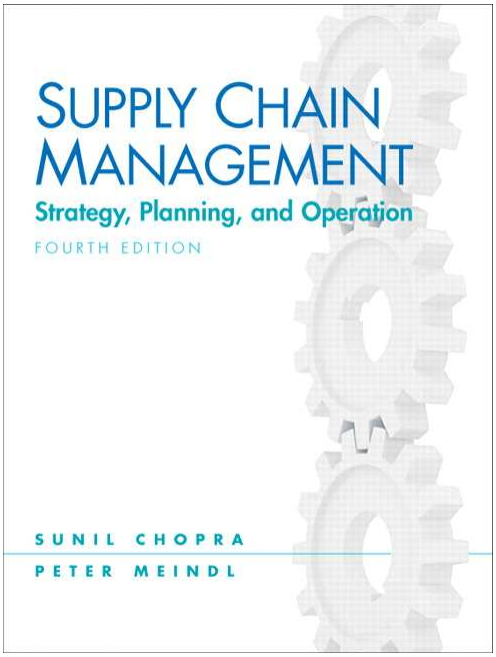
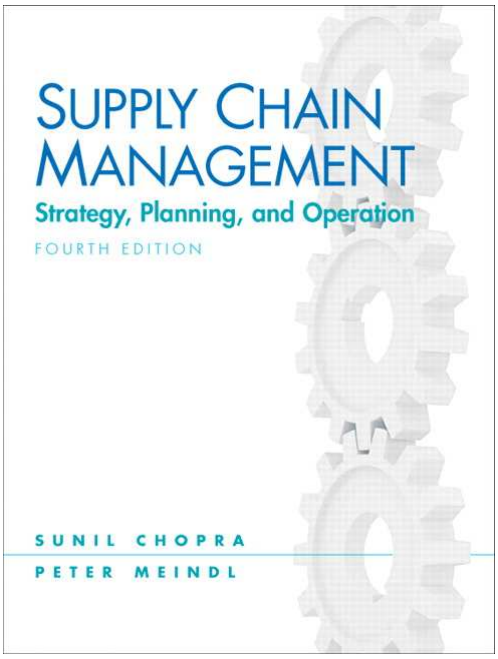


PLANNING Phase

- Chapter 7 Demand Forecasting in a Supply Chain
- Chapter 8 Aggregate Planning in a Supply Chain
- Chapter 9 Planning Supply and Demand in a Supply Chain
- Chapter 12 Determining the Optimal Level of Product Availability
- Chapter 13 Transportation
- Chapter 14 Sourcing
- Chapter 15 Pricing



Demand Forecasting in a Supply Chain

Role of Forecasting in a Supply Chain - 1

- The basis for all strategic and planning decisions in a supply chain
- Used for both push and pull processes
  - For push processes, a manager must plan the level of activity, be it production, transportation, or any other planned activity
  - For pull processes, a manager must plan the level of available capacity and inventory but not the actual amount to be executed
  - In both instances, the first step a manager must take is to forecast what customer demand will be.
- Examples:
  - Production: scheduling, inventory, aggregate planning
  - Marketing: sales force allocation, promotions, new production introduction
  - Finance: plant/equipment investment, budgetary planning
  - Personnel: workforce planning, hiring, layoffs

- Pull Example: Dell

uses a forecast of future demand to determine
- the quantity of components to have on hand (a push process)
- the capacity needed in its plants (for pull production).

- Push Example: Intel

needs forecasts to determine its own production and inventory levels.
Intel's suppliers also need forecasts for the same reason.

Characteristics of Forecasts

- Forecasts are always wrong. Should include expected value and measure of error.
- Long-term forecasts are less accurate than short-term forecasts (forecast horizon is important)
- Aggregate forecasts are more accurate than disaggregate forecasts

Components of a Forecast - Introduction

- customer demand is influenced by a variety of factors and can be predicted, at least with some probability, if a company can determine the relationship between these factors and future demand.
- To forecast demand, companies must first identify the factors that influence future demand and then ascertain the relationship between these factors and future demand.

7-Eleven Japan

- Seven-Eleven Japan provides its store managers with a state-of-the-art decision support system that makes a demand forecast and provides a recommended order.
- The store manager, however, is responsible for making the final decision and placing the order, because he or she may have access to information about market conditions that are not available in historical demand data.
- This knowledge of market conditions is likely to improve the forecast.
  - For example, if the store manager knows that the weather is likely to be rainy and cold the next day, he or she can reduce the size of an ice cream order to be placed with an upstream supplier, even if demand was high during the previous few days when the weather was hot.
- In this instance, a change in market conditions (the weather) would not have been predicted using historical demand data.
- A supply chain can experience substantial payoffs from improving its demand forecasting through qualitative human inputs.

Components of a Forecast

- A company must be knowledgeable about numerous factors that are related to the demand forecast. Some of these factors are:
  - Past demand
  - Lead time of product
  - Planned advertising or marketing efforts
  - State of the economy
  - Planned price discounts
  - Actions that competitors have taken
- For example, historically a firm may have experienced low demand for chicken noodle soup in July and high demand in December and January.
  - If the firm decides to discount the product in July, the situation is likely to change, with some of the future demand shifting to the month of July.
  - The firm should make its forecast taking this factor into consideration.

Forecasting Methods

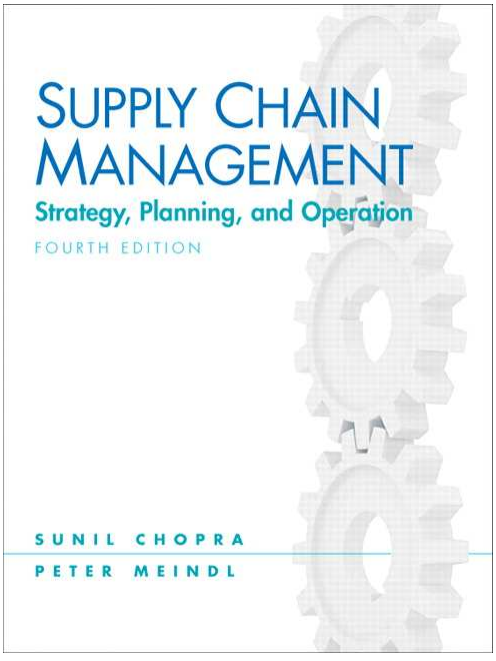
- Qualitative: primarily subjective; rely on judgment and opinion
- Time Series: use historical demand only
  - Static
  - Adaptive
- Causal: use the relationship between demand and some other factor to develop forecast
- Simulation
  - Imitate consumer choices that give rise to demand
  - Can combine time series and causal methods

Forecasting Method Selection

- A company may find it difficult to decide which method is most appropriate for forecasting.
- In fact, several studies have indicated that using multiple forecasting methods to create a combined forecast is more effective than using any one method alone.
- Time-series methods, which are most appropriate when future demand is related to historical demand, growth patterns, and any seasonal patterns.

Basic Approach to Demand Forecasting

- Understand the objectives of forecasting
- Integrate demand planning and forecasting
- Identify major factors that influence the demand forecast
- Understand and identify customer segments
- Determine the appropriate forecasting technique
- Establish performance and error measures for the forecast



Aggregate Planning in the Supply Chain

Role of Aggregate Planning in a Supply Chain

- Capacity has a cost, lead times are greater than zero
- Therefore, companies must make decisions regarding
  - capacity levels,
  - production levels,
  - outsourcing, and
  - promotions well before demand is known.
- A company must anticipate demand and determine, in advance of that demand, how to meet it.

Role of Aggregate Planning in a Supply Chain

- Aggregate planning:
  - process by which a company determines levels of capacity, production, subcontracting, inventory, stockouts, and pricing over a specified time horizon
  - goal is to satisfy demand while maximizing profit.
  - This level of detail makes aggregate planning a useful tool for thinking about decisions with an intermediate time frame of between roughly 3 and 18 months.
  - Therefore, aggregate planning answers the question, "How should a firm best utilize the facilities that it currently has?"

Role of Aggregate Planning in a Supply Chain

- The aggregate planner's main objective is to identify the following operational parameters over the specified time horizon:
  - production rate: the number of units to be completed per unit time (such as per week or per month)
  - Workforce: the number of workers/units of capacity needed for production
  - Overtime: the amount of overtime production planned
  - machine capacity level: the number of units of machine capacity needed for production
  - Subcontracting: the subcontracted capacity required over the planning horizon
  - Backlog: demand not satisfied in the period in which it arises but carried over to future periods
  - inventory on hand: the planned inventory carried over the various periods in the planning horizon

The Aggregate Planning Problem

Given the demand forecast for each period in the planning horizon, determine the production level, inventory level, and the capacity level for each period that maximizes the firm's (supply chain's) profit over the planning horizon

Information Needed for an Aggregate Plan

- Demand forecast in each period
- Production costs
  - labor costs, regular time ($/hr) and overtime ($/hr)
  - subcontracting costs ($/hr or $/unit)
  - cost of changing capacity: hiring or layoff ($/worker) and cost of adding or reducing machine capacity ($/machine)
- Labor/machine hours required per unit
- Inventory holding cost ($/unit/period)
- Stockout or backlog cost ($/unit/period)
- Constraints:
  - limits on overtime, layoffs, capital available, stockouts and backlogs
  - Constraints from suppliers to the enterprise

Outputs of Aggregate Plan

- Production quantity from regular time, overtime, and subcontracted time:
  - used to determine number of workers and supplier purchase levels
- Inventory held:
  - used to determine how much warehouse space and working capital is needed
- Backlog/stockout quantity:
  - used to determine what customer service levels will be
- Machine capacity increase/decrease:
  - used to determine if new production equipment needs to be purchased
- A poor aggregate plan can result in lost sales, lost profits, excess inventory, or excess capacity, thereby raising costs

Aggregate Planning Strategies

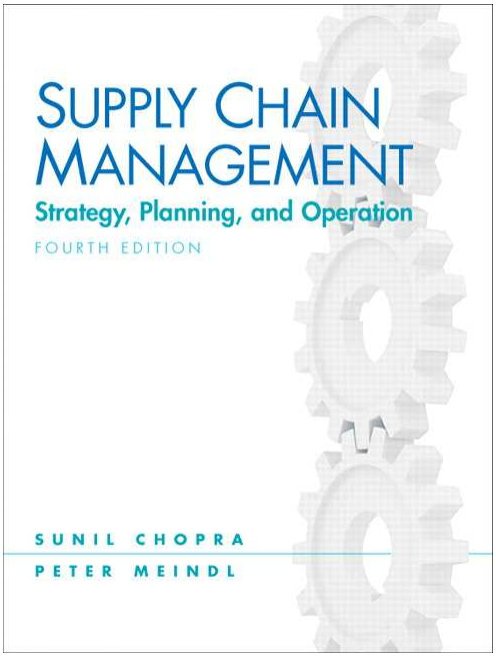
- Trade-off between capacity, inventory, backlog/lost sales
  - Arriving at the most profitable combination of trade-offs is the goal of aggregate planning.
- Given that demand varies over time, the relative level of the three costs leads to one of them being the key lever the planner uses to maximize profits.
  - If the cost of varying capacity is low, a company may not need to build inventory or carry backlogs.
  - If the cost of varying capacity is high, a company may compensate by building some inventory and carrying some backlogs from peak demand periods to off-peak demand and periods.

Aggregate Planning Strategies

- three distinct aggregate planning strategies for achieving balance between these costs
  - Chase strategy – using capacity as the lever
  - Time flexibility from workforce or capacity strategy – using utilization as the lever
  - Level strategy – using inventory as the lever
- These strategies involve trade-offs among capital investment, workforce size, work hours, inventory, and backlogs/lost sales.
- Mixed strategy – a combination of one or more of the first three strategies and are referred to as *tailored strategies*

FORECAST ERROR IN AGGREGATE PLANS

- The aggregate planning methodology we have discussed in this chapter does not take into account any forecast error.
- Forecasting errors are dealt with using
  - either *safety inventory,* defined as inventory held to satisfy demand that is higher than forecasted
  - or *safety capacity, defined as capacity used to satisfy* demand that is higher than forecasted.
- A company can create a buffer for forecast error using safety inventory and safety capacity in a variety of ways, some of which are listed next.
  - Use overtime as a form of safety capacity.
  - Carry extra workforce permanently as a form of safety capacity.
  - Use subcontractors as a form of safety capacity.
  - Build and carry extra inventories as a form of safety inventory.
  - Purchase capacity or product from an open or spot market as a form of safety capacity.



Sales and Operations Planning

Responding to Predictable Variability in a Supply Chain

- Predictable variability is change in demand that can be forecasted
- Can cause increased costs and decreased responsiveness in the supply chain
- A firm can handle predictable variability using two broad approaches:
  - Manage supply using capacity, inventory, subcontracting, and backlogs
  - Manage demand using short-term price discounts and trade promotions

Managing Supply

- Managing capacity
  - Time flexibility from workforce
  - Use of seasonal workforce
  - Use of subcontracting
  - Use of dual facilities – dedicated and flexible
  - Designing product flexibility into production processes
- Managing inventory
  - Using common components across multiple products
  - Building inventory of high demand or predictable demand products

Inventory/Capacity Trade-off

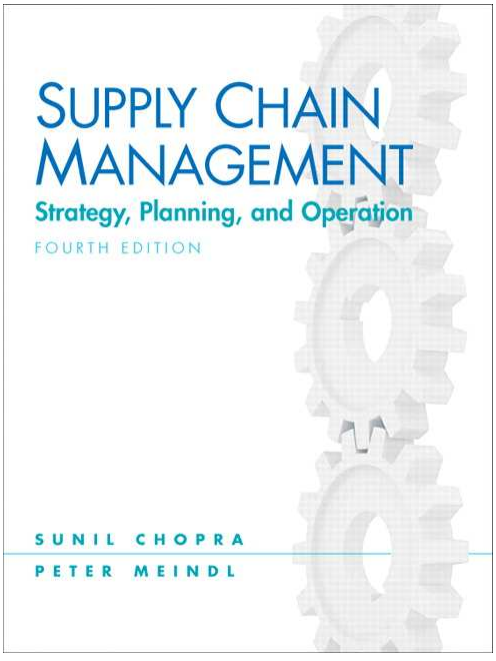
- Leveling capacity forces inventory to build up in anticipation of seasonal variation in demand
- Carrying low levels of inventory requires capacity to vary with seasonal variation in demand or enough capacity to cover peak demand during season

Managing Demand

- Promotion
- Pricing
- Timing of promotion and pricing changes is important
- Demand increases can result from a combination of three factors:
  - Market growth (increased sales, increased market size): Toyota promotion on Camry
  - Stealing share (increased sales, same market size): The same example
  - Forward buying (same sales, same market size)): The same example

Demand Management

- Pricing and aggregate planning must be done jointly
- Factors affecting discount timing
  - Product margin: Impact of higher margin ($40 instead of $31)
  - Consumption: Changing fraction of increase coming from forward buy
  - Forward buy



Determining the Optimal Level of Product Availability

Mattel, Inc. & Toys 'R Us

Mattel was hurt last year by inventory cutbacks at Toys 'R Us, and officials are also eager to avoid a repeat of the 1998 Thanksgiving weekend. Mattel had expected to ship a lot of merchandise after the weekend, but retailers, wary of excess inventory, stopped ordering from Mattel. That led the company to report a $500 million sales shortfall in the last weeks of the year ... For the crucial holiday selling season this year, Mattel said it will require retailers to place their full orders before Thanksgiving. And, for the first time, the company will no longer take reorders in December, Ms. Barad said. This will enable Mattel to tailor production more closely to demand and avoid building inventory for orders that don't come.

- *Wall Street Journal*, Feb. 18, 1999

Importance of the Level of Product Availability

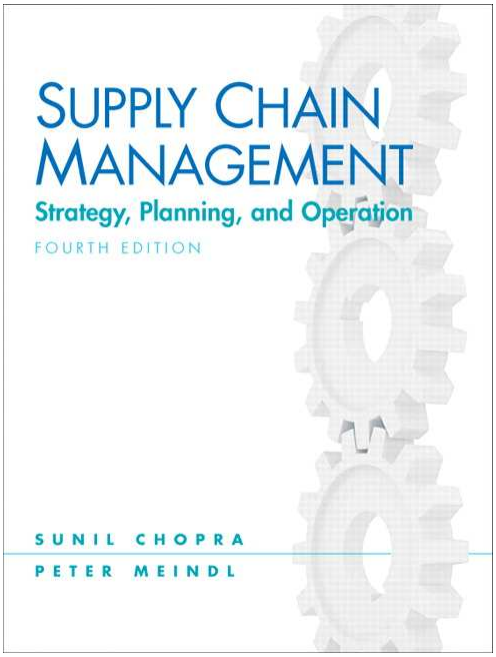
- Product availability measured by cycle service level or fill rate
- Also referred to as the customer service level
- Product availability affects supply chain responsiveness
- Trade-off:
  - High levels of product availability ➔ increased responsiveness and higher revenues
  - High levels of product availability ➔ increased inventory levels and higher costs
- Product availability is related to profit objectives, and strategic and competitive issues (e.g., Nordstrom, supermarkets, e-commerce retailers)
- What is the level of fill rate or cycle service level that will result in maximum supply chain profits?

Factors Affecting the Optimal Level of Product Availability

- Cost of overstocking
- Cost of under stocking
- Possible scenarios
  - Seasonal items with a single order in a season
  - One-time orders in the presence of quantity discounts
  - Continuously stocked items
    - » Demand during stock out is backlogged
    - » Demand during stock out is lost

Managerial Levers to Improve Supply Chain Profitability

- "Obvious" actions
  - Increase salvage value of each unit (include selling to outlet stores)
  - Decrease the margin lost from a stockout (arranging for backup sourcing)
- Improved forecasting
- Quick response
- Postponement
- Tailored sourcing



Transportation in a Supply Chain

Factors Affecting Transportation Decisions

- Carrier (party that moves or transports the product)
  - Vehicle-related cost
  - Fixed operating cost
  - Trip-related cost
- Shipper (party that requires the movement of the product between two points in the supply chain)
  - Transportation cost
  - Inventory cost
  - Facility cost

Transportation Modes

- Trucks
  - TL
  - LTL
- Rail
- Air
- Water
- Pipeline
- Package Carriers

Intermodal

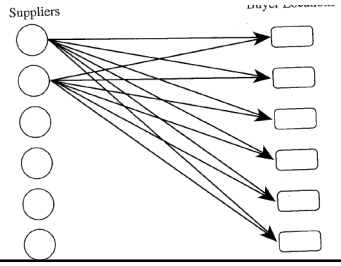
- Use of more than one mode of transportation to move a shipment to its destination
- Most common example: rail/truck
- Also water/rail/truck or water/truck
- Grown considerably with increased use of containers
- Increased global trade has also increased use of intermodal transportation
- More convenient for shippers (one entity provides the complete service)
- Key issue involves the exchange of information to facilitate transfer between different transport modes

Design Options for a Transportation Network

- What are the transportation options? Which one to select? On what basis?
- Direct shipping network
- Direct shipping with milk runs
- All shipments via central DC
- Shipping via DC using milk runs
- Tailored network

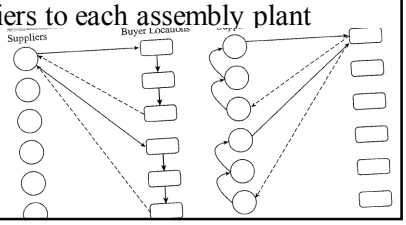
Direct shipping network

- a trade-off between transportation and inventory costs
- is justified if demand at buyer locations is large enough that optimal replenishment lot sizes are close to a TL from each supplier to each location.
- The major advantage: elimination of intermediate warehouses and its simplicity of operation and coordination
- the supply chain manager only needs to decide on the quantity to ship and the mode of transportation to use.



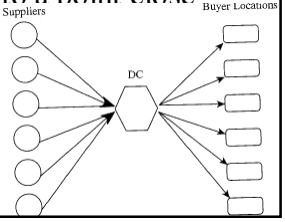
Direct shipping with milk runs

- n which a truck either delivers product from a single supplier to multiple retailers or goes from multiple suppliers to a single buyer location
- When using this option, a supply chain manager has to decide on the routing of each milk run
- provides the benefit of eliminating intermediate warehouses, whereas milk runs lower transportation cost by consolidating shipments to multiple locations on a single truck
- Toyota uses milk runs from many suppliers to each assembly plant



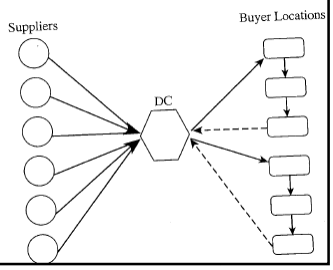
All shipments via central DC

- The buyer divides locations by geographic region and a DC is built for each region
- The DC is an extra layer between suppliers and buyer locations and can play two different roles:
  - to store inventory
  - to serve as a transfer location.
- The presence of a DC allows a supply chain to achieve economies of scale for inbound transportation to a point close to the final destination
- Cross-Docking
- Wal-Mart



Shipping via DC using milk runs

- milk runs can be used from a DC if lot sizes to be delivered to each buyer location are small.
- Milk runs reduce outbound transportation costs by consolidating small shipments.
- Seven-Eleven Japan



Tailored network

- transportation uses a combination of cross-docking, milk runs, and TL and LTL carriers, along with package carriers in some cases.
- The goal is to use the appropriate option in each situation.
  - High demand products to high-demand retail outlets may be shipped directly,
  - low demand products or shipments to low-demand retail outlets are consolidated to and from the DC.
- The complexity of managing this transportation network is high because different shipping procedures are used for each product and retail outlet.
- Operating a tailored network requires significant investment in information infrastructure to facilitate the coordination.
- Such a network, however, allows for the selective use of a shipment method to minimize the transportation as well as inventory costs.

Trade-offs in Transportation Design

- Transportation and inventory cost trade-off
  - Choice of transportation mode
  - Inventory aggregation
- Transportation cost and responsiveness trade-off

Choice of Transportation Mode

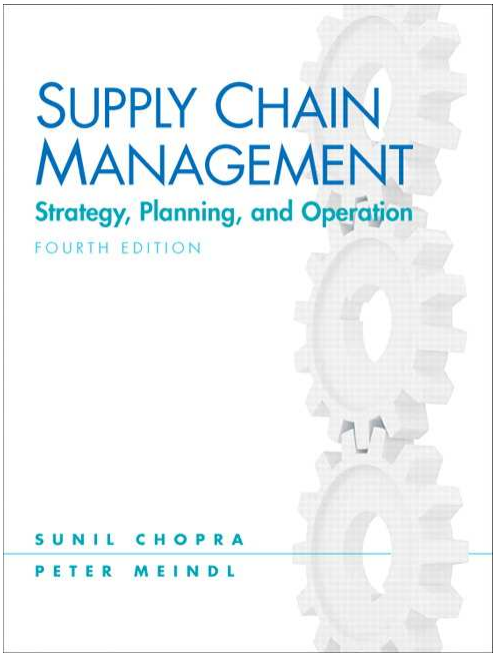
- A manager must account for inventory costs when selecting a mode of transportation
- A mode with higher transportation costs can be justified if it results in significantly lower inventories

Inventory Aggregation: Inventory vs. Transportation Cost

- As a result of physical aggregation
  - Inventory costs decrease
  - Inbound transportation cost decreases
  - Outbound transportation cost increases
- Inventory aggregation decreases supply chain costs if the product has a high value to weight ratio, high demand uncertainty, or customer orders are large
- Inventory aggregation may increase supply chain costs if the product has a low value to weight ratio, low demand uncertainty, or customer orders are small

Trade-offs Between Transportation Cost and Customer Responsiveness

- Temporal aggregation is the process of combining orders across time
- Temporal aggregation reduces transportation cost because it results in larger shipments and reduces variation in shipment sizes
- However, temporal aggregation reduces customer responsiveness



Sourcing Decisions in a Supply Chain

The Role of Sourcing in a Supply Chain

- Purchasing, also called procurement, is the process by which companies acquire raw materials, components, products, services, or other resources from suppliers to execute their operations.
- Sourcing is the set of business processes required to purchase goods and services

Outsourcing vs. Off-shoring

- A firm *off-shores a supply chain function if it maintains ownership* but moves the production facility offshore.
- A firm *outsources if the firm* hires an outside firm to perform an operation rather than executing the operation within the firm.
- A firm should consider outsourcing if the growth in surplus is large with a small increase in risk.

HOW DO THIRD PARTIES INCREASE THE SUPPLY CHAIN SURPLUS

- Capacity aggregation (Intel, Magna Steyr)
- Inventory aggregation (Brightstar)
- Transportation aggregation by transportation intermediaries (UPS, FedEx; DaimlerChrysler and Ford.)
- Transportation aggregation by storage intermediaries (Grainger and McMaster-Carr)
- Procurement aggregation (FleetXchange)
- Information aggregation
- Receivables aggregation (Brightstar)
- Relationship aggregation
- Lower costs and higher quality

Benefits of Effective Sourcing Decisions

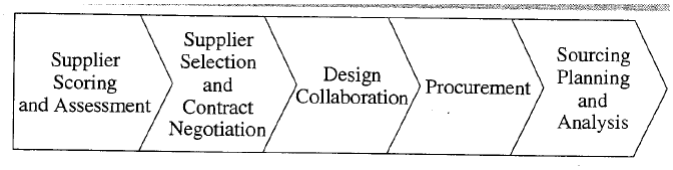
- Better economies of scale can be achieved if orders are aggregated
- More efficient procurement transactions can significantly reduce the overall cost of purchasing
- Design collaboration can result in products that are easier to manufacture and distribute, resulting in lower overall costs
- Good procurement processes can facilitate coordination with suppliers
- Appropriate supplier contracts can allow for the sharing of risk
- Firms can achieve a lower purchase price by increasing competition through the use of auctions

RISKS OF USING A THIRD PARTY

- *The process is broken*
- *Underestimation of the cost of coordination*
- *Reduced customer/supplier contact*
- *Loss of internal capability and growth in third-party power*
- *Leakage of sensitive data and information*
- *Ineffective contracts*

Sourcing Process

- Sourcing processes include:
  - Supplier scoring and assessment
  - Supplier selection and contract negotiation
  - Design collaboration
  - Procurement
  - Sourcing planning and analysis



Supplier Assessment Factors

- Replenishment Lead Time
  - As the replenishment lead time from a supplier grows, the amount of safety inventory that needs to be held by the buyer also grows
- On-Time Performance
  - On-time performance affects the variability of the lead time.
  - A reliable supplier has low variability of lead time, whereas an unreliable supplier has high variability.
  - As the variability of lead time grows, the required safety inventory at the firm grows very rapidly

Supplier Assessment Factors

- Supply Flexibility
  - Supply flexibility is the amount of variation in order quantity that a supplier can tolerate without letting other performance factors deteriorate.
  - The less flexible a supplier is, the more lead-time variability it will display as order quantities change.
  - Supply flexibility thus affects the level of safety inventory that the firm will have to carry.
- Delivery Frequency / Minimum Lot Size
  - The delivery frequency and the minimum lot size offered by a supplier affect the size of each replenishment lot ordered by a firm.
  - As the replenishment lot size grows, the cycle inventory at the firm grows, thus increasing the cost of holding inventory

Supplier Assessment Factors

- Supply Quality
  - A worsening of supply quality increases the variability of the supply of components available to a firm
- Inbound Transportation Cost
  - The total cost of using a supplier includes the inbound transportation cost of bringing material in from the supplier.
  - Sourcing a product overseas may have lower product cost but generally incurs a higher inbound transportation cost, which must be accounted for when comparing suppliers.
  - The distance, mode of transportation, and delivery frequency affect the inbound transportation cost associated with each supplier.

Supplier Assessment Factors

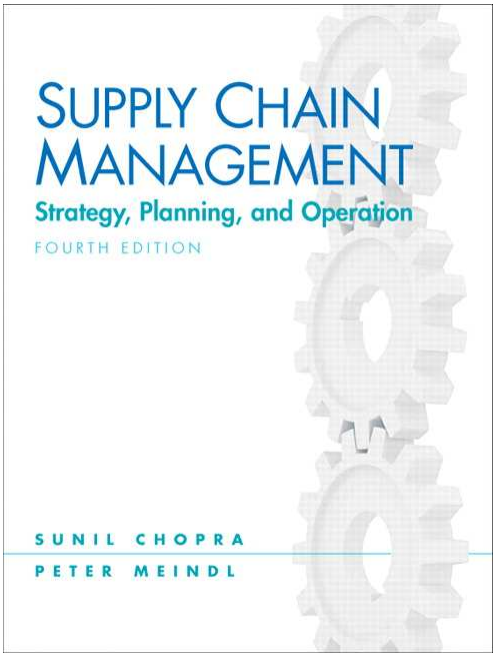
- Pricing Terms
  - Pricing terms include the allowable time delay before payment has to be made and any quantity discounts offered by the supplier.
  - Price terms also include discounts for purchases above certain quantities.
- Information Coordination Capability
  - The information coordination capability of a supplier is harder to quantify, but it affects the ability of a firm to match supply and demand.
  - Good coordination results in better replenishment planning, thus decreasing both the inventory carried as well as the sales lost because of lack of availability.
  - Good information coordination also decreases the bullwhip effect and results in lower production, inventory, and transportation costs while improving responsiveness to the customer

Supplier Assessment Factors

- Exchange Rates, Taxes, Duties
  - Although exchange rates, taxes, and duties are not supplier dependent, they can be significant for a firm with a global manufacturing and supply base.
- Supplier Viability
  - Given the impact that suppliers have on a company's performance, an important factor in picking a supplier is the likelihood that it will be around to fulfill the promises it makes.
  - This consideration can be especially important if the supplier is providing mission -critical products and it would be difficult to find a replacement for.

Single/ Multiple Sourcing

- Before selecting suppliers, a firm must decide whether to use single sourcing or multiple suppliers.
- Single sourcing guarantees the supplier sufficient business when the supplier has to make a significant buyer-specific investment.
  - The buyer-specific investment may take the form of plant and equipment designed to produce a part that is specific to the buyer or may take the form of expertise that needs to be developed.
  - Single sourcing is also used in the automotive industry for parts such as seats that must arrive in the sequence of production.
    - » Coordinating such sequencing is impossible with multiple sources.
    - » As a result, auto companies have a single seat source for each plant but multiple seat sources across their manufacturing network.
- Having multiple sources ensures a degree of competition and also the possibility of a backup should a source fail to deliver.
- A good test of whether a firm has the right number of suppliers is to analyze what impact deleting or adding a supplier will have.



Pricing and Revenue Management in the Supply Chain

The Role of Pricing and Revenue Management in the Supply Chain

- Revenue management is the use of pricing to increase the profit generated from a limited supply of supply chain assets
- Revenue management may also be defined as the use of differential pricing based on customer segment, time of use, and product or capacity availability to increase supply chain profits
- Most common example is probably in airline pricing

Conditions Under Which Revenue Management Has the Greatest Effect

- The value of the product varies in different market segments (Example: airline seats)
- The product is highly perishable or product waste occurs (Example: fashion and seasonal apparel)
- Demand has seasonal and other peaks (Example: products ordered at Amazon.com)
- The product is sold both in bulk and on the spot market (Example: owner of warehouse who can decide whether to lease the entire warehouse through long-term contracts or save a portion of the warehouse for use in the spot market)

Pricing and Revenue Management for Multiple Customer Segments

- If a supplier serves multiple customer segments with a fixed asset, the supplier can improve revenues by setting different prices for each segment
- To differentiate between the various segments, the firm must create barriers by identifying product or service attributes that the segments value differently.

Pricing and Revenue Management for Multiple Customer Segments

- To use revenue management successfully when serving multiple customer segments, a firm must use the following tactics effectively:
  - Price based on the value assigned by each segment
  - Use different prices for each segment
  - Forecast at the segment level

Pricing and Revenue Management for Perishable Assets

- Any asset that loses value over time is perishable
- Examples: high-tech products such as computers and cell phones, high fashion apparel, underutilized capacity, fruits and vegetables
- Two basic approaches:
  - Vary price over time to maximize expected revenue (Dynamic Pricing)
  - Overbook sales of the asset to account for cancellations

Pricing and Revenue Management for Seasonal Demand

- Seasonal peaks of demand are common in many supply chains
- Examples: Most retailers achieve a large portion of total annual demand in December (Amazon.com)
- Off-peak discounting can shift demand from peak to non-peak periods
- Charge higher price during peak periods and a lower price during off-peak periods

Pricing and Revenue Management for Bulk and Spot Customers

- Most consumers of production, warehousing, and transportation assets in a supply chain face the problem of constructing a portfolio of long-term bulk contracts and short-term spot market contracts
- The basic decision is the size of the bulk contract
- The fundamental trade-off is between wasting a portion of the low-cost bulk contract and paying more for the asset on the spot market