Inventory is inventory held in case demand exceeds expectation; it is held to counter uncertainty. If the world were perfectly predictable, only cycle inventory would be

needed. Because demand is uncertain and may exceed expectations, however, companies hold safety inventory to satisfy an unexpectedly high demand. Managers face a key decision when determining how much safety inventory to hold. Choosing safety inventory involves making a trade-off between the costs of having too much inventory and the costs of losing sales owing to not having enough inventory.

Seasonal Inventory is built up to counter predictable seasonal variability in demand. Companies using seasonal inventory buildup inventory in periods of low demand and store it for periods of high demand, when they will not have the capacity to produce all that is demanded. Managers face key decisions in determining whether to build seasonal inventory and, if they do build it, in deciding how much to build. The basic trade-off supply chain managers face in determining how much seasonal inventory to build is the cost of carrying the additional seasonal inventory versus the cost of having a more flexible production rate.

Level of Product Availability is the fraction of demand that is served on time from product held in inventory. A high level of product availability provides a high level of responsiveness but increases cost because much inventory is held but rarely used. In contrast, a low level of product availability lowers inventory holding cost but results in a higher fraction of customers who are not served on time. The basic trade-off when determining the level of product availability is between the cost of inventory to increase product availability and the loss from not serving customers on time.

Inventory-Related Metrics

Inventory-related decisions affect the cost of goods sold, the C2C cycle, the assets held by the supply chain, and its responsiveness to customers. A manager should track the following inventory-related metrics that influence supply chain performance:

• **C2C cycle time** is a high-level metric that includes inventories, accounts payable, and receivables.

• **Average inventory** measures the average amount of inventory carried. Average inventory should be measured in units, days of demand, and financial value.

• **Inventory turns** measure the number of times inventory turns over in a year. It is the ratio of average inventory to either the cost of goods sold or sales.

• **Products with more than a specified number of days of inventory** identifies the products for which the firm is carrying a high level of inventory. This metric can be used to identify products that are in oversupply or to identify reasons that justify the high inventory, such as price discounts or a product being a very slow mover.

• **Average replenishment batch size** measures the average amount in each replenishment order. The batch size should be measured by SKU in terms of both units and days of demand. It can be estimated by averaging over time the difference between the maximum and the minimum inventory (measured in each replenishment cycle) on hand.

• **Average safety inventory** measures the average amount of inventory on hand when a replenishment order arrives. Average safety inventory should be measured by SKU in both units and days of demand. It can be estimated by averaging over time the minimum inventory on hand in each replenishment cycle.

• **Seasonal inventory** measures the amount by which the inflow of product exceeds its sales (beyond cycle and safety inventory). Seasonal inventory is built up solely to deal with anticipated spikes in demand.

Fill rate (order/case) measures the fraction of orders/demand that were met on time from inventory. Fill rate should be averaged not over time but over a specified number of units of demand (say, every thousand or million).

• **Fraction of time out of stock** measures the fraction of time that a SKU had zero inventory. This fraction can be used to estimate the lost sales during the stockout period.

• **Obsolete inventory** measures the fraction of inventory older than a specified obsolescence date.

TRANSPORTATION

Transportation moves product between different stages in a supply chain and affects both responsiveness and efficiency. Faster transportation is more expensive but allows a supply chain to be more responsive. As a result, the supply chain may carry lower inventories and have fewer facilities.

The appropriate choice of transportation allows a firm to adjust the location of its facilities and inventory to find the right balance between responsiveness and efficiency. A firm selling high-value items such as pacemakers may use rapid transportation to be responsive while centralizing its facilities and inventory to lower cost. In contrast, a firm selling low-value, high demand items like light bulbs may carry a fair amount of inventory close to the customer but then use low-cost transportation such as sea, rail, and full trucks to replenish this inventory from plants located in low-cost countries.

Components of Transportation Decisions

The key components of transportation that companies must analyze when designing and operating a supply chain.

Design of Transportation Network The transportation network is the collection of transportation modes, locations, and routes along which product can be shipped. A company must decide whether transportation from a supply source will be direct to the demand point or will go through intermediate consolidation points. Design decisions also include whether multiple supply or demand points will be included in a single run.

Choice of Transportation Mode The mode of transportation is the way a product is moved from one location in the supply chain network to another. Companies can choose among air, truck, rail, sea, and pipeline as modes of transport for products. Today,

information goods can also be sent via the Internet. Each mode has different characteristics with respect to the speed, size of shipments (individual parcels to pallets to full trucks to entire ships), cost of shipping, and flexibility that lead companies to choose one mode over the others.

Transportation-Related Metrics

Inbound transportation decisions affect the cost of goods sold, whereas outbound transportation costs are part of the selling, general, and administrative expenses. Thus, transportation costs affect the profit margin. A manager should track the following transportation-related metrics that influence supply chain performance:

- **Average inbound transportation cost** typically measures the cost of bringing product into a facility. Ideally, this cost should be measured per unit brought in, but it is often measured as a percentage of sales or cost of goods sold (COGS). The inbound transportation cost is generally included in COGS. It is useful to measure this cost separately for each supplier.

- **Average incoming shipment size** measures the average number of units or dollars in each incoming shipment at a facility.

- **Average inbound transportation cost per shipment** measures the average transportation cost of each incoming delivery. Along with the incoming shipment size, this metric identifies opportunities for greater economies of scale in inbound transportation.

- **Average outbound transportation cost** measures the cost of sending product out of a facility to the customer. Ideally, this cost should be measured per unit shipped, but it is often measured as a percentage of sales. It is useful to separate this metric by customer.

- **Average outbound shipment size** measures the average number of units or dollars on each outbound shipment at a facility.

- **Average outbound transportation cost per shipment** measures the average transportation cost of each outgoing delivery. Along with the outgoing shipment size, this metric identifies opportunities for greater economies of scale in outbound transportation.

- **Fraction transported by mode** measures the fraction of transportation (in units or dollars) using each mode of transportation. This metric can be used to estimate whether certain modes are overused or underused.

INFORMATION

Good information can help improve the utilization of supply chain assets and the coordination of supply chain flows to increase responsiveness and reduce costs. Seven-Eleven Japan uses information to improve product availability while decreasing inventories. Airlines routinely use information to offer the right number of seats at a discount price, leaving sufficient seats for business customers who make reservations at the last minute and are willing to pay a

higher price. Each of these examples illustrates the importance of information as a key driver that can be used to provide higher responsiveness while simultaneously improving efficiency.

As more information is shared across a supply chain, the complexity and cost of both the required infrastructure and the follow-up analysis grow exponentially. The marginal value provided by the information shared, however, diminishes as more and more information becomes available. It is thus important to evaluate the minimum information required to accomplish the desired objectives.

Components of Information Decisions

Push Versus Pull When designing processes of the supply chain, managers must determine whether these processes are part of the push or pull phase in the chain. Push systems start with forecasts that are used to build the master production schedule and roll it back, creating schedules for suppliers with part types, quantities, and delivery dates. Pull systems require information on actual demand to be transmitted extremely quickly throughout the entire chain so production and distribution of products can reflect the real demand accurately.

Coordination and Information Sharing Supply chain coordination occurs when all stages of a supply chain work toward the objective of maximizing total supply chain profitability based on shared information. Lack of coordination can result in a significant loss of supply chain surplus. Coordination among different stages in a supply chain requires each stage to share appropriate information with other stages. Information sharing is thus crucial to the success of a supply chain.

Sales and operations Planning Sales and operations planning (S&OP) is the process of creating an overall supply plan (production and inventories) to meet the anticipated level of demand (sales). The S&OP process starts with sales and marketing communicating their needs to the supply chain, which, in turn, communicates to sales and marketing whether the needs can be met, and at what cost. The goal of S&OP is to come up with an agreed-upon sales, production, and inventory plan that can be used to plan supply chain needs and project revenues and profits.

Enabling Technologies Many technologies exist to share and analyze information in the supply chain. Managers must decide which technologies to use and how to integrate them into their supply chain. Some of these technologies include the following:

1. Electronic data interchange (EDI) was developed in the 1970s to facilitate the placement of instantaneous, paperless purchase orders with suppliers. Relative to EDI, the Internet conveys much more information using a standard infrastructure allowing supply chains to improve both efficiency and responsiveness.

2. Enterprise resource planning (ERP) systems provide the transactional tracking and global visibility of information from within a company and across its supply chain. This

realtime information helps a supply chain improve the quality of its operational decisions. ERP systems keep track of the information, whereas the Internet provides one method with which to view this information.

4. Supply chain management (SCM) software uses the information in ERP systems to provide analytical decision support in addition to the visibility of information. ERP systems show a company what is going on, whereas SCM systems help a company decide what it should do.

5. Radio frequency identification (RFID) consists of an active or passive radio frequency (RF) tag, applied to the item being tracked, and an RF reader/emitter. A passive tag draws energy from the reader, whereas an active tag has its own battery and draws power from it. RFID has many potential uses. It can be used in manufacturing to check availability of the entire bill of materials. The technology can make the receiving of a truck much faster and cheaper. Full implementation of RFID could eliminate the need for manual counting and bar-code scanning at the receiving dock. It can also be used to get an exact count of incoming items and items in storage.

Information-Related Metrics

A manager should track the following information-related metrics that influence supply chain performance:

• **Forecast horizon** identifies how far in advance of the actual event a forecast is made. The forecast horizon must be greater than or equal to the lead time of the decision that is driven by the forecast.

• **Frequency of update** identifies how frequently each forecast is updated. The forecast should be updated somewhat more frequently than a decision will be revisited, so large changes can be flagged and corrective action taken.

• **Forecast error** measures the difference between the forecast and actual demand. The forecast error is a measure of uncertainty and drives all responses to uncertainty, such as safety inventory or excess capacity.

• **Seasonal factors** measure the extent to which the average demand in a season is above or below the average in the year.

• **Variance from plan** identifies the difference between the planned production/inventories and the actual values. These variances can be used to raise flags that identify shortages and surpluses.

• **Ratio of demand variability to order variability** measures the standard deviation of incoming demand and supply orders placed.

SOURCING

The role that sourcing plays in the supply chain and key sourcing related decisions that managers need to make. Sourcing is the set of business processes required to purchase goods and services. Managers must first decide whether each task will be performed by a responsive or efficient source and then whether the source will be internal to the company or a third party. Sourcing decisions should be made to increase the size of the total surplus to be shared across the supply chain. Outsourcing to a third party is meaningful if the third party raises the supply chain surplus more than the firm can on its own. In contrast, a firm should keep a supply chain function in-house if the third party cannot increase the supply chain surplus or if the risk associated with outsourcing is significant. Sourcing decisions should aim to provide the appropriate level of responsiveness at the lowest cost.

Components of Sourcing Decisions

In-House or Outsource The most significant sourcing decision for a firm is whether to perform a task in-house or outsource it to a third party. Within a task such as transportation, managers must decide whether to outsource all of it, outsource only the responsive component, or outsource only the efficient component. This decision should be driven in part by its impact on the total supply chain surplus. It is best to outsource if the growth in total supply chain surplus is significant with little additional risk.

Supplier Selection Managers must decide on the number of suppliers they will have for an activity. They must then identify the criteria along which suppliers will be evaluated and how they will be selected.

Procurement is the process of obtaining goods and services within a supply chain. Managers must structure procurement with a goal of increasing supply chain surplus. For example, a firm should set up procurement for direct materials to ensure good coordination between the supplier and buyer. In contrast, the procurement of MRO products should be structured to ensure that transaction costs are low.

Sourcing-Related Metrics

Sourcing decisions have a direct impact on the cost of goods sold and accounts payable. The performance of the source also affects quality, inventories, and inbound transportation costs. A manager should track the following sourcing-related metrics that influence supply chain performance:

• **Days payable outstanding** measures the number of days between when a supplier performed a supply chain task and when it was paid for.

• **Average purchase price** measures the average price at which a good or service was purchased during the year. The average should be obtained by weighting each price by the quantity purchased at that price.

• **Range of purchase price** measures the fluctuation in purchase price during a specified period. The goal is to identify if the quantity purchased correlated with the price.

• **Average purchase quantity** measures the average amount purchased per order. The goal is to identify whether a sufficient level of aggregation is occurring across locations when placing an order.

• **Supply quality** measures the quality of product supplied.

• **Supply lead time** measures the average time between when an order is placed and when the product arrives. Long lead times reduce responsiveness and add to the inventory the supply chain must carry.

• **Percentage of on-time deliveries** measures the fraction of deliveries from the supplier that were on time.

• **Supplier reliability** measures the variability of the supplier's lead time as well as the delivered quantity relative to plan. Poor supplier reliability hurts responsiveness and adds to the amount of inventory the supply chain must carry.

PRICING

The role of Pricing in supply chain is the process by which a firm decides how much to charge customers for its goods and services. Pricing affects the customer segments that choose to buy the product, as well as influencing the customer's expectations. This directly affects the supply chain in terms of the level of responsiveness required as well as the demand profile that the supply chain attempts to serve.

Pricing is also a lever that can be used to match supply and demand, especially when the supply chain is not very flexible. Short-term discounts can be used to eliminate supply surpluses or decrease seasonal demand spikes by moving some of the demand forward. All pricing decisions should be made with the objective of increasing firm profits. This requires an understanding of the cost structure of performing a supply chain activity and the value this activity brings to the supply chain. The steady prices ensure that demand stays relatively stable.

Components of Pricing Decisions

Pricing and Economies of Scale Most supply chain activities display economies of scale. The small production runs more expensive per unit than large production runs. Loading and unloading costs make it cheaper to deliver a truckload to one location than to four. In each case, the provider of the supply chain activity must decide how to price it appropriately to reflect these economies of scale. A commonly used approach is to offer quantity discounts. Care must be taken to ensure that quantity discounts offered are consistent with the economies of scale in the underlying process.

Everyday Low Pricing Versus High–Low Pricing A firm such as Costco practices at its warehouse stores, keeping prices steady over time. In contrast, most supermarkets practice high–low pricing and offer steep discounts on a subset of their product every week. The Costco pricing strategy results in relatively stable demand. The high–low pricing strategies lead to different demand profiles that the supply chain must serve.

Fixed Price Versus Menu Pricing A firm must decide whether it will charge a fixed price for its supply chain activities or have a menu with prices that vary with some other attribute, such as the response time or location of delivery. If marginal supply chain costs or the value to the customer vary significantly along some attribute, it is often effective to have a pricing menu. For example, A customer pays an additional shipping fee for home delivery but pays nothing for a personal pickup.

Pricing-Related Metrics

Pricing directly affects revenues but can also affect production costs and inventories, depending on its impact on consumer demand. A manager should track the following pricing-related metrics.

• **Profit margin** measures profit as a percentage of revenue. A firm needs to examine a wide variety of profit margin metrics to optimize its pricing, including dimensions such as type of margin (gross, net, and so on), scope (SKU, product line, division, firm), customer type, and others.

• **Days sales outstanding** measures the average time between when a sale is made and when the cash is collected.

• **Incremental fixed cost per order** measures the incremental costs that are independent of the size of the order. These include changeover costs at a manufacturing plant or order processing or transportation costs that are incurred independent of shipment size at a mail-order firm.

• **Incremental variable cost per unit** measures the incremental costs that vary with the size of the order. These include picking costs at a mail-order firm or variable production costs at a manufacturing plant.

• **Average sale price** measures the average price at which a supply chain activity was performed in each period. The average should be obtained by weighting the price with the quantity sold at that price.

• **Average order size** measures the average quantity per order. The average sale price, order size, incremental fixed cost per order, and incremental variable cost per unit help estimate the contribution from performing the supply chain activity.

• **Range of sale price** measures the maximum and the minimum of sale price per unit over a specified time horizon.

• **Range of periodic sales** measures the maximum and minimum of the quantity sold per period (day/week/month) during a specified time horizon. The goal is to understand any correlation between sales and price and any potential opportunity to shift sales by changing price over time.