

LEAN SUPPLY CHAIN MANAGEMENT**Modules**

1. Lean Supply Chain Management
2. Six Sigma
3. Agile Supply Chain Management
4. E Marketing
5. SCOR Model

Rationale and Logic

This lecture takes into account the important concepts relating to lean as well as agile supply chain management which have gained recognition as acceptable form of supply chain that brings competitive advantage to the enterprises. Supply chain management (SCM) has been a major component of competitive strategy to enhance organizational productivity and profitability. The virtual university student should be able to gain an insight and preferably a management strategy in place to link these important modules and formulate a road map for supply chain maturity model for their enterprise and its partners.

MODULE 1: LEAN SUPPLY CHAIN MANAGEMENT

In the 1990s, supply chain management professional experts combined 4 important strategies and management philosophies like Quick Response, Efficient Consumer Response, Just In Time, and Keiretsu Relationships. For the sake of easy reference, the special characteristics related to each strategy and philosophy is represented in the form of a table below

<i>SR. #</i>	<i>NAME/CONCEPT</i>	<i>CHARACTERISTIC</i>
1	Quick response(QR)	Speed & flexibility
2	Efficient Consumer Response (ECR)	Speed & flexibility
3	Just in Time	Continuous reduction of waste
4	Keiretsu Relationships	Including suppliers in JIT/TQM efforts

These approaches have emerged as philosophies & practices known as Lean Production (or Lean Manufacturing) & Six Sigma. A very common example readily identifiable and acceptable to both Academia and Practitioners is the synonymous Lean Production & the Toyota Production System.

Virtual University students are reminded that JIT emphasizes: Reduction of waste, continuous improvement, synchronization of material flows within the organization /enterprise and finally channel integration by extending partnerships in the supply chain.

If the Supply Chain Management Department wants to adopt a Lean Production or more correctly the Toyota Production System, there would be more or less four stages which in sequential order are presented in the form of the table below: -

<i>STAGES</i>	<i>CHARACTERISTICS</i>
Stage 1	Enterprise is internally focused & functions managed separately. Silo effect is reactive & short-term goal oriented.
Stage 2	Enterprise integrates efforts & resources among internal functions.
Stage 3	Enterprise links suppliers/customers with enterprise's processes.
Stage 4	Enterprise broadens supply chain influence beyond immediate or first-tier suppliers & customers.

Lean Production: *is an operating philosophy of waste reduction & value enhancement & was originally created as Toyota Production System (TPS) by key Toyota executives.* Early versions were based on Ford assembly plants & U.S. supermarket distribution systems. The key concepts incorporated in TPS are Muda (waste in all aspects of production), Kanban (signal card & part of JIT), and Statistical process control (SPC) as part of TQM efforts and Poka-Yoke - error or mistake-proofing. Supply chain management (SCM) seeks to incorporate Lean elements using cross-training, satisfying internal customer demand, quickly moving products in the production system, communicating demand forecasts & production schedules up the supply chain and optimizing inventory levels across the supply chain

Lean Production & Supply Chain Management often considers the important concept of Channel integration which describes extending alliances to suppliers' suppliers & customers' customers. However, the silo effect works against channel integration.

<i>Stage 1</i> Internal Focused	<i>Stage 2</i> Functional Integration	<i>Stage 3</i> Internal Integration	<i>Stage 4</i> External Integration
Functional Silos	Internal flow of goods	Integration of flow in firm	Integration with suppliers and customers
Top-down management	Emphasis on cost reduction	Lean activities for goods and information	Integration explored with 2 nd & 3 rd tier suppliers and customers
Internal performance measures	Efficiencies gained by Internal Integration	Measurement of supplier performance and customer service	Alliance Development
Reactive, Short term planning			
No internal integration			

The Elements of Lean Production

The constituents of Lean Production are waste reduction, lean supply chain relationships, lean layouts, inventory & setup time reduction, small batch scheduling, continuous improvement and workforce Empowerment.

Waste (Muda) Reduction

Enterprises reduce costs & add value by eliminating waste from the productive system. Supply Chain and Operation Managers already know that waste encompasses wait times, inventories,

material & people movement, processing steps, variability, any other non-value-adding activity. Japanese expert, Taiichi Ohno described the seven wastes as follows: -

<i>Sr. #</i>	<i>Wastes</i>	<i>Description</i>
1	Overproducing	Unnecessary production to maintain high utilizations
2	Waiting	Excess idle machine & operator & inventory wait time
3	Transportation	Excess movement of materials & multiple handling
4	Over-processing	Non-value adding manufacturing & other activities
5	Excess Inventory	Storage of excess inventory
6	Excess Movement	Unnecessary movements of employees
7	Scrap & Rework	Scrap materials & rework due to poor quality

For the sake of academic interest, Virtual University Students are also invited to observe the 5 –S associated with lean production, which are of extreme value when dealing with Japanese and global companies.

*We are now in a position to identify the most common of **Lean Supply Chain Relationships** and the important concept of lean layouts. Virtual University students are already aware of Inventory reduction, set up time reduction and Just in Time concepts. All these are important concepts and are considered to a logical part of lean supply chains.*

Virtual University students should remember that: -

1. SCM partners (Suppliers & customers) as well as enterprise need to work to remove waste, reduce cost, & improve quality & customer service
2. JIT purchasing includes delivering smaller quantities, at right time, delivered to the right location, in the right quantities
3. Enterprises develop lean supply chain relationships with key customers. Mutual dependency & benefits occur among these partners.

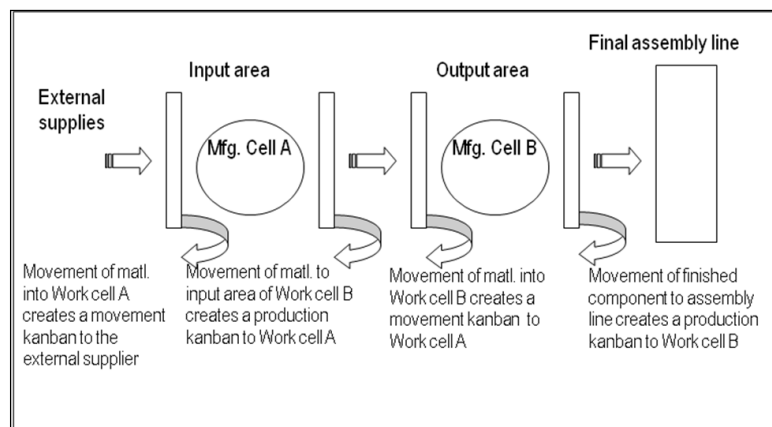
Supply Chain network designs should comply with “Lean Layouts” requirements especially the following reasons

1. Move people & materials when & where needed, ASAP
2. Lean layouts are very visual (lines of visibility are unobstructed) with operators at one processing center able to monitor work at another
 - a. Manufacturing cells by processing similar parts or components saving duplication of equipment & labor
 - b. Also are often U-shaped to facilitate easier operator & material movements

Supply Chain Managers often over emphasize **Inventory & Setup Time Reduction** primarily because of the fact that these are the sources where cost cutting can improve controls over movement of products, services, information and cash flow and reduction of unfavorable risks. Student are requested to remember that

1. Excess inventory is a waste
2. Reducing inventory levels causes production problems
3. Once problems are detected, they can be solved.
4. The end result is a smoother running organization with less inventory investment.

Students are also recommended that they pay special attention to the relationship between JIT & Supply Chain Management. The picture more or less explains this critical relationship by identifying the movement of material from manufacturing cell A to cell B and to final assembly line as a finished component. It also shows the production of Kanbans.



Virtual University students already know that why incremental or **Small**

Batch Scheduling is always considered a favorable strategy by supply chain managers. A very fundamental reason being that Small batch scheduling drives down costs by –

1. Reducing purchased, WIP, & finished goods inventories
2. Makes the enterprise more flexible to meet customer demand

Also Small production batches are accomplished with the use of **KANBANS**. Remember that Kanbans generate demand for parts at all stages of production creating a “pull” system

Another important dimension with respect to JIT & Supply Chain Management is the continuous improvement and workforce commitment. Again for the sake of reference, the two concepts are being presented

Continuous Improvement (Kaizen): Is the continuous approach to reduce process, delivery, & quality problems, such as machine breakdown problems, setup problems, & internal quality problems

Workforce Commitment: Supply Chain as well as other managers must support Lean Production by providing subordinates with the skills, tools, time, & other necessary resources to identify problems & implement solutions

We now take a more strategic concept by considering the relationship between Lean Production & the Environment. Students are reminded that

Lean green practices help the supply chain as well as the environment and the enterprise in the following ways

1. Reducing the cost of environmental management
2. Leading to improved environmental performance.
3. Increasing the possibility that enterprises will adopt more advanced environmental management

Most of the supply chains are now facing regulatory compliance for carbon footprint. Virtual University students are also aware of the problems faced in the field of energy management in Pakistan where International pressures and investors do not show favorable response for Coal based power plants because of this. Remember it is very vital that either the enterprises operations are Carbon-neutral or interventional programs are in place to offset the *carbon footprint* of an enterprise's operations.

Supply Chain managers often employ Six Sigma strategies to ensure that there is no wastage and even if waste is generated it is one a time instance and through learning curves the process is improved. Students already know that Six Sigma relates to near quality perfection (the statistical likelihood of non-defects 99.99966% of the time); this concept was pioneered by Motorola in 1987. Six Sigma is in reality a statistics-based decision-making framework designed to make significant quality improvements in value-adding processes.

Six Sigma Metrics

# of std dev above the mean	% of defect-free output	DPMO
2	69.15	308,537
2.5	84.13	158,686
3	93.32	66,807
3.5	97.73	22,750
4	99.38	6,210
4.5	99.865	1,350
5	99.977	233
5.5	99.9968	32
6	99.99966	3.4

Note: standard deviations include 1.5 sigma "drift"

Lean Six Sigma (Lean Six σ) describes

the assimilation of lean production and Six Sigma quality practices. At the same time both the concepts use

- a. High quality input materials, WIP, and finished goods
- b. Continuous Improvement (Kaizen)

Lean and Six Sigma use complementary tool sets and are not competing philosophies

Virtual University students are suggested that not only they should be able to remember and convey these important concepts at their enterprise level but also share it with the enterprise supply chain partners.

1. Process integration & communication lead to fewer negative chain reactions along the supply chain, such as greater levels of safety stock, lost time & less productivity
2. Six Sigma is an enterprise and supply chain-wide philosophy, that emphasizes a commitment toward excellence & encompasses suppliers' employees, and customers

Elements of Six Sigma are more or less based on Deming's 14 points

1. Create constancy of purpose to improve product & service.

2. Adopt the new philosophy.
3. Cease dependence on inspection to improve quality.
4. End the practice of awarding business on the basis of price.
5. Constantly improve the production & service system.
6. Institute training on the job.
7. Institute leadership.
8. Drive out fear.
9. Break down barriers between departments.
10. Eliminate slogans & exhortations.
11. Eliminate quotas.
12. Remove barriers to pride of workmanship.
13. Institute program of self-improvement
14. Put everyone to work to accomplish the transformation

Elements of Six Sigma also make use of concepts developed by Crosby's, which are also known as four Absolutes of Quality

1. The definition of quality is conformance to requirements
2. The system of quality is prevention.
3. Performance standard is zero defects.
4. The measure of quality is the price of nonconformance

Elements of Six Sigma can be understood better by following Juran's concept of quality planning, quality control and quality improvement.

1. **Quality Planning:** Identify internal/external customers & their needs; develop products that satisfy those needs. Managers set goals, priorities, & compare results
2. **Quality Control:** Determine what to control, establish standards of performance, measure performance, interpret the difference, & take action
3. **Quality Improvement:** Show need for improvement, identify projects for improvement, implement remedies, and provide control to maintain improvement.

We will now elaborate our discussion on Elements of Six Sigma by considering the objectives and categories measured in order to identify the enterprise and supply chain for **Malcolm Baldrige National Quality Award**. This award has a criterion which requires fulfillment of definite objectives relating to quality achievement and improvement with respect to certain categories measured.

Objectives: Some of the most objectives that are pursued include:

1. Stimulate enterprises to improve
2. Recognize enterprises for quality achievements,
3. Establish guidelines so that organizations can evaluate their improvement & provide guidance to others

Categories Measured

1. Leadership
2. Strategic planning
3. Customer & market focus
4. Information & analysis

5. Human resource focus
6. Process management
7. Business Results

ISO 9000 and ISO 14000 Families of Management Standards are a must for most of the manufacturing and service based enterprises

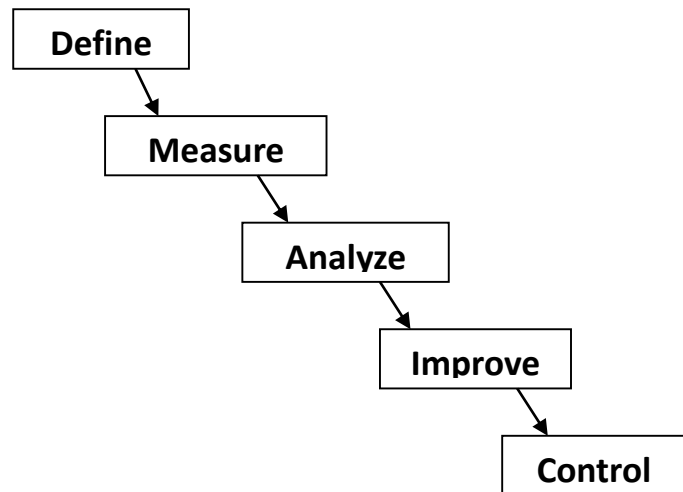
1. International Organization for Standardization (ISO) located in Switzerland has total of 163 member countries, with few other countries in the process of becoming members.
2. ISO 9000 and 14000 govern quality and environmental certification standards of production, respectively.
3. The ISO 9000 standards were adopted in the US by ANSI and ASQ.

The DMAIC Improvement Cycle is very important and shows an information based system that helps an organization to design its system and after careful analysis improve the output or performance. DMAIC is an abbreviation that represents the important concepts of Define, Measure, Analyze, Improve and Control. It can be used for improvement projects even outside the domain of Six Sigma.

Another important concept is DFSS which refers to Design for Six Sigma and is a business-process management "methodology" related to traditional Six Sigma. It is applicable in different industries, like finance, marketing, basic engineering, process industries, waste management, and electronics.

Six Sigma Training Levels

It is important that Supply Chain Managers be aware of the importance of Black Belt certification and quality elements of Six Sigma. This has become an industrial standard and followed religiously at leading organizations like General Electric Corporation.



<i>Levels</i>	<i>Description</i>
Yellow Belt	Basic understanding of Six Sigma Methodology and tools in the DMAIC problem solving process. Team member on process improvement project.
Green Belt	A trained team member allowed to work on small, carefully defined Six Sigma projects, requiring less than a Black Belt's full-time commitment.
Black Belt	Thorough knowledge of Six Sigma philosophies and principles. Coaches successful project teams. Identifies projects and selects project team members.
Master Black Belt	A proven mastery of process variability reduction, waste reduction and growth principles and can effectively present training at all levels

Statistical Tools of Six Sigma

Methods, Tools & Techniques are vital to the success of any Six Sigma project. Every stage of a Six Sigma project recipe requires a mix of these methods, tools & techniques. Let us in a few words appraise what we mean by these keywords.

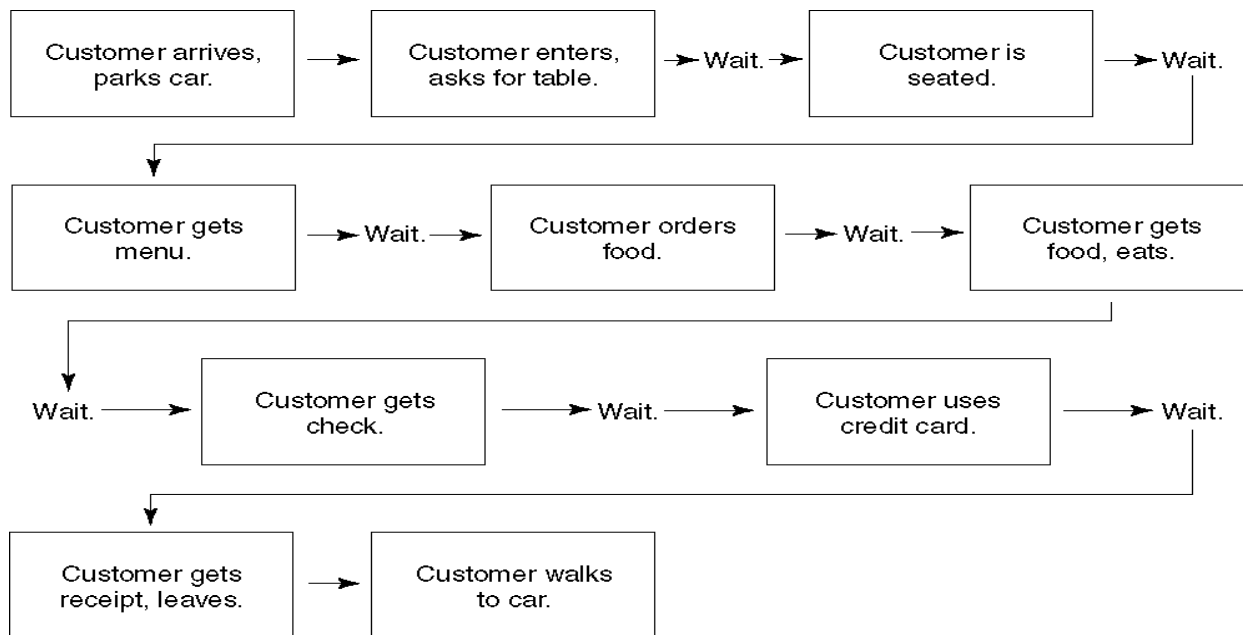
1. Method is a way of doing something in a systematic way. The word "systematic" implies an orderly logical sequence of steps or tasks.
2. Tool provides a mechanical or mental advantage in accomplishing a task.

3. Technique is a specific approach to efficiently accomplish a task in a manner that may not be immediately obvious.

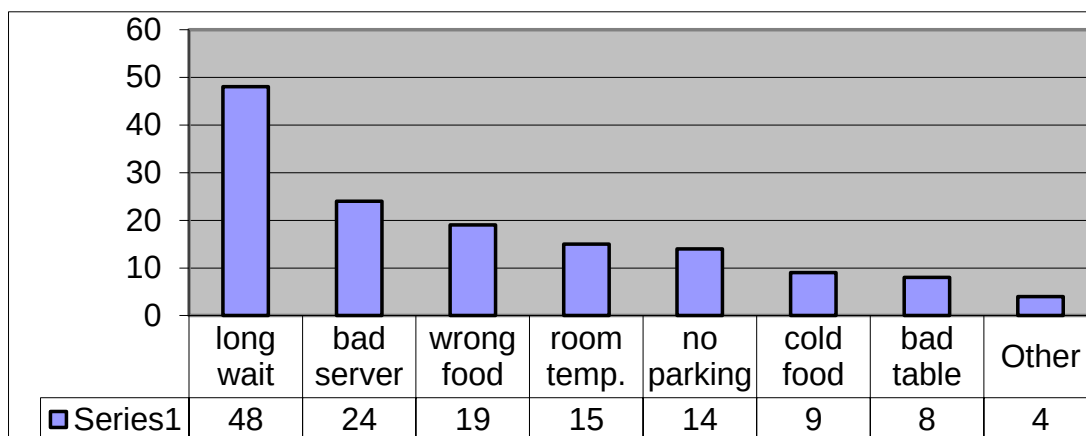
Some of the statistical tools used in six sigma methodology include brainstorming, affinity diagrams, flow diagrams, scatter plot, box plot, fish bone, sampling, SIPOC (Statistical Process Control) so and so forth.

A few of these commonly used statistical tools are represented here

1. **Flow Diagrams:** Annotated boxes representing process to show the flow of products or customers. We represent the case of a patron visiting a restaurant and the whole process is captured in the form of a flow diagram.

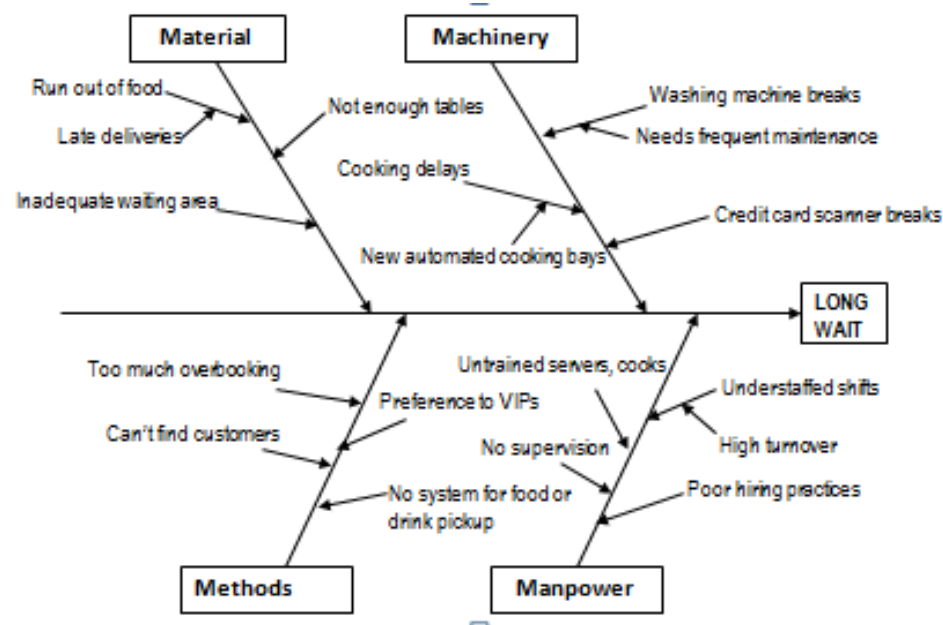


2. **Check Sheets:** used to determine frequencies for specific problems
3. **Pareto Charts:** used for presenting data in an organized fashion, indicating process problems from most to least severe.



PARETO CHART FOR RESTAURANT PROBLEMS

4. **Cause and Effect Diagrams (Fishbone or Ishikawa diagrams):** used to aid in brainstorming & isolating the causes of a problem. You have already seen a Pareto chart representing problems in service at a restaurant now let us construct a fish bone diagram



5. **Statistical Process Control:** Allows enterprises to visually monitor process performance, compare the performance to desired levels or standards and take corrective action.

Enterprises normally gather process performance data, create control charts to monitor process variability and then collect sample measurements of the process over time and plot on charts.

Statistical Process Control normally takes into account the following type of measurements

1. Natural variations: expected and random (can't control)
2. Assignable variations: have a specific cause (can control)
3. Variable data: continuous, (e.g., weight)
4. Attribute data: indicate some attribute such as color & satisfaction, or beauty.

Statistical Process Control makes use of two types of Variable Control Charts namely:

1. x-bar chart tracks central tendency of sample means
2. R-chart tracks sample ranges

The following steps are involved in Statistical Process Control (SPC)

1. Gather data when the process is in control.
2. Calculate the mean & the range for each sample.
3. Calculate the overall mean and average range of all the samples. Use the x-means to calculate the upper & lower control limits.
4. Use the means & control limits to construct x-bar and R control charts.
5. Collect samples over time and plot.

Some of the common formulas used in the statistical process control charts both for x-bar chart and R charts are presented.

Acceptance Sampling technique can be best used by a supply chain if it is able to set agreed upon quality criteria both for the suppliers as

$$\bar{x} = \frac{\sum_{i=1}^k \bar{x}_i}{k} \quad \bar{R} = \frac{\sum_{i=1}^k R_i}{k}$$

$$UCL_{\bar{x}} = \bar{x} + A_2 \bar{R} \quad UCL_R = D_4 \bar{R}$$

$$LCL_{\bar{x}} = \bar{x} - A_2 \bar{R} \quad LCL_R = D_3 \bar{R}$$

well as for the consumer's side. This actually takes into account both the producer's risk as well as the consumer's risk.

1. When shipments are received from suppliers, samples are taken and measured against the quality acceptance standard. Shipment is assumed to have the same quality.
2. Sampling is less time-consuming than testing every unit but can result in errors

Producer's risk: A buyer rejects a shipment of good quality units because the sample quality level did not meet standards (type I error)

Consumer's risk: Buyer accepts a shipment of poor-quality units because the sample falsely provides a positive answer (type II error)

MODULE 3: THE AGILE SUPPLY CHAIN

This module addresses the key concept of Agile Supply Chain and briefly explains what the dimensions of the Agile Supply Chain are.

The concept of Agility is represented by the fact that a supply chain is said to be agile if possesses one or more of the characteristics of Market Sensitive, Virtual, Network based and Process Integration. The characteristics are briefly discussed as follows.

1. Market sensitive: Supply chain is capable of reading and responding to real demand
2. Virtual: Information-based supply chain, rather than inventory-based.
3. Network based: EDI and internet enable partners in the supply chain to act upon the real demand
4. Process integration: Collaborative working between buyers and suppliers, joint product development, common systems and shared information

Demand characteristics and supply capabilities are represented in a tabular form

THE CONCEPT OF AGILITY IN TERMS OF LEAN AND AGILE SUPPLY CHAIN MANAGEMENT

<i>Distinguishing attributes</i>	<i>Lean supply</i>	<i>Agile supply</i>
Typical products	Commodities	Fashion goods
Marketplace demand	Predictable	Volatile
Product variety	Low	High
Product life cycle	Long	Short
Customer drivers	Cost	Availability
Profit margin	Low	High
Dominant costs	Physical costs	Marketability costs
Stock out penalties	Long-term contractual	Immediate and volatile
Purchasing policy	Buy materials	Assign capacity
Information enrichment	Highly desirable	Obligatory
Forecasting mechanism	Algorithmic	Consultative

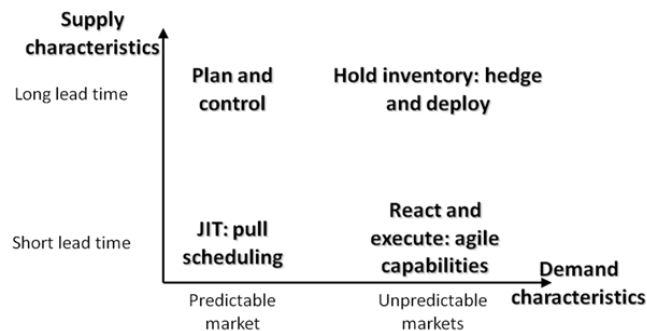
<i>Characteristic</i>	<i>Lean</i>	<i>Agile</i>
Logistics focus	Eliminate waste	Customers and markets
Partnerships	Long-term, stable	Fluid clusters
Key measure	Output measure such as productivity and cost	Measure capabilities, and focus on customer satisfaction
Process focus	Work standardization, conformance to standards	Focus on operator self-management to maximize autonomy
Logistics planning	Stable, fixed period	Instantaneous response

THE CONCEPT OF AGILITY IN TERMS OF MARKET WINNERS AND MARKET QUALIFIERS

Agile Supply	1. <u>Quality</u> 2. <u>Cost</u> 3. <u>Lead Time</u>	1. <u>Service Level</u>
Lean Supply	1. <u>Quality</u> 2. <u>Lead Time</u> 3. <u>Service Level</u>	1. <u>Cost</u>

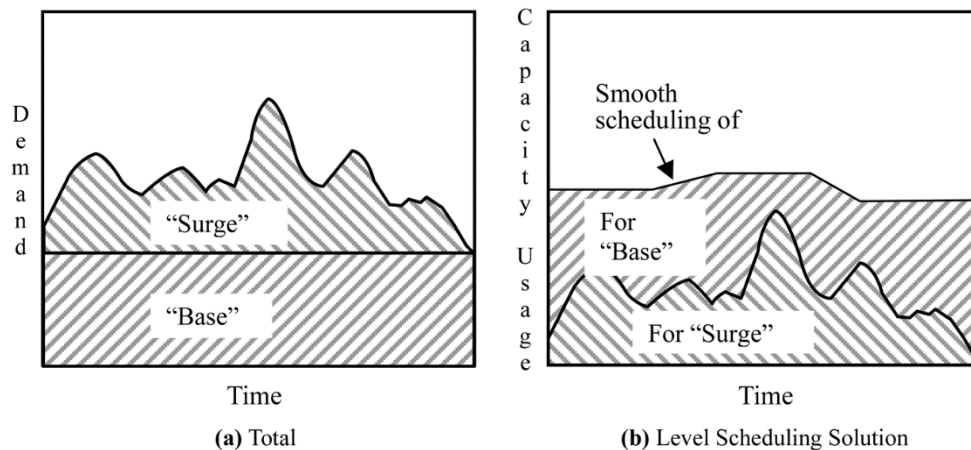
Market Qualifiers Market Winners

THE CONCEPT OF AGILITY IN TERMS OF DEMAND CHARACTERISTICS AND SUPPLY CAPABILITIES



LEAD TIMES AND PREDICTABILITY OF MARKETS

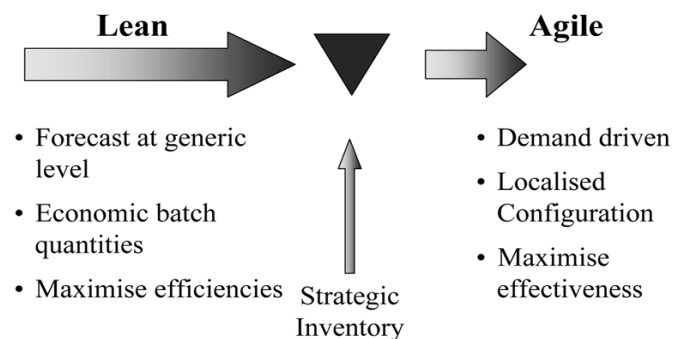
APPLICATION OF LEAGILITY: SEPARATION OF 'BASE' AND 'SURGE' DEMANDS



Agility reflects making use of market knowledge and a virtual corporation to exploit profitable opportunities in a *volatile* market place. Leanness refers to developing a value stream to eliminate all waste, including time, and to ensure a *level* schedule.

The decoupling point is also the point at which strategic stock is often held as a buffer between fluctuating customer orders and/or product variety and smooth production output.

Preconditions for successful agile practice include enterprise-level reality check and cost of complexity sanity check. Lowering the cost of complexity focuses on avoiding overly expensive agility. Forecasts help to reduce the need for last minute crises either in an external and internal



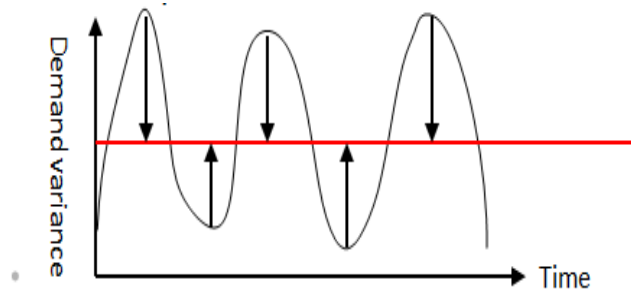
way. External demand forecast focuses on demand for the product or service and internal forecast focuses on financial forecast, asset forecast or capability to complete the supply chain requirements.

Three characteristics of supply chain operations related to agile

1. Mastering and benefiting from variation in demand;
2. Very fast response to market opportunities;
3. Unique or low volume response.

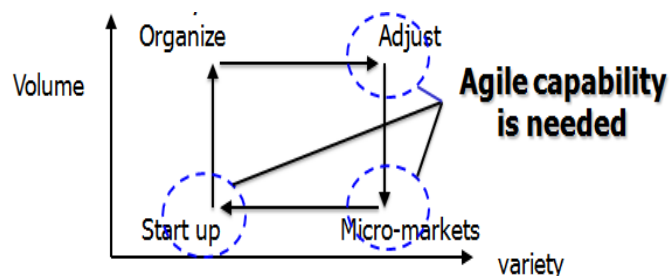
Agile practices benefiting from variance is possible if the supply chain manager is able to identify the three sources of demand uncertainty of Seasonality, Product life cycles and End-customer demand.

End-customer demand is more towards shift in tastes than agile practices while product life cycle is represented in the figure below which identifies the need for agile capability.

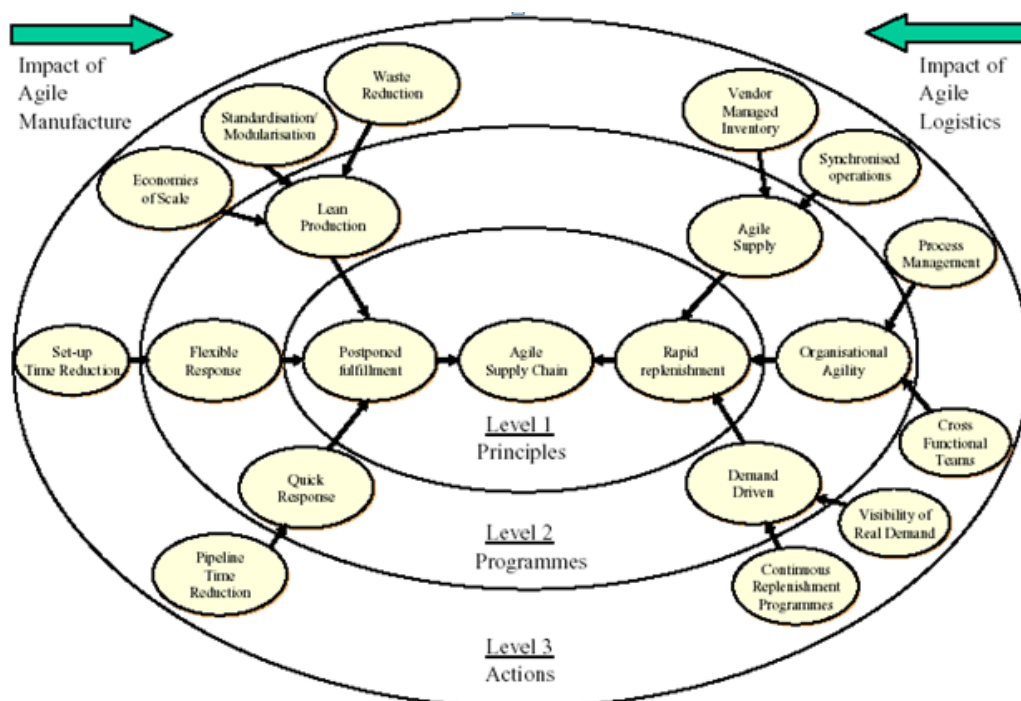


Quite often enterprises benefit from short time windows. The decreased D-time requires different levels of agility (Vendor Maintained Inventory “VMI” & Quick Response “QR”) through speed of replenishment, upstream time sensitivity and information dissemination and alignment.

Another popular agile practice is to benefit from small volume. The small volume is a result of micro-markets, customization and rapid responsiveness. Three common approaches of agile strategy related to small volume are the changeover flexibility, modularity at the network level and service-based and information-based solutions.



Benefiting from small volume is represented graphically as Variety decrease



AN INTEGRATED MODEL FOR ENABLING THE AGILE SUPPLY CHAIN

MODULE 4: E-marketing

E-marketing means using digital technologies to help an enterprise and its supply chain partners to sell its goods or services. These technologies are a valuable complement to traditional marketing methods whatever be the size of the enterprise or its business model.

The basics of marketing remain the same – creating a strategy to deliver the right messages to the right people. What has changed is the number of options the enterprises have. Though businesses will continue to make use of traditional marketing methods, such as advertising, direct mail and PR, e-marketing adds a whole new element to the marketing mix.

Many businesses are producing great results with e-marketing and its flexible and cost-effective nature makes it particularly suitable for small businesses.

THE BENEFITS OF E-MARKETING

E-marketing gives businesses of any size access to the mass market at an affordable price and, unlike TV or print advertising, it allows truly personalized marketing. Specific benefits of e-marketing include:

<i>CHARACTERISTICS</i>	<i>DESCRIPTION</i>
1 Global reach	A website can reach anyone in the world who has internet access. This allows business to find new markets and compete globally for only a small investment.
2. Lower cost	A properly planned and effectively targeted e-marketing campaign can reach the right customers at a much lower cost than traditional marketing methods.
3 Trackable, measurable results	Marketing by email or banner advertising makes it easier to establish how effective your campaign has been. Businesses can obtain detailed information about customers' responses to their advertising.
4 24-hour marketing	With a website, customers can find out about products even if the business display center or office is closed.
5 Personalization	If the customer database is linked to the enterprise website, then whenever someone visits the site, they can be greeted with targeted offers. The more they buy from the enterprise, the more the website can refine the customer profile and market effectively to them.
6 One-to-one Marketing	e-marketing lets the business reach people who want to know about their products and services instantly. For example, many people take mobile phones and PDAs wherever they go. Combine this with the personalized aspect of e-marketing, and you can create very powerful, targeted campaigns.
7 More interesting Campaigns	e-marketing helps create interactive campaigns using music, graphics and videos.
8 Better conversion rate	If a business has a website, then customers are only ever a few clicks away from completing a purchase. Unlike other media which require people to get up and make a phone call, post a letter or go to a shop, e-marketing is seamless.

Shifting to Brand Management by Building a Modular E-business

With the strategy and tactics for e-Marketing available to electronic business systems, the logical conclusion is a shift to modular business. A company could concentrate solely on managing its brand, outsourcing all physical aspects of the business to others. As these activities are moved to specialist third parties, the core management activities will change

The truth of e-business is that it changes businesses and merges industries. It destroys industries and appears unstoppable when taken in the traditional context. E-marketing over comes the traditional business barriers.

Lean Supply Chain: Management Principles and Practices

As E-marketing enables an enterprise to overcome traditional business limitation, we are now in a position to elaborate our discussion on Lean supply chain. Lean supply chain management represents a new way of thinking about supplier networks. Lean principles require cooperative supplier relationships while balancing cooperation and competition. Cooperation involves collaborative relationships & coordination mechanisms. Supplier partnerships and strategic alliances represent a key feature of lean supply chain. Also the point that makes the discussion worthwhile is that **E-marketing makes the simultaneous application of lean and agile principles** without compromising the robustness of the supply chain as well as the long term sustainable potential profits.

Theory: Lean represents a “Hybrid” Approach to Organizing Inter enterprise relationships.

1. “Markets” (Arm’s Length): Lower production costs, higher coordination costs
 - a. Enterprise buys (all) inputs from outside specialized suppliers
 - b. Inputs are highly standardized; no transaction-specific assets
 - c. Prices serve as sole coordination mechanism
2. “Hierarchies” (Vertical Integration): Higher production costs, lower coordination costs
 - a. Enterprise produces required inputs in-house (in the extreme, all inputs)
 - b. Inputs are highly customized, involve high transaction costs or dedicated investments, and require close coordination
3. “Lean” (Hybrid): Lowest production and coordination costs; economically most efficient choice--new model
 - a. Enterprise buys both customized & standardized inputs
 - b. Customized inputs often involve dedicated investments
 - c. Partnerships & strategic alliances provide collaborative advantage

IMPORTANT NOTE

Lean Supply Chain Management Principles more or less are derived from basic lean principles. Some of these common principles are

1. Focusing on the supplier network value stream
2. Eliminating waste
3. Synchronizing flow
4. Minimizing both transaction and production costs
5. Establishing collaborative relationships while balancing cooperation and competition
6. Ensuring visibility and transparency
7. Developing quick response capability
8. Managing uncertainty and risk
9. Aligning core competencies and complementary capabilities
10. Fostering innovation and knowledge-sharing

Another important observation being that **synchronized production and delivery throughout the Supplier Network is a central lean concept** and is possible through: -

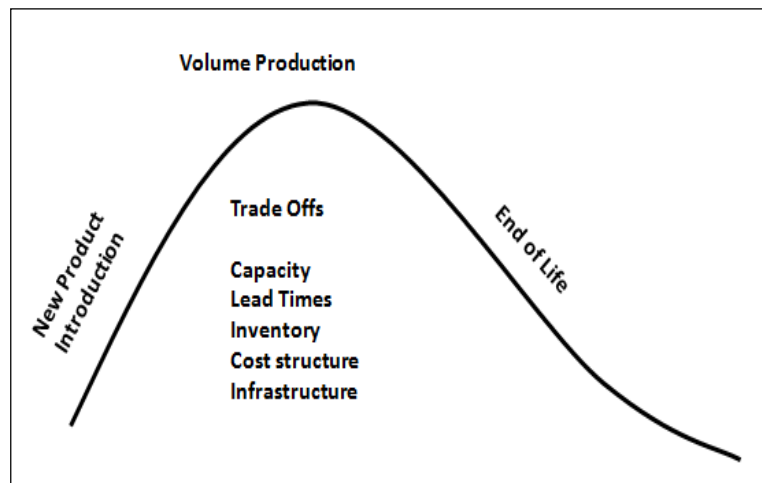
1. Integrated supplier lead times and delivery schedules
2. Flows from suppliers pulled by customer demand by making use of concepts of time, load leveling, line balancing and single piece flow.
3. Minimized inventory through all tiers of the supply chain
4. On-time supplier delivery to point of use
5. Minimal source or incoming inspection

6. Effective two-way communication links to coordinate production & delivery schedules
7. Striving for zero quality defects essential to success
8. Greater efficiency and profitability throughout the supplier network

It is worth noting that **supplier partnerships and strategic alliances ensure substantial performance improvements** through Long-term relationships and mutual commitments, intensive and regular sharing of technical and cost information and mutual assistance and joint problem-solving strategies. Also Incentives for increased innovation are possible through cost- sharing, risk-sharing and knowledge-sharing strategies. Increased mutual commitment to improving joint long- term competitive performance is possible by providing leadership.

Lean Supply Chain Leadership is normally achieved through sales and operations planning, supply chain management, new product design, end of life exit, replenishment trade-offs and material flow and assessing efficiency and yields

Product Life Cycle Planning incorporates cradle to grave approach and is represented in the figure below



Future in Lean Supply Chain

Lean Supply Chain in the future would be characterized by the following

1. Would be driven by effective sales and operations planning
2. Would allow effective supply chain planning
3. Would ideally balance new and current products and services
4. Would employ timely, effective replenishment. Would enable timely success measurement by employing MES, ERP generate data/analysis/correction.

Effective sales and operations planning relates to integrating enterprise orders and forecast. It also incorporates preliminary business plan which include new products, current models, end of life details. Management also urges the supply chain manager to check the capacity, on hand, and on order. Enterprise also focuses on its production schedules, ensures on time delivery/completions and scheduled shipment to customers and measure results. These not only maximize the leadership but also minimize risk.

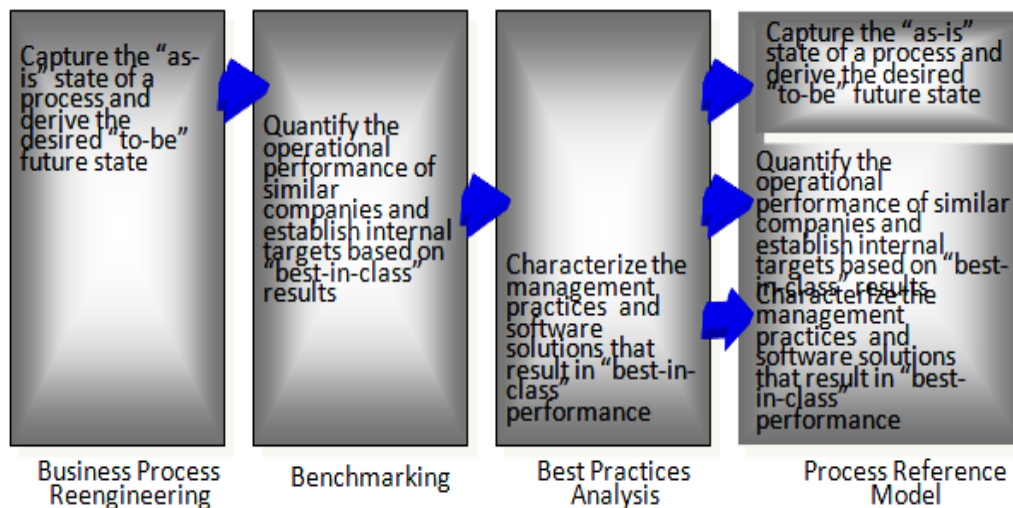
Lean supply chain of the future may be displaying the characteristics of agile supply chain and it is possible that the agile supply chain would be displaying the characteristics of the lean supply. This conundrum would be addressed by the future trends in E-marketing and how E-marketing would help the inter-firm relationships to avoid losses and register sustainable profits.

Module 5: SUPPLY CHAIN OPERATIONS REFERENCE (SCOR) MODEL

Supply-chain operations reference-model (SCOR) is a process reference model for supply chain management. This reference model allows user to address, improve, and communicate supply chain management practices

within and between all the organizations in the extended enterprise. It was developed by Supply Chain Council (SCC). SCC is an independent, not-for-profit corporation organized in 1996 by Global management consulting enterprise, Pittiglio Rabin Todd & McGrath (PRTM) and Market research enterprise, Advanced Manufacturing Research (AMR) in Cambridge, Massachusetts.

The Supply Chain Council (SCC) started with 69 voluntary companies; now close to 1400 members. The SCC objective is to develop a standard supply-chain process reference model enabling effective communication among the supply chain partners, by using standard terminology to better communicate and learn the supply chain issues. It also uses standard metrics to compare and measure the supply chain performances. Supply Chain Operations Reference Model (SCOR) Integrates **Business Process Reengineering**, Benchmarking, and **Process Measurement (Best Practices)** into a cross-functional framework.



The Primary Use of SCOR model is to describe measure and evaluate supply chain configurations. The SCOR model contains standard descriptions of management processes, a framework of relationships among the standard processes, standard metrics to measure process performance, management practices that produce best-in-class performance

Supply Chain Operations Reference Model (SCOR) enables the companies to evaluate and compare their performances with other companies effectively, identify and pursue specific competitive advantages and identify software tools best suited to their specific process requirements

Scope (Boundaries) of SCOR Model: Supply Chain Operations Reference Model (SCOR) spans:

- All customer interactions, from order entry through paid invoice.
- All product (physical material and service) transactions, from supplier's supplier to customer's customer, including equipment, supplies, spare parts, bulk product, software, etc.
- All market interactions, from the understanding of aggregate demand to the fulfillment of each order

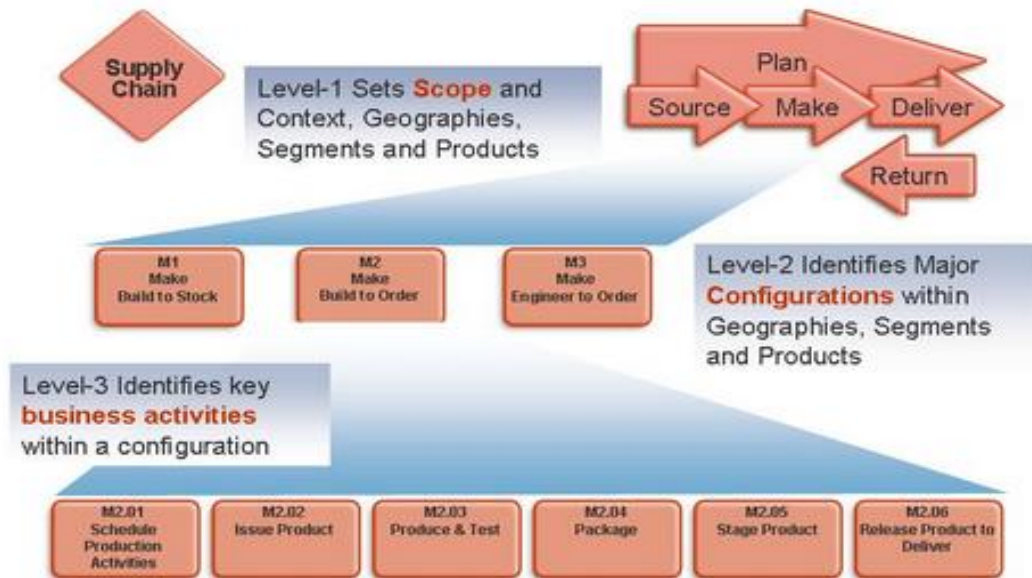
SCOR does not attempt to describe every business process or activity, including:

- Sales and marketing (demand generation)
- Research and technology development
- Product development
- Some elements of post-delivery customer support

Supply Chain Operations Reference Model (SCOR): Basic management processes are represented to identify desired objectives and the set of activities.

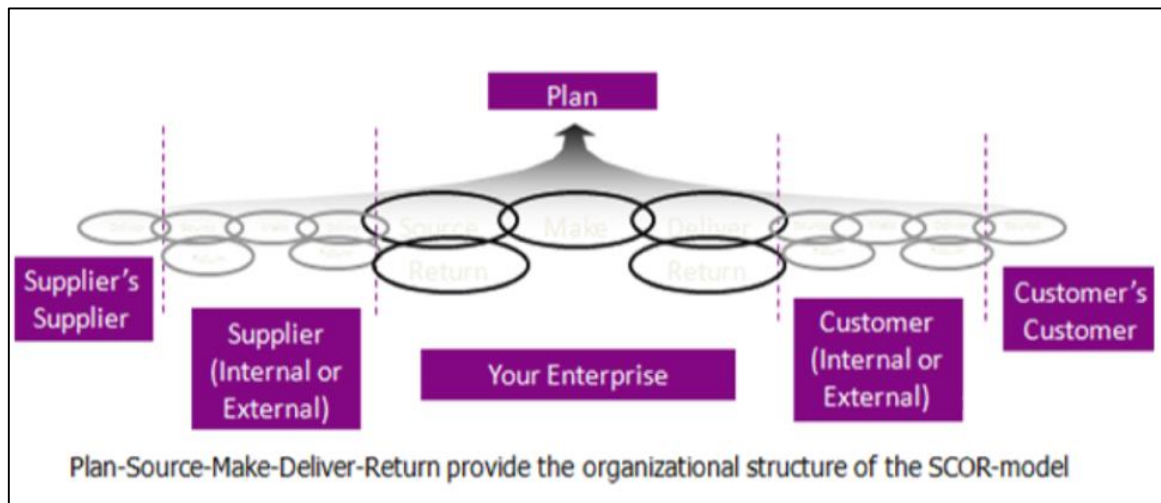
SCOR Framework Levels

SCOR
Supply-Chain Council



Scope of Basic Management Processes

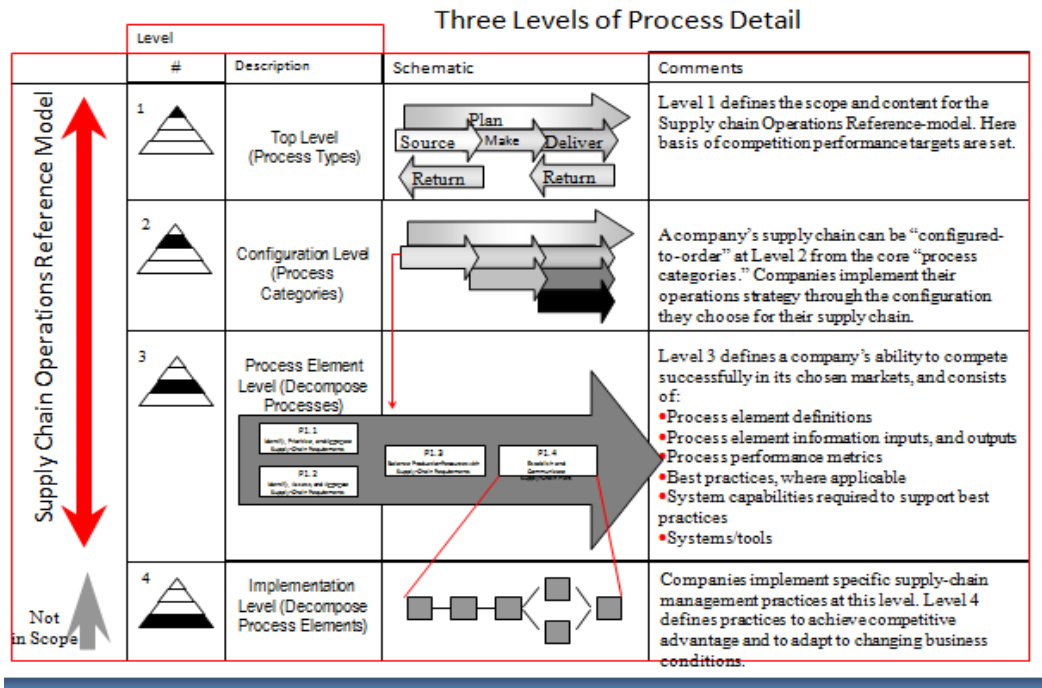
1. *Plan* refers to the processes that balance aggregate demand and supply to develop a course of action which best meets sourcing, production and delivery requirements. It allows the supply chain managers (and the enterprise) to balance resources with requirements and establish as well as communicate plans for the whole supply chain.
2. *Source* identifies the processes that procure goods and services to meet planned or actual demand as well as schedule deliveries (receive, verify and transfer).



Plan-Source-Make-Deliver-Return

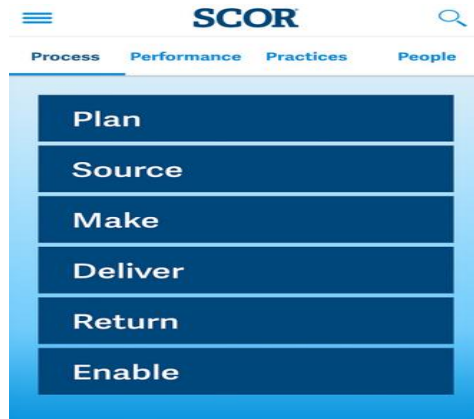
3. *Make* relates to the processes that transform product to a finished state to meet planned or actual demand through schedule production.
4. *Deliver* focuses on processes that provide finished goods and services to meet planned or actual demand, typically including order management, transportation management, and distribution management. Warehouse management from receiving and picking product to load and ship product.

5. *Return* concentrates on processes associated with returning or receiving returned products) and manages return business rules



The three levels are considered the most important when focusing on SCOR Model.

SCOR applets available to supply chain professionals using android devices



SCOR QUICK REFERENCE GUIDE (Version 11)

The Supply Chain Operations Reference (SCOR®) model explains the business behavior related with all phases of satisfying a customer's demand. The model itself is controlled around the six primary management processes of Plan, Source, Make, Deliver, Return and Enable. Using these process building blocks, the SCOR model can be used to illustrate supply chains that are very simple or very complex using a common set of definitions across disparate industries. Today public and private organizations and companies around the world use the model as a foundation for global and site-specific supply chain improvement projects.

Level 1 Performance Metrics		Customer-Facing			Internal-Facing	
		Supply Chain Reliability	Responsiveness	Flexibility	Facing	
					Cost	Assets
Performance Attributes						
Delivery performance	✓					
Fill rate	✓					
Perfect order fulfillment	✓					
Order fulfillment lead time		✓				
Supply Chain Response Time				✓		
Production flexibility				✓		
Total SCM cost				✓		
Cost of Goods Sold				✓		
Value-added productivity					✓	
Warranty cost or returns processing cost					✓	
Cash-to-cash cycle time						✓
Inventory days of supply						✓
Asset turns						✓

END OF LECTURE 9: GIST AND CRUX:

1. *Lean Supply Chain Management ideally results in lower productive costs and coordination costs. Lean Supply Chain Management focuses on long-term relationships and mutual commitments, intensive and regular sharing of technical and cost information along with mutual assistance and joint problem-solving. Pre-sourcing and Early Supplier Involvement can lead to Lean Supply Chain Management.*
2. *Six Sigma also helps in Lean Supply Chain Management implementation. Six Sigma is a fact (data) based approach to improving a process or function for the purpose of increasing customer satisfaction and thereby achieving significant sustainable supply chain benefits. Six Sigma's DMAIC process can be achieved through the application of industry benchmarking and broader frame works like Supply Chain Operations Reference (SCOR) Model.*
3. *Agile Supply Chain Management is implemented by enterprises so the organization can quickly adjust their sourcing, logistics and sales. Agile supply chain is constructed to be highly flexible for the purpose of being able to quickly adapt to changing situations. This methodology is considered important for organizations that want to be able to adapt to unanticipated external economic changes, such as economic swings, changes in technology or changes to customer demand.*
4. *E Marketing plays a number of important behind the scenes roles both in coordinating long term plans and controlling the daily physical flow of goods throughout the supply chain. Supply chain managers normally place a special emphasis on the important aspect of relationship building in order to ensure that E marketing helps the supply chain partners to optimize their sustainable long term profits.*
5. *SCOR Model provides strategic benefits to partners of the Supply Chain enterprise. It is a process reference model which integrates well known and proven concepts of business process reengineering, bench marking and process measurements into cross functional framework.*

UNDERSTANDING THE SUPPLY CHAIN PROCESS**Rationale and logic**

Lecture 10 & 11 introduces the concept of a supply chain from a strategic framework perspective. We will not try to challenge the popular saying that “**Amateurs Talk about Strategy, dilettantes Talk about Tactics, and Professionals Talk about Logistics.**” Rather we will judiciously present the case that amateurs, dilettantes and professionals all need to have a thorough knowledge of Strategic framework

The goal of the next 6 lectures is to provide a strategic framework (also known as structure, template, skeleton, support, frame, scope, outline or agenda) that can be used to analyze design, planning, and operational decisions in a supply chain. These modules would help us establish the framework in the next two lectures. This development of the framework will also help to understand strategic goals and structure of various popular corporations with trend setting strategies for supply chains. The managers should learn the difference between firm and enterprise. The word firm is used for consultancy and Enterprise for corporations in the domain of Supply Chain

Learning Objectives

1. Identify the Supply Chain Process with Strategic Framework Perspective
2. Recognize the flows within and across a Supply Chain
3. Discuss the objective of a supply chain and the impact of supply chain decisions on the success of an Enterprise.
4. Classify the three key supply chain decision phases and explain the significance of each one (covered in Lecture 11)
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MODULE 1: IDENTIFY SUPPLY CHAIN PROCESSES WITHIN A STRATEGIC FRAMEWORK

The first step in any task associated with the development of a framework pertains to the drawing up of boundaries, what to include and what not to include. Virtual University students are already aware of the term, SCOPE. SCM is now readily identifiable to products and services or more correctively to Productive Systems.

Supply Chain Managers of the future, i.e. the Virtual University students can use SCM concept for commodities like bread, detergent or FMCGs. The items they buy in a routine. The students can also identify supply chain processes involved in a variety of products, for example, consumer durable products such as a television, automobile, etc. Building upon the same concept of SCM, the students can take this discussion into Services, global, galactic space travel, space research and beyond the solar system all relate to management of Supply Chains

Supply Chain Processes are identified by briefly stating these six steps

Step I: Identify the Supply Chain and its stages.

Step II: Identify Supply Chain Objective.

Step III: Identify supply chain surplus or supply chain profitability.

Step IV: Identify real supply chain improvement (involves increasing the total surplus in the supply chain as well as the profits of each party. At this stage, the importance of managing supply chains effectively needs to be emphasized in order to maximize the total surplus).

Step V: Identify the three decision phases (, i.e., supply chain strategy or design, supply chain planning, and supply chain operations)

Step VI: Identify the importance of the decisions made in each of these phases with respect to profitability. Examples (we have covered this throughout the semester in various modules) from manufacturing and services side. For example, supply chain strategy or design phase involves network configuration decisions (plant and warehouse location, transportation decisions, etc.)

Supply planning involves effectively matching demand and supply through aggregate planning, inventory management, etc.

Finally, supply chain operation focuses on a variety of operational decisions that include scheduling of shipments, satisfying customer orders, and specific activities relating to operations at plants and warehouses.

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Within each enterprise (company), the supply chain includes all functions involved in fulfilling a customer request i.e. product development, marketing, operations, distribution, finance, customer service. Customer is an integral part of the supply chain and probably the sole reason why a supply chain exists, as it's the customer's requirement of a product or service that is taken up as a mission by the enterprise to fulfill and complete.

Supply Chain includes movement of products from suppliers to manufacturers to distributors and information, funds, and products in both directions. Consultants and practitioners often use the term “supply network” or “supply web”. To be more judicious supply chain involves everybody, from the customer all the way to the last supplier. The key flows in the supply chain are - information, product, and cash. It is through these flows that a supply chain fills a customer order. The management of these flows is key to the success or failure of a firm. Comparative examples of Dell & Compaq, Amazon & Borders bring out the fact that all supply chain interaction is through these flows.

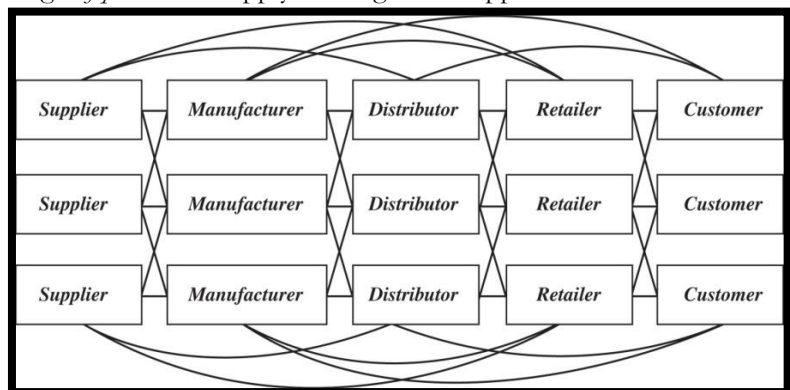
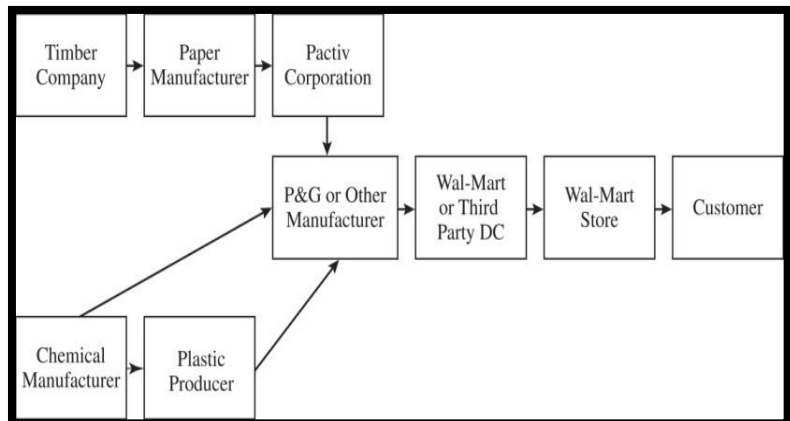
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The term *supply chain may also imply that only one player is involved at each stage*. In reality, a manufacturer may receive material from several suppliers and then supply several distributors.

Thus, most supply chains are actually 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, above.



LOGIC: WHY THESE FLOWS ARE IMPORTANT?

Supply chain flows are important, because there is a close connection between the design and management of supply chain flows (product, information, and cash) and the success of a supply chain. The success of many

companies can be directly traced to the design and management of an appropriate supply chain. The failure of many businesses can be linked directly to their inability to effectively design and manage supply chain flows. Supply Chain Managers in training are requested to write a paragraph on Comparison between apple and gateway supply chains in their log books.

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The objective of any supply chain is more or less very much the same **TO MAXIMIZE OVERALL VALUE CREATED**. This alone can be used as the logic to explain the mission critical state of being for a **NOT FOR PROFIT ENTERPRISE (ORGANIZATION)**. Similarly, the business students are well aware that this concept is the logic for all the **FOR PROFIT PRODUCTIVE SYSTEMS**.

Example: A customer purchases a cell phone from Best cell mobile for Rs.10 K (revenue). Supply chain incurs costs (information, storage, transportation, components, assembly, etc.). Difference between 10K and the sum of all of these costs is the supply chain profit. Supply chain profitability is total profit to be shared across all stages of the supply chain.

Success should be measured by total supply chain profitability, not profits at an individual stage. Also remember Customer is the only source of revenue. Sources of cost include flows of information, products, or funds between stages of the supply chain. Effective supply chain management is the management of flows between and among supply chain stages to maximize total supply chain surplus.

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Virtual University students are urged to observed and appreciate escalation of profits for Wal-Mart (\$1 billion sales in 1980 to \$408 billion in 2010) and Seven-Eleven Japan (¥1 billion sales in 1974 to ¥3 trillion in 2009). At the same time, they are advised to observe the sad failures of Supply Chains like the enterprise Webvan folded in two years, Book Sellers Borders, recorded a decline in sales and profits \$4 billion in 2004 to \$2.8 billion in 2009.

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1. *Supply Chain Framework helps in the design, implementation, operation and control of supply chain.*
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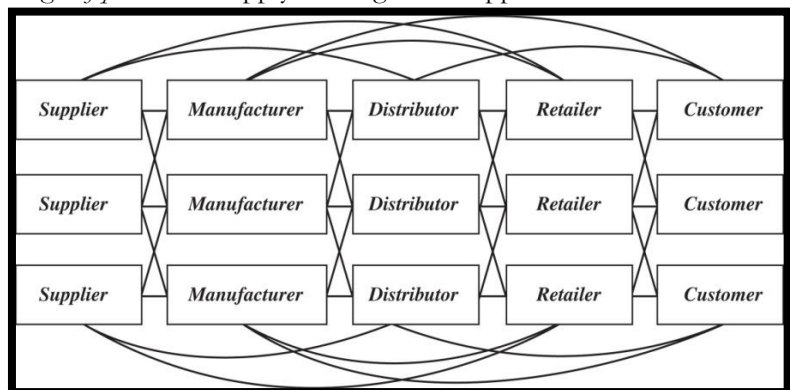
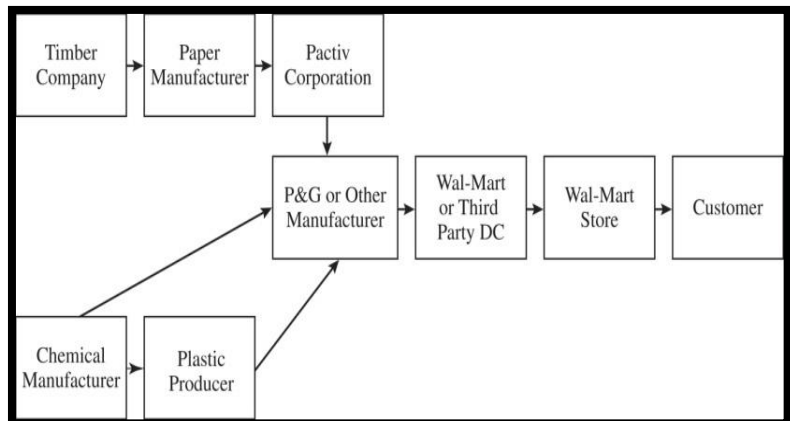
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UNDERSTANDING THE SUPPLY CHAIN PROCESS (II)

This lecture would allow us to complete the Supply Chain Strategic Framework discussion initiated in last lecture. Ideally after this lecture the students would be able to develop a strategic supply chain framework perspective. Lecture 11 covers three important modules pertaining to decision phases, process view and supply chain macro processes and at the same time covers the 4 critical learning objectives: -

1. Discuss the objective of a supply chain and explain the impact of supply chain decisions on the success of a firm.
2. Identify the three key supply chain decision phases and explain the significance of each one.
3. Describe the cycle and push/pull views of a supply chain.
4. Classify the supply chain macro processes in a firm.

The three modules below form the very basis for Supply Chain with respect to design strategy, planning and operation.

Module 4: Decision Process (Phases) of a Supply Chain. This is a minor module as we have dedicated lectures on these decision phases.

Module 5: Process View of a Supply Chain. This is more critical than modules 4 and 6 as this module actually would be cross referred directly as well as indirectly, however this fact does not take away the importance of modules 4 and 6.

Module 6: Supply Chain Macro Processes. This module is probably a revisit of important concepts already known to the virtual university students.

Savvy Supply Chain Managers Register Supply Chain Profit: Savvy supply chain managers always aim to identify the three levels of decision making. In other words, if they are trained to carry out strategic, tactical and operational supply chain decision making then can ensure the enterprise as well as the supply chain partners (suppliers as well as retailers/distributors) to register supply chain surplus called supply chain profit.

Decisions as opportunities to register supply chain profit: Virtual University students are requested to develop a supply chain strategy that would provide opportunities for them as well as the enterprise to register profits in the operational, tactical and strategic time horizons. This is contingent to the critical fact that supply chain design, planning and operations have goals, aims and objectives aligned to achieve this.

The supply chain managers should be ready to understand that when they are making decisions in the strategic (design) phase the nature of the decisions relates to structure (or infrastructure) of the supply chain over a long period of time.

These structure decisions pertaining to **either the entire supply chain or only the distribution network design** are actually “**long term capital budgeting irreversible decisions**” which cannot be reversed or changed in the short term time frame. Reversing such decisions would warrant additional costs. This additional cost if transferred to the customer would lead to the customer changing his preference to your competitors’ product or service eventually resulting in lowering of supply chain surplus or lowering of the value of the product in the eyes of your customer. If you have a weak supply chain strategy or supply chain design it will amplify problems and losses in the operational phase.

Cost Minimization or Profit Maximization: Virtual University students are already aware of important concepts of services blueprint and concurrent engineering, where 80 percent of the costs can be actually locked in at the design phase. The same concepts actually allow the supply chain to lock in costs to achieve the perspective or objective of “**cost minimization or profit maximization**”. A supply chain can actually offer its product at a competitive rate as well as an attractive option to the potential customers.

In contrast to the above, absence of a proper design would **create a never ending story** in which the supply chain manager would be compelled to run around and fine tune the cost structure. This can eventually lead

to supply chain disruptions and supply chain profits being compromised. Quite often this is unacceptable for any enterprise to pursue such a tactic.

Another important phase of Supply Chain ideally following the supply chain design is the supply chain planning. Normally planning is a critical activity that often occupies the pivotal position in the phases of the supply chain. Some supply chain analysts suggest that supply chain design is a part and parcel of supply chain planning where as there are others who clearly distinguish that supply chain

MODULE 4: DECISION PHASES OF A SUPPLY CHAIN

Supply chain management requires many decisions relating to the flow of information, product, and funds. These decisions fall into three groups or phases, depending on the frequency of each decision and the time frame over which a decision phase has an impact. Please refer to the table on the next page which presents the sample senior management question with respect to the three phases of design, planning and operation. Virtual University students are requested to formulate their own questions in view of their enterprises product offering, market and location of warehouses, distribution centers, distributor and retailer relationships.

<i>IF THE ENTERPRISE IS IN THE</i>	<i>SAMPLE SENIOR MANEGEMNT QUESTIONS</i>
Supply chain Strategy or Design Phase	How to structure the supply chain over the next several years?
Supply chain Planning	Decisions over the next quarter or year
Supply Chain Operation	Daily or weekly operational decisions

MODULE 4A: SUPPLY CHAIN DESIGN PHASE

An important phase of supply chain is the supply chain design phase. This module presents the basis for Supply Chain design, planning and operation. This module would always be important for any enterprise in the quest to answer its design, planning and operation questions.

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: Strategic decisions made by companies include the location and capacities of production and warehouse 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 utilized.

An enterprise must ensure that the supply chain configuration supports its strategic objectives during this phase.

Take the universal supply chain example of Dell. Dell's decisions regarding the location and capacity of its manufacturing facilities, warehouses, and supply courses are all supply chain design or strategic decisions. Supply chain design decisions are typically made for the long term (a matter of years) and are very expensive to alter on short notice. Consequently, when companies make these decisions, they must take into account uncertainty in anticipated market conditions over the next few years.

Decisions about the structure of the supply chain and what processes each stage will perform

Strategic supply chain decisions normally include verdict about

1. Locations and capacities of facilities
2. Products to be made or stored at various locations
3. Modes of transportation
4. Information systems

Supply chain design must support strategic objectives and face the most important constraint that is that the supply chain design decisions are long-term and expensive to reverse. The decision must take into account market uncertainty.

Businesses of today are focused on real life data and interested in real time information and willing to pay for this real life information.

This brings us to another important concept that when you deal your supply chain as strategic perspective you should treat them as strategic assets. Supply chain design should provide support to, it should complement and supplement

MODULE 4 B: SUPPLY CHAIN PLANNING

Virtual University students or supply chain managers in training should pay attention to the important concept of supply chain planning. This phase pertains to decisions made for the time frame considered to be a quarter to a year. Therefore, the supply chain's configuration determined in the strategic phase is fixed. The configuration establishes constraints within which planning must be done.

Enterprises start the planning phase with a forecast for the coming year (or a comparable time frame) of demand in different markets. Planning includes 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 promotions. Dell's decisions regarding markets a given production facility will supply and target production quantities at different locations are classified as planning decisions. Planning establishes parameters within which a supply chain will function over a specified period of time. In the planning phase, companies must include uncertainty in demand, exchange rates, and competition over this time horizon in their decisions.

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. The configuration establishes constraints within which planning must be done.

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MODULE 4C: SUPPLY CHAIN OPERATION

The time horizon here is weekly or daily, and 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 that 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.

Virtual University students are requested to identify the constraints established by the configuration and planning policies, **the goal during the operation phase is to exploit the reduction of uncertainty and optimize performance.**

The design, planning, and operation of a supply chain have a powerful impact on overall profitability and success. Continuing with the ever famous Dell Computer supply chain example, in the early 1990s, Dell management began to focus on improving the supply chain performance. Both profitability and the stock price have soared and Dell stock has had outstanding returns over this period.

MODULE 5: PROCESS VIEW OF A SUPPLY CHAIN

Virtual University students are requested to develop the process view of a supply chain as a bare minimum requirement of understanding the supply chain.

There are two views of a supply chain, i.e., the cycle view and the push/pull. These views are introduced and explained in this critical module. The dilemma associated with this concept is that supply chain managers either bring it down to the nuts and bolts (micro level) of discussing minute activities or keep it at the macro level of the organization. This leads to an inadequate development of the understanding of this important concept. Supply Chain managers of tomorrow are requested to view the supply chain as a cycle or combination of push and pull views.

The main aspects that need to be covered in the cycle view primarily include the **activities** and **responsibilities** involved in each cycle and to some extent an introduction to what decision models are applicable in each of these cycles.

Supply chain managers often fall a victim to paying undue importance to production schedule in order to maintain the inventory level that they over stock and lead to higher levels of inventory level which increase upstream leading to “Bull Whip Effect”. However, the best strategy is to make judicious use of simple techniques such as Economic Order Quantity (EOQ), etc., can be mentioned as tools in replenishment order cycle, and similarly be aware of the production planning and scheduling models **as a part** of the manufacturing cycle. Also the concept of EOQ as a part of the inventory management for the enterprise has now been extended to the entire supply chain as we already know that we know compare the supply chain with another supply chain and do not merely compare the products.

A supply chain is a sequence of processes (please refer to other module handouts) and flows that take place within and between different supply chain stages and combine to fill a customer need for a product.

In discussing push/pull view of a supply chain, it would be useful for the supply chain manager to provide examples of their own companies should set their push/pull boundary. The Dell and paint industry examples in the text provide an excellent means to make this point.

The relationship between the two process views and the three supply chain macro processes, i.e., Customer Relationship Management (CRM), Internal Supply Chain Management (ISCM) and Supplier Relationship Management (SRM) can be established.

Also “*Cycle View*” is the processes in a supply chain are divided into a series of cycles, each performed at the interfaces between two successive supply chain stages. At the same time *Push/Pull View* represent the processes in a supply chain are divided into two categories depending on whether they are executed in response to a customer order (*pull*) or in anticipation of a customer order (*push*). Their key difference is the uncertainty during the two phases.

The **cycle view** divides the supply chain into a series of **4 cycles** between the **5 different stages** of a supply chain. The cycles are the customer order cycle, replenishment cycle, manufacturing cycle and procurement cycle. The supply chain is a concatenation of cycles with each cycle at the interface of two successive stages in the supply chain. Each cycle involves the customer stage placing an order and receiving it after it has been supplied by the supplier stage.

- One difference is in size of order. Second difference is in predictability of orders - orders in the procurement cycle are predictable once manufacturing planning has been done.

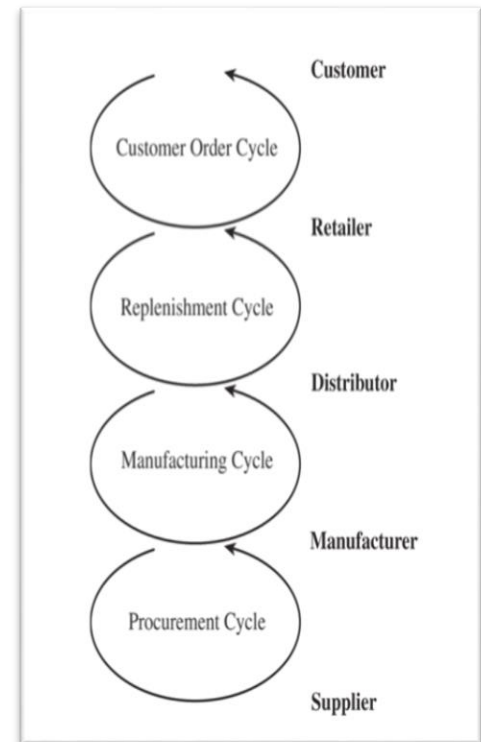
- This is the predominant view for ERP systems. It is a transaction level view and clearly defines each process and its owner.

Cycle View of Supply Chain Process has following cycles

1. Customer order cycle
2. Replenishment cycle (at retailer/distributor)
3. Manufacturing cycle (distributor/manufacture)
4. Procurement cycle (manufacturer/supplier)

The information flows from top to bottom and the products flow from bottom to top.

1. The customer order cycle occurs at the customer/retailer interface and includes all processes directly involved in receiving and filling the customer.
2. The replenishment cycle occurs at the retailer/distributor interface and includes all processes involved in replenishing retailer inventory.
3. The manufacturing cycle typically occurs at the distributor/manufacturer (or retailer/manufacturer) interface and includes all processes involved in replenishing distributor (or retailer) inventory.
4. The procurement cycle occurs at the manufacturer/supplier interface and includes all processes necessary to ensure that the materials are available for manufacturing according to schedule.



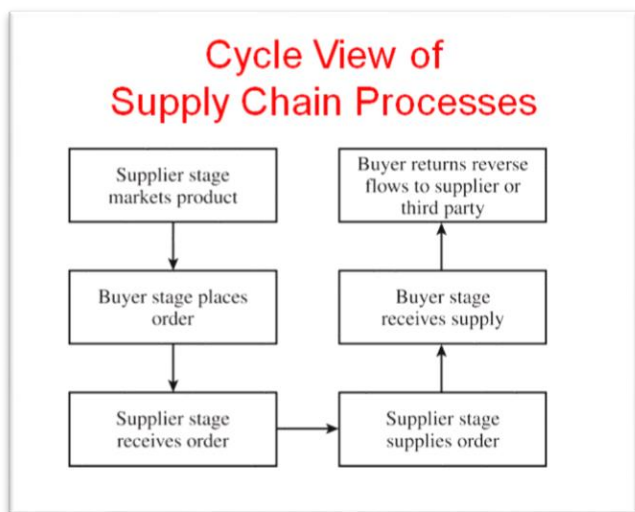
Inventory levels are build up to the acceptable levels through the replenishment cycle. The acceptable levels are more than the safety stock levels to ensure undisrupted supply chain operation within the important parameters of supply chain design and planning.

The take away from this discussion is to identify the six processes which can be identified at each stage as shown below

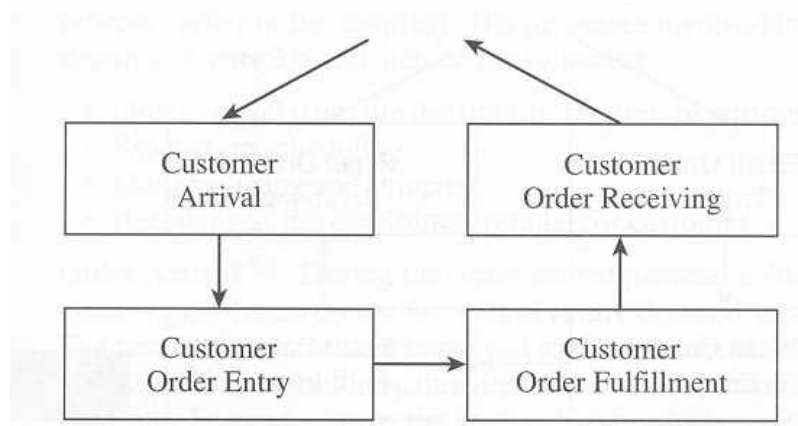
Cycle View of Supply Chain Processes

1. Supplier stage markets product.
2. Buyer stage places order
3. Supplier stage receives order
4. Supplier stage supplies order
5. Buyer stage receives supplies
6. Buyer returns reverse flows to supplier or third party

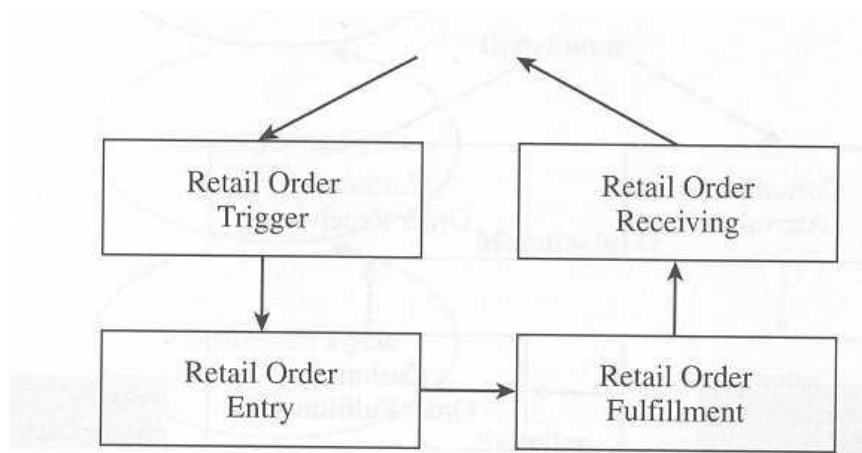
These steps hold value and some of them become of critical nature especially when dealing with a reverse supply chain. Virtual University students are already aware of a supply chain failure example in the form of Webvan. This company mishandled the concept of reverse supply chain. This is in reality a potential failure for all supply chains. If customer needs are not properly fulfilled the entire knowledge system would not be able to rescue the supply chain. The nobles of supply chain designs will result in supply chain loss if they are poorly executed.



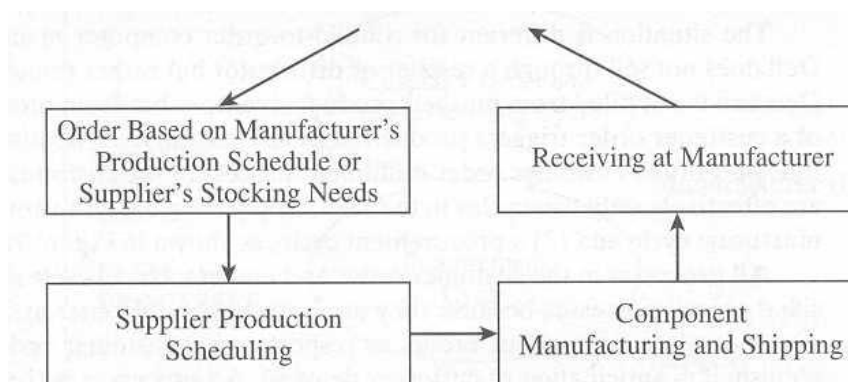
Customer Order Cycle

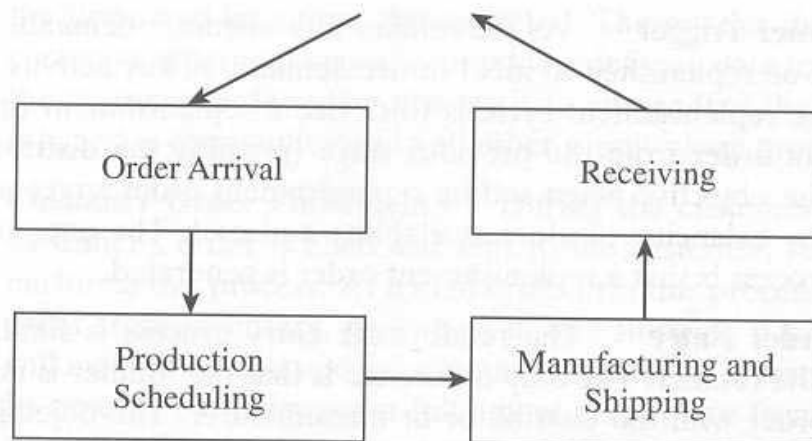


Replenishment Cycle



Manufacturing Cycle





Virtual University students are requested to learn the critical concept of 4 cycles, 5 interfaces and 6 processes at each interface in order to develop a clear perspective about supply chains cycle view

This completes our discussion on the cycle view of the supply chain; let us now focus our attention on the push/pull view of the supply chain process.

PUSH/PULL VIEW OF SUPPLY CHAIN PROCESSES

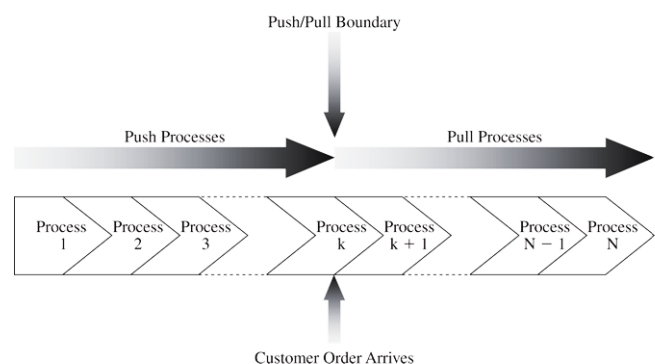
Simply said virtual university would be aware of the simplest form of pushed strategy, that is the manufacturer manufactures the product and pushes the product to the customer. Another case being that the manufacturer only makes the product on receipt of the order, which signifies pull strategy. This often allows the enterprise to add in those innovative features which would ensure the enterprise to be declared “order winner” and attain competitive advantage.

Supply chain processes fall into one of two categories depending on the timing of their execution relative to customer demand i.e. pulls and push.

Pull process is the reactive execution. In other words, it is initiated in response to a customer order. Similarly Push process is a speculative execution or in other words it is initiated in anticipation of customer orders.

Push/Pull Boundary: Push/pull boundary separates push processes from pull processes.

The push/pull view of the supply chain divides supply chain processes into two categories based on whether they are executed in response to a customer order or in anticipation of customer orders. Pull processes are initiated in response to a customer order. Push processes are initiated and performed in anticipation of customer orders. The push/pull boundary separates push processes from pull processes.



This view is very useful when considering strategic decisions relating to supply chain design, because it forces a more global consideration of supply chain processes as they relate to the customer orders.

Dell religiously pursued its Dell Direct Marketing Supply Chain strategy till 2006 when it decided to opt for the retail stores probably to counter the increase in sales and revenue after Compaq/HP merger.

Virtual University students are requested to understand that we can combine the push/pull and cycle views; we have two obvious examples in the form of L.L. Bean and Dell. Virtual University students are

recommended to understand that the relative proportion of push and pull processes can have an impact on supply chain performance

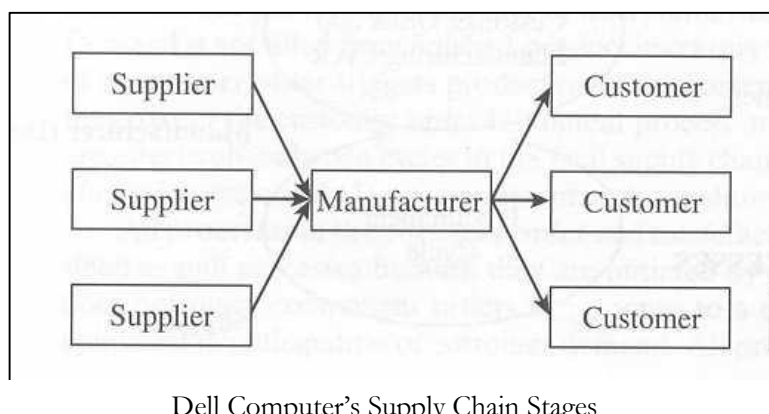
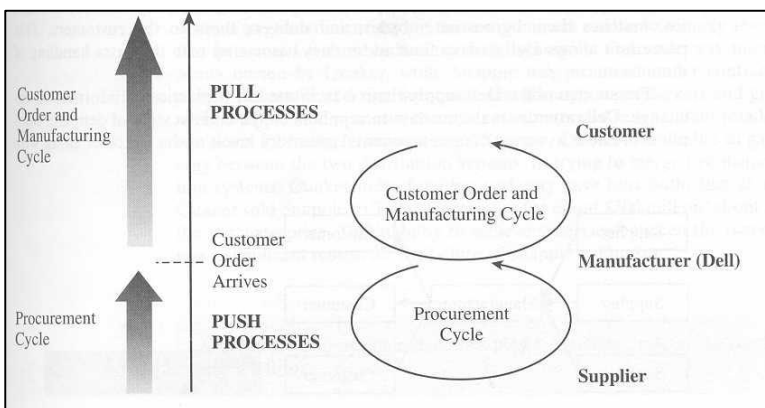
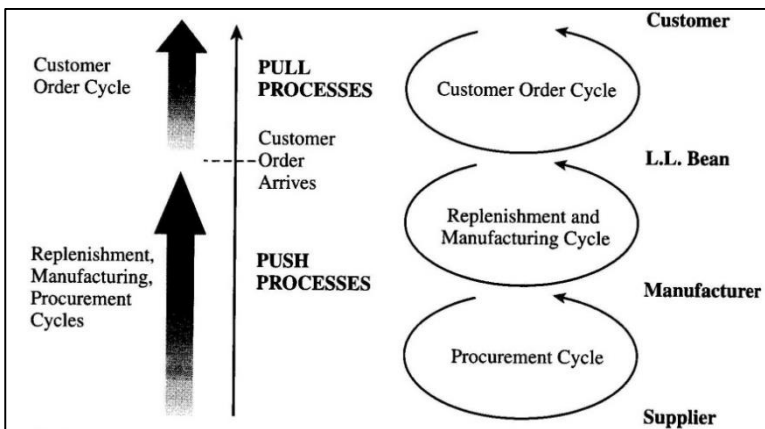
Some supply chain has both push and pull in its chain and we can identify this push/pull process boundary. Here is an example of LL Beans supply chain. L.L.Bean, Inc. branded as L.L.Bean, is an American privately held mail-order, online, and retail company founded in 1912 by Leon Leonwood Bean and currently based in Freeport, Maine, United States. It specializes in clothing and outdoor recreation equipment. The customer order cycle is a pull process and replenishment, manufacturing and procurement cycles are push process. Here the push processes are large as compared to pull processes.

The Dell Computer's Supply Chain Example

In this company, the customer order and manufacturing cycles are pull process and only the procurement cycle is push process. Thus number of pull processes is large as compared to number of pull processes. There is a close connection between the design and management of supply chain flows and the success of a supply chain. VU students are already aware of the DELL story. Dell has only 10 days of inventory contrast to other pc makers of 80 to 100 days. The success of the Dell supply chain is facilitated by sophisticated information exchange. (Customized web pages) and outsourcing.

There are certain business logics which allow any enterprise to plan push and pull strategy under a specific circumstance. It is the test of expertise of the supply chain management team or senior management where they draw the boundary between push and pull strategy application.

A simple paint job at home would expose the Virtual University Student to a skilled painter probably not educated but well aware of using paint additives to paint different walls of the same room. The same strategy is exploited by the global paint industry. The paint industry makes use of concept of processing the chemical paint to a basic color to the retail outlet as a push strategy. At the retail store special shades are added to provide the customer with different shades of paints as a part of pull strategy. This pull strategy is based on induced demand of the customer.



Dell Computer's Supply Chain Stages

MODULE 6: SUPPLY CHAIN MACRO PROCESSES

Virtual University Students are already aware of the fact that all processes within a supply chain can be classified into three macro processes, which are:

1. Customer Relationship Management (CRM)
2. Internal Supply Chain Management (ISCM)
3. Supplier Relationship Management (SRM)

Some textbooks call ISCM as Integrated Supply Chain Management but we are more comfortable with the term Internal Supply Chain Management, as we are dealing supply chain processes, concept, and terms from the Enterprise perspective. Integration among the above three macro processes and the different interfaces is critical for effective and successful supply chain management.

Supply Chain Macro Processes of Supplier Relationship Management was covered in earlier lectures and normally include Source, Negotiate, Buy, Design and Supply Collaboration. Similarly, Integrated Supply Chain Management Processes include Strategic Planning, Demand Planning, Supply Planning, Fulfillment and field service. Customer Relationship Management includes market, price, sell, call center and Order Management.



Customer Relationship Management (CRM) includes all processes that focus on the interface between the firm and its customers such as marketing, sales, call center management and order management.

Virtual University students must have reached a stage in their education endeavor where they are already aware that enterprises pay special attention for orientation and training of their workforce for Customer Relationship Management.

Internal Supply Chain Management (ISCM) includes all processes that are internal to the enterprise such as

1. Finalization of demand & supply plans,
2. Preparation of inventory management policies,
3. Order fulfillment and planning of capacity.

Inventory management policy is normally finalized by senior management but you as a supply chain manager can play an effective part. Also for order fulfillment and planning of capacity, not only the new machines' capacities are considered but existing machines are also considered.

Supplier Relationship Management (SRM) includes all processes that focus on the interface between a firm and its suppliers such as

1. Evaluation and selection of suppliers,
2. Negotiation of supply terms and
3. Communication regarding new products and orders

Suppliers' loyalty depends on the relationship the enterprise pursues with the supplier.

EXAMPLES OF SUPPLY CHAINS

Virtual University Students are suggested to appreciate the following important points about the different companies which are normally taken up as case studies. Even though the same enterprises, have been known to have pursued different supply chain strategies in different periods of time. These points appear in the form of questions to give an insight to students who want to pursue a career as a supply chain professional.

These enterprises represent different industries and in one way or another provide an opportunity to the supply chain manager to be aware of the design, operation and management of a supply chain under certain as well as uncertain environmental conditions.

The questions below are just of academic interest and may not be seriously tackled but they do give an excellent clue about the point of difference **between the two companies** being **compared**.

Gateway and Apple: Tech Industry focusing on Electronic Gadgets, laptops and cells

1. The difference in business models due to which Gateway choose not to carry any finished-product inventory at its retail stores. While at the same time Apple choose to carry inventory at its stores.
2. How positively the supply chain is influenced by investment in retail stores which carry finished-goods inventory. What are the characteristics of products that are most suitable to be carried in finished-goods inventory? What characterizes products that are best manufactured to order?
3. How does product variety affect the level of inventory a retail store must carry?
4. Is a direct selling supply chain without retail stores always less expensive than a supply chain with retail stores?
5. What factors explain the success of Apple retail and the failure of Gateway country stores?

Zara: Apparel Industry

1. What advantage does Zara gain against the competition by having a very responsive supply chain?
2. Why has Inditex chosen to have both in-house manufacturing and outsourced manufacturing? Why has Inditex maintained manufacturing capacity in Europe even though manufacturing in Asia is much cheaper?
3. Why does Zara source products with uncertain demand from local manufacturers and products with predictable demand from Asian manufacturers?
4. What advantage does Zara gain from replenishing its stores multiple times a week compared to a less frequent schedule? How does the frequency of replenishment affect the design of its distribution system?
5. Do you think Zara's responsive replenishment infrastructure is better suited for online sales or retail sales?

W.W. Grainger and McMaster-Carr: Catalogue

1. How many Distributor Centers (DCs) should be built and where should they be located?
2. How should product stocking be managed at the DCs? Should all DCs carry all products?
3. What products should be carried in inventory and what products should be left with the supplier to be shipped directly in response to a customer order?
4. What products should W.W. Grainger carry at a store?
5. How should markets be allocated to DCs in terms of order fulfillment? What should be done if an order cannot be completely filled from a DC? Should there be specified backup locations? How should they be selected?
6. How should replenishment of inventory be managed at the various stocking locations?
7. How should Web orders be handled relative to the existing business? Is it better to integrate the Web business with the existing business or to set up separate distribution?
8. What transportation modes should be used for order fulfillment and stock replenishment?

Toyota: Automobile Industry

1. Where should plants be located, what degree of flexibility should each have, and what capacity should each have?
2. Should plants be able to produce for all markets?
3. How should markets be allocated to plants?
4. What kind of flexibility should be built into the distribution system?
5. How should this flexible investment be valued?
6. What actions may be taken during product design to facilitate this flexibility?

Amazon and Independent Merchants

1. Why did Amazon decide to allow other merchants to use its supply chain expertise?
2. What advantages do merchants have when partnering with Amazon?
3. Should Amazon stock every product it sells?
4. What advantage can bricks-and-mortar players derive from setting up an online channel? How should they use the two channels to gain a maximum advantage?
5. What advantages or disadvantages do large book retailers gain by letting Amazon manage their supply chain?
6. For which products does the online channel offer the greatest advantage relative to retail stores? What characterizes these products?

SUMMARY OF LEARNING OBJECTIVES**1. Discuss the objective of a supply chain of an enterprise**

- A. The objective of a supply chain should be to maximize overall supply chain profitability.
- B. Supply chain profitability is the difference between the revenue generated from the customer and the total cost incurred across all stages of the supply chain.
- C. Supply chain decisions have a large impact on the success or failure of each enterprise because they significantly influence both the revenue generated and the cost incurred.
- D. Successful supply chains manage flows of product, information, and funds to provide a high level of product availability to the customer while keeping costs low.

2. Identify the three key supply chain decision phases

- A. Supply chain decisions may be characterized as strategic (design), planning, or operational, depending on the time period during which they apply.
- B. Strategic decisions relate to supply chain configuration. These decisions have a long-term impact lasting several years.
- C. Planning decisions cover a period of a few months to a year and include decisions such as production plans, subcontracting, and promotions over that period. Operational decisions span from minutes to days and include sequencing production and filling specific orders.
- D. Strategic decisions define the constraints for planning decisions, and planning decisions define the constraints for operational decisions.

3. Describe the cycle and push/pull views of a supply chain.

- A. A cycle view of a supply chain divides processes into cycles, each performed at the interface between two successive stages of a supply chain.
- B. Each cycle starts with an order placed by one stage of the supply chain and ends when the order is received from the supplier stage.

- C. A push/pull view of a supply chain characterizes processes based on their timing relative to that of a customer order.
- D. Pull processes are performed in response to a customer order, whereas push processes are performed in anticipation of customer orders.

4. Classify the supply chain macro processes in an enterprise.

- A. All supply chain processes can be classified into three macro processes based on whether they are at the customer or supplier interface or are internal to the enterprise.
- B. The CRM macro process consists of all processes at the interface between the enterprise and the customer that work to generate, receive, and track customer orders.
- C. The ISCM macro process consists of all supply chain processes that are internal to the enterprise and work to plan for and fulfill customer orders.
- D. The SRM macro process consists of all supply chain processes at the interface between the enterprise and its suppliers that work to evaluate and select suppliers and then source goods and services from them.

Virtual University students have already understood the concept of supply chain and logistics, we will close our lecture discussion on a popular proverb attributed King Richard III which spells out the critical aspect of Supply Chain with respect to strategic, tactical and operational points of view. A popular version goes like this and traces the importance of supply chain, where a simple loss of nail means a loss of kingdom.

For Want of a Nail

*For want of a nail the shoe was lost.
For want of a shoe the horse was lost.
For want of a horse the rider was lost.
For want of a rider the message was lost.
For want of a message the battle was lost.
For want of a battle the kingdom was lost.
And all for the want of a horseshoe nail.*

END OF LECTURE 11: GIST AND CRUX:

1. *Supply Chain process is directly linked to various levels of decision making with Supply Chain design, planning and operation reflecting Strategic, Tactical and Operational decision. Supply chain management involves the management of flows between and among stages in a supply chain to maximize total profitability.*
2. *Supply Chain managers are trained to identify the cycle view and push/pull concepts. Different enterprises use different strategies to exploit the different cycles to achieve supply chain surplus. The business models/ supply chains of Dell and Compaq/HP comes to mind.*
3. *Push and pull strategies enjoy a unique status both in traditional business models as well as E Marketing based business models.*
4. *Push and pull boundaries actually help Supply Chain Managers to formulate a strategy that help them to smoothly operate the supply chain and increase its revenues.*
5. *Supply Chain Macro processes have attained the status of a mature subject in business with different specialization studies in place to help enterprises hire the trained and business savvy managers. VU students can identify some of the classes they have already studied in their MBA program which focus on these macro processes.*



Supply Chain Management

- ◆ Supply Chain: The sequence of organizations - their facilities, functions, and activities - that are involved in producing and delivering a product or service.

Sometimes referred to as value chains or Extended Value Chains



What is Supply Chain Management?

- ◆ Managing supply chain flows and assets, *to maximize supply chain surplus*
- ◆ What is *supply chain surplus*?
 - Supply chain surplus refers to what the customer has paid - total cost expended by supply chain in filling order.



Mission-Strategy-Tactics- Decisions

- ◆ **Mission**, Mission statement
 - The reason for existence of an organization

- ◆ **Strategy**
 - A plan for achieving organizational goals

- ◆ **Tactics**
 - The actions taken to accomplish strategies

- ◆ **Operational decisions**
 - Day to day decisions to support tactics



Decision Levels

◆ Strategic:

- Long term, permanence of many years

◆ Tactical

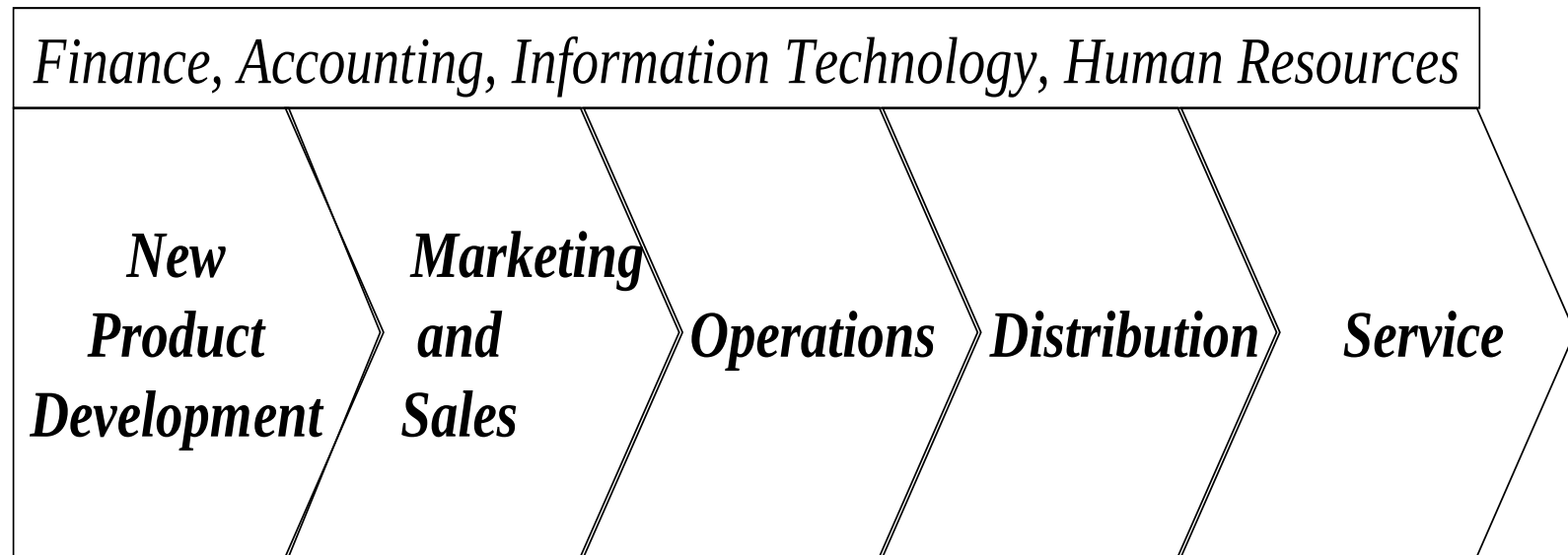
- Intermediate time range, usually three months to a year

◆ Operational

- Short range, week or less



The Value Chain: Linking Supply Chain and Business Strategy





Product Development strategy



Strategies

- ◆ **Marketing and sales strategy** relates to positioning, pricing and promotion of products/services
 - e.g. Never offer more than 40% discount
 - e.g. EDLP = every day low price
 - » At Wal-Mart
 - e.g. Demand smoothing via time based coupons
 - » BestBuy

- ◆ **Supply chain management** strategy relates to procurement, transportation, storage and delivery
 - e.g. Never use more than 1 supplier for every input
 - e.g. Never expedite orders just because they are late
 - e.g. Always use domestic suppliers within the sales season not in advance.



2.2. Achieving Strategic Fit

- ◆ Introduction
- ◆ How is strategic fit achieved?
- ◆ Other issues affecting strategic fit



Success or Failure for Strategic Fit

- ◆ All processes and functions that are part of an organization's value chain contribute to its success or failure:
 - These processes and functions do not operate in isolation.
 - No one process or function can ensure the chain's success.
 - Failure at any one process or function can lead to failure of over chain.



Success or Failure for Strategic Fit

◆ The success or failure is thus linked to 3 reasons:

1. The competitive strategy and all the functional strategies must fit together to form a coordinated over all strategy. Each functional strategy must support other functional strategies and help a firm reach its competitive strategy goal



Success or Failure for Strategic Fit

◆ The success or failure is thus linked to 3 reasons:

2. The different functions in a company must appropriately structure their processes and resources to be able to execute these strategies successfully



Success or Failure for Strategic Fit

◆ The success or failure is thus linked to 3 reasons:

3. The design of the overall supply chain and the role of each stage must be aligned to support the supply chain strategy.

How is Strategic Fit Achieved?

- ◆ Step 1: Understanding the customer and supply chain uncertainty
- ◆ Step 2: Understanding the supply chain
- ◆ Step 3: Achieving strategic fit

Step 1: Understanding the customer and supply chain uncertainty

- ◆ A firm must understand the customer needs for each targeted segment and the uncertainty these needs impose on supply chain.
- ◆ These needs help the company define the desired cost and requirements.
- ◆ The supply chain uncertainty helps the organization to identify the extend of unpredictability of demand, disruption and delay that the supply chain must be prepared for.

Step 1: Understanding the Customer and Supply Chain Uncertainty

◆ Requires identifying:

- **The needs of the customer segment being served**
- **Quantity of product needed in each lot**
- **Response time customers will tolerate**
- **Variety of products needed**
- **Service level required**
- **Price of the product**
- **Desired rate of innovation in the product**

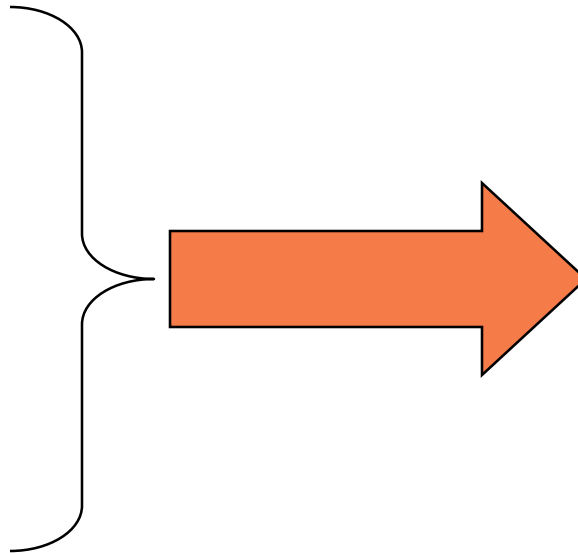
Step 1: Understanding the Customer and Supply Chain Uncertainty

- ◆ Overall attribute of customer demand
- ◆ Demand uncertainty
- ◆ Implied demand uncertainty: Resulting uncertainty for the supply chain given the portion of the demand the supply chain must handle and attributes the customer desires.

Achieving Strategic Fit

◆ Understanding the Customer

- Lot size
- Response time
- Service level
- Product variety
- Price
- Innovation



***Implied
Demand
Uncertainty***

Impact of Customer Needs on Implied Demand Uncertainty

Customer Need	Causes implied demand uncertainty to increase because ...
Range of quantity increases	Wider range of quantity implies greater variance in demand
Lead time decreases	Less time to react to orders
Variety of products required increases	Demand per product becomes more disaggregated
Number of channels increases	Total customer demand is now disaggregated over more channels
Rate of innovation increases	New products tend to have more uncertain demand
Required service level increases	Firm now has to handle unusual surges in demand

Levels of Implied Demand Uncertainty

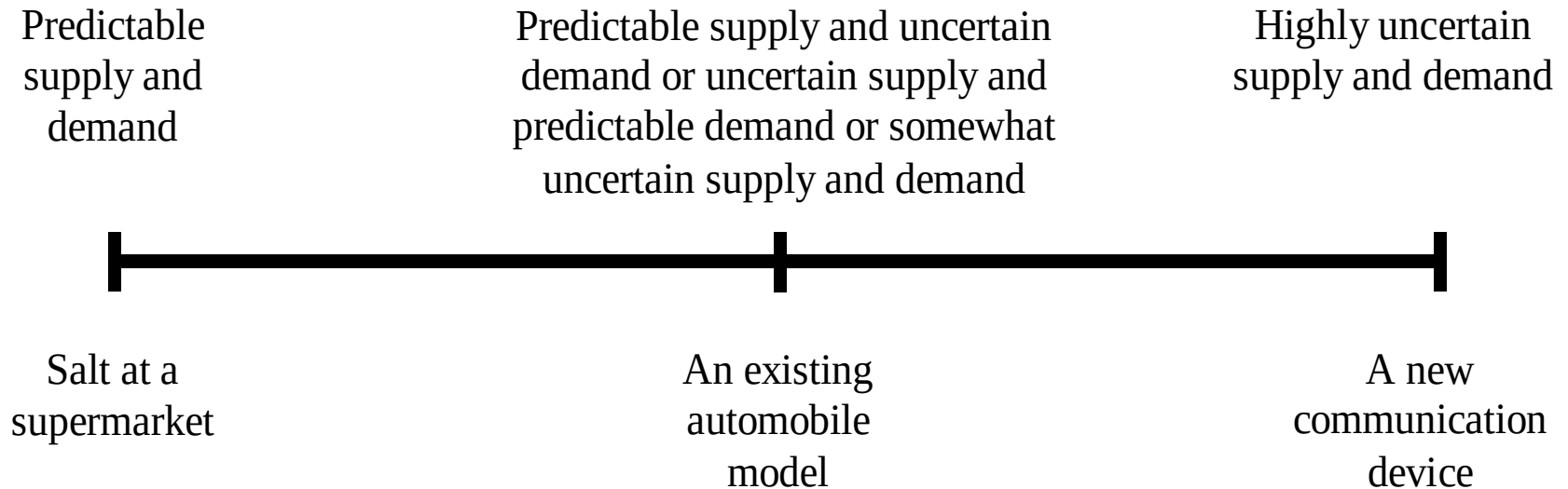


Figure 2.2: The Implied Uncertainty (Demand and Supply)

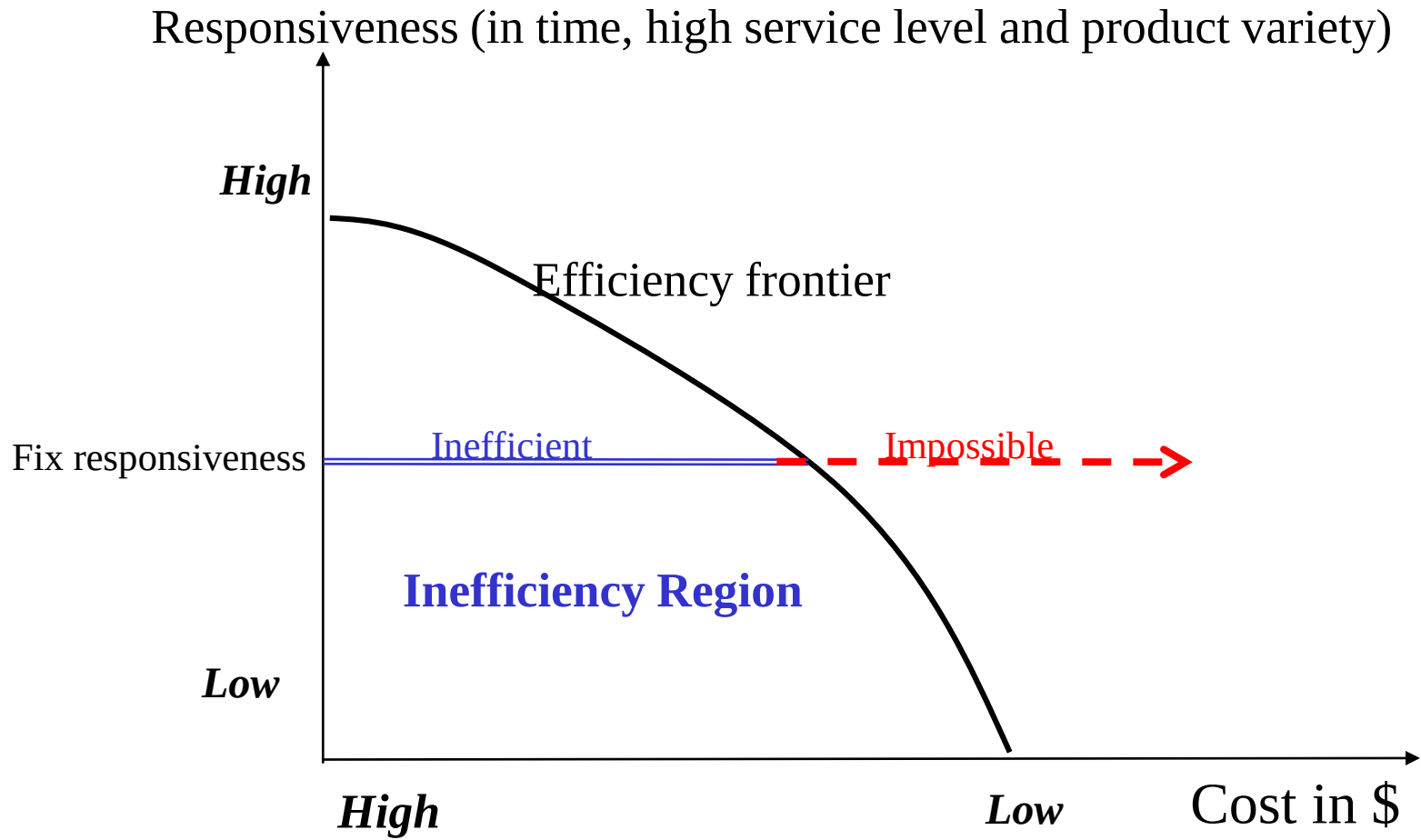
Correlation Between Implied Demand Uncertainty and Other Attributes

Attribute	Low Implied Uncertainty	High Implied Uncertainty
Product margin	Low	High
Avg. forecast error	10%	40%-100%
Avg. stockout rate	1%-2%	10%-40%
Avg. forced season-end markdown	0%	10%-25%

Step 2: Understanding the Supply Chain

- ◆ How does the firm best meet demand?
- ◆ Dimension describing the supply chain is supply chain responsiveness.
- ◆ Supply chain responsiveness -- Ability to:
 - Respond to wide ranges of quantities demanded
 - Meet short lead times
 - Handle a large variety of products
 - Build highly innovative products
 - Meet a very high service level

Understanding the Supply Chain: Cost-Responsiveness Tradeoff



Why decreasing slope (concave) for the efficiency frontier?

Step 3: Achieving Strategic Fit

- ◆ If a mismatch exists between what the supply chain does particularly well and the desired customer needs, the company will either need to restructure the supply chain to support the competitive strategy or alter its competitive strategy.

Responsiveness Spectrum

1. *Production scheduled ahead in months with little flexibility.*
2. *A make to stock manufacturer with production lead time of several weeks.*

**1.Highly
efficient**

**2.Somewhat
efficient**

**3.Somewhat
responsive**

**4.Highly
responsive**



*Integrated
steel mill*

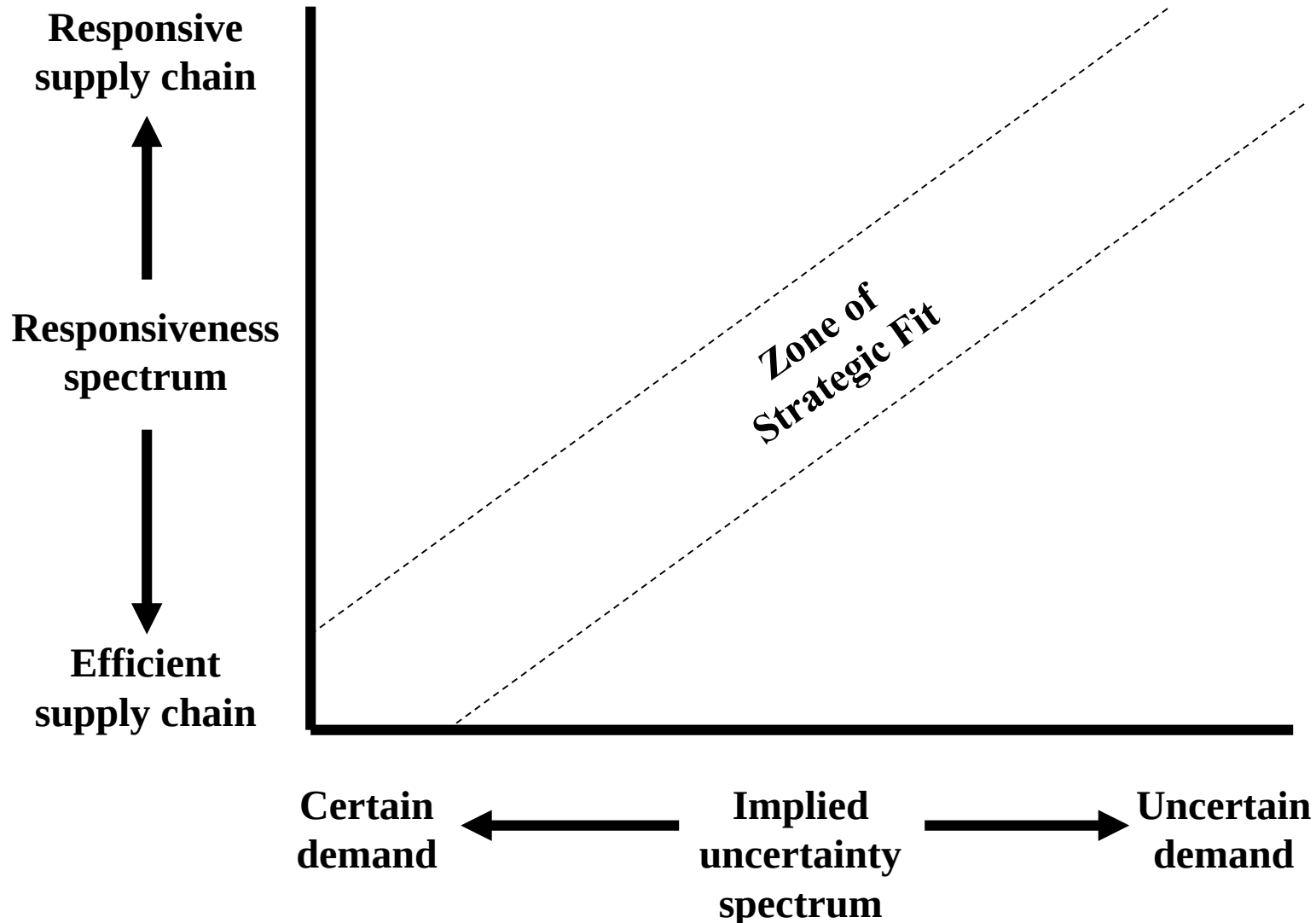
*Hanes
apparel*

*Most
automotive
production*

7-11 Japan

3. *Delivering a large variety of products in a couple of weeks.*
4. *Changing merchandize mix by location and time of day.*

Achieving Strategic Fit Shown on the Uncertainty/Responsiveness Map (Fig. 2.5)



Step 3: Achieving Strategic Fit

◆ Two key points:

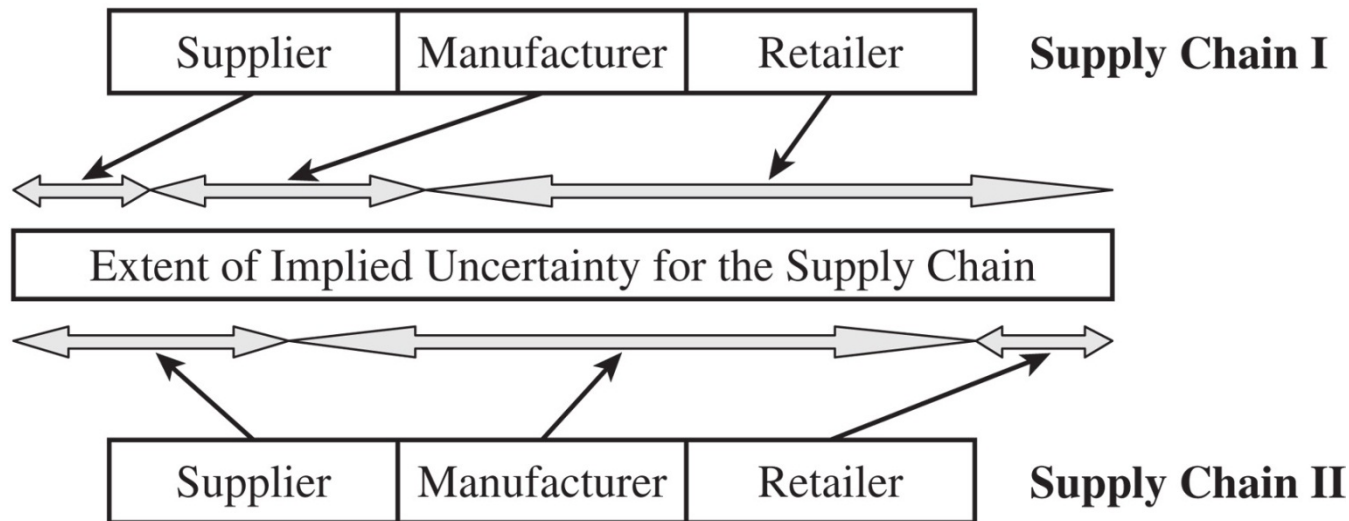
- There is *no* right supply chain strategy independent of competitive strategy.
- There *is* a right supply chain strategy for a given competitive strategy.

Roles and Allocations

Supplier absorbs the least implied uncertainty and must be very efficient.

Manufacturer absorbs less implied uncertainty and must be somewhat efficient.

Retailer absorbs most of the implied uncertainty and must be very responsive.



Supplier absorbs less implied uncertainty and must be somewhat efficient.

Manufacturer absorbs most of the implied uncertainty and must be very responsive.

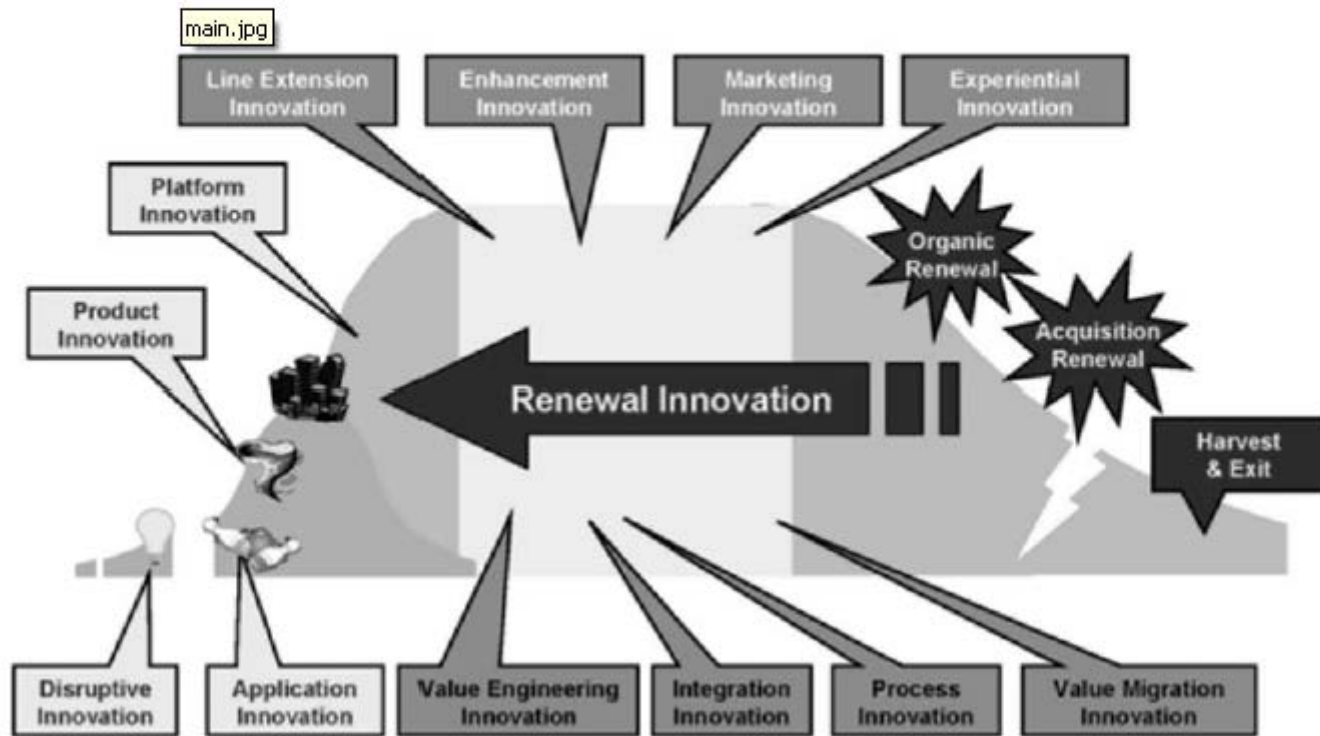
Retailer absorbs the least implied uncertainty and must be very efficient.

Product Life Cycle

- ◆ The demand characteristics of a product and the needs of a customer segment change as a product goes through its life cycle.
- ◆ Supply chain strategy must evolve throughout the life cycle.
- ◆ Early: Uncertain demand, high margins (time is important), product availability is most important, cost is secondary.
- ◆ Late: Predictable demand, lower margins, price is important.

Relationship between SCM and PLC

Innovation Occurs Everywhere in the Lifecycle



Graphic from: Geoffrey Moore: Dealing with Darwin. Penguin Books, 2008

Expanding Strategic Scope

◆ Scope of strategic fit

- The functions and stages within a supply chain that devise an integrated strategy with a shared objective.
- One extreme: Each function at each stage develops its own strategy.
- Other extreme: All functions in all stages devise a strategy jointly.

◆ Five categories:

- Intra-company intra-operation scope
- Intra-company intra-functional scope
- Intra-company inter-functional scope
- Inter-company inter-functional scope
- Flexible inter-functional scope

Intra-company – *Intra-operation scope*

Intra-operation scope – Minimize local cost view

- Each stage of the supply chain devises strategy independently.
- The resulting collection of strategies normally do not align.
- This was the popular strategy of 1950s and 1960s, with cost minimization for each operation within each stage of supply chain.

Strategic Scope:

Intracompany Intraoperation Scope

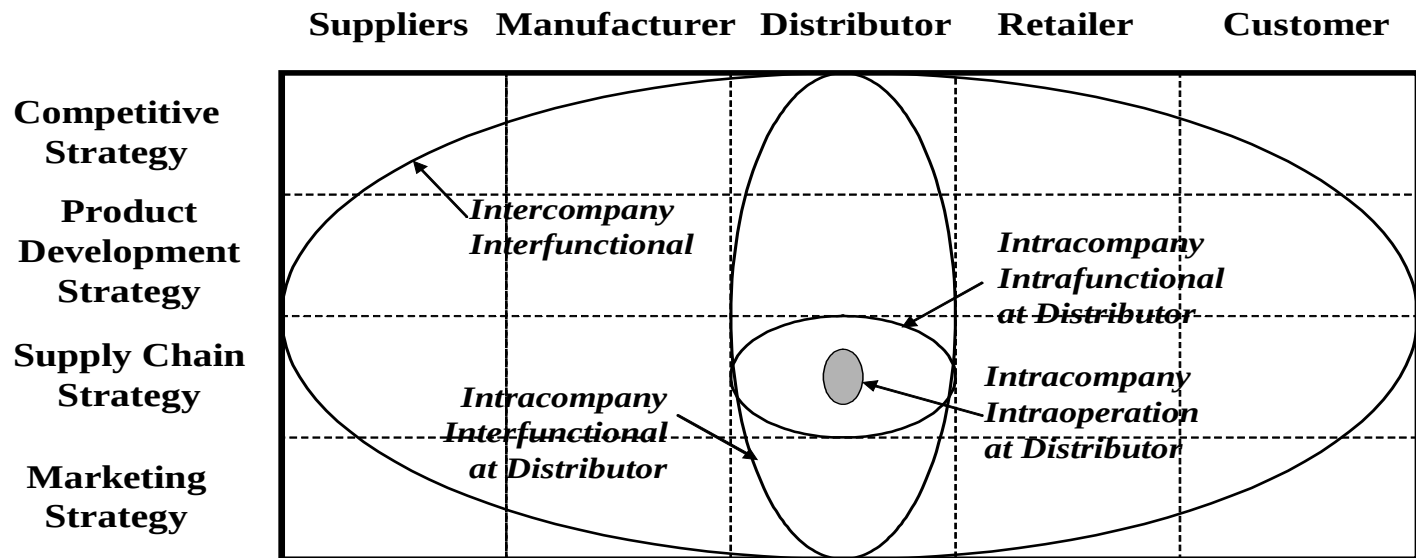
	Suppliers	Manufacturer	Distributor	Retailer	Customer
Competitive Strategy					
Product Dev. Strategy					
Supply Chain Strategy					
Marketing Strategy					

Intracompany-Intrafunctional view

Scope

- ◆ *Intra-functional* view – Minimize total functional cost
 - This came as a result of recognition of failure of Intra-company Intra-operation strategy.
 - **Firms align all operations within a function.**
 - **For instance, the use of air freight could only be justified if the resulting savings in inventories and improved responsiveness would justify the increase in transportation costs.**

Different Scopes of Strategic Fit Across a Supply Chain



Inter-company Inter-functional Scope

Intercompany scope – **Maximize supply chain surplus**

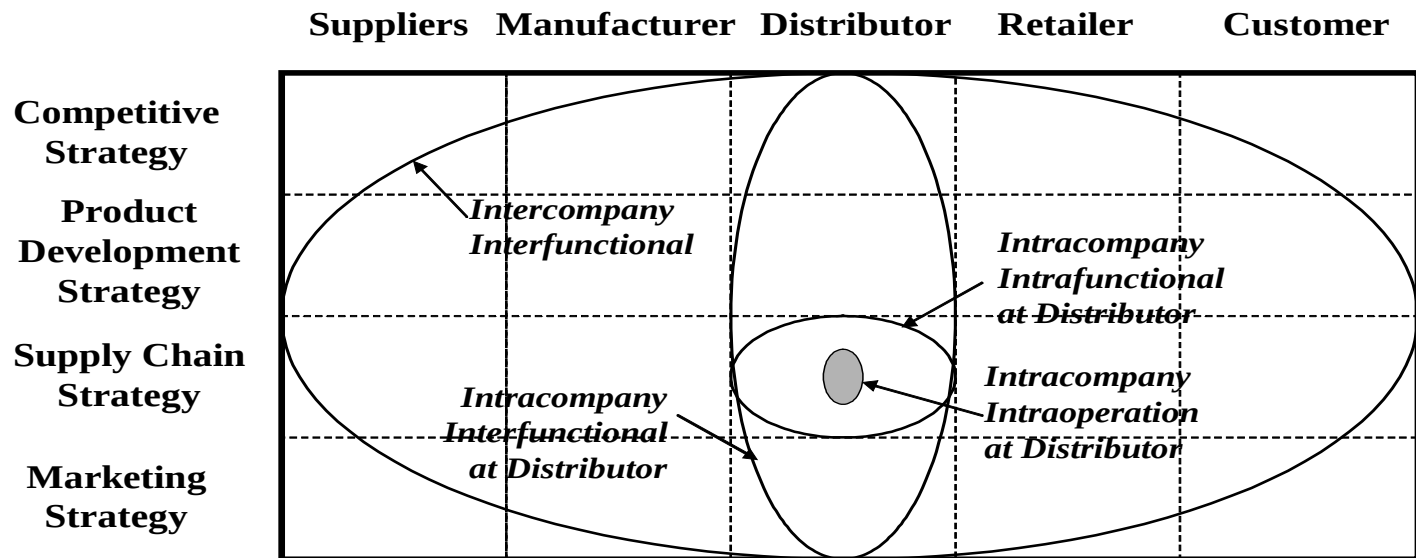
- The goal of only maximizing company profits can sometime lead to conflict between stages of supply chain.
- A common conflict being that supplier or the manufacturer. may want the other party to hold more profit so as to safe guard their own profits.
- The supply chain surplus can be compared to the pie, if the parties fight, the stronger party will have more share of the pie while reducing the size of the pie.

Intercompany Interfunctional Scope

Intercompany scope – **Proposes a different approach**

- Supplier and customer work together and share information to reduce total cost and grow supply chain surplus.
- By working together and sharing info they can reduce the inventories and total cost thus growing supply chain surplus.
- Higher the supply chain surplus, the more competitive the supply chain is.

Different Scopes of Strategic Fit Across a Supply Chain



Agile inter-company Scope

- ◆ *Agile intercompany scope* – A firm's ability to achieve strategic fit when partnering with supply chain stages that change over time.
- ◆ Dynamics exits – Product life cycle get shorter and companies try to satisfy the changing needs of individual customers.

Agile inter-company Scope

- ◆ In such situations, a company may have to partner with many different firms depending on the product being produced and the customer being served – strategic fit should have agile intercompany scope.

Quaid-e-Azam Strategy

◆ “My message to you all is of hope, courage and confidence. Let us mobilize all our resources in a systematic and organized way and tackle the grave issues that confront us with grim determination and discipline worthy of a great nation.”

◆ Eid-ul-Azha Message to the Nation

October 24, 1947

Learning Objectives

1. Impellers of the Supply Chain
 1. Empowered Customers
 2. IS and IT Tools Development
 3. Globalization
2. Supply Chain Concepts
 1. Systems Concept
 2. Total Cost Concept
 3. Trade off Concept
3. Identify the major drivers of supply chain performance

Learning Objectives

4. Describe key financial measures of firm performance.
5. Discuss the role of each driver in creating strategic fit between the supply chain strategy and the competitive strategy.
6. Define the key metrics that track the performance of the supply chain in terms of each driver.
7. SCOR Model.

Impellers of the Supply Chain

- ◆ Impellers of supply chain development include those forces that are reshaping the businesses of today in a hyper competitive environment.
 1. Empowered Customers:
 2. IS and IT Tools Development
 3. Globalization

Supply Chain Concepts

1. Systems Concept
2. Total Cost Concept
3. Trade off Concept

Total Cost Concept

1. Businesses should be viewed as Integrated systems and Interconnected chains with multiple links
2. Value delivered to the customer can only be increased if the total cost of the entire supply chain is reduced.

Why Financial Measures

Why Financial Measures

- ◆ While there is no right or wrong answer regarding the exact definition of supply chain management, the underlying effect of such a diversity of opinions is that the supply chain becomes a set of functionally dispersed ‘islands of power’.

Financial Measures Of Performance

- ◆ From a shareholder perspective, return on equity (ROE) is the main summary measure of a firm's performance.

$$ROE = \frac{\text{Net Income}}{\text{Average Shareholder Equity}}$$

Financial Measures Of Performance

- ◆ Return on assets (ROA) measures the return earned on each dollar invested by the firm in assets.

$$ROA = \frac{\text{Earnings before interest}}{\text{Average Total Assets}}$$

$$= \frac{\text{Net Income} + \left[\text{Interest expense} \times (1 - \text{tax rate}) \right]}{\text{Average Total Assets}}$$

Financial Measures Of Performance

- ◆ An important ratio that defines financial leverage is **ACCOUNTS PAYABLE TURNOVER** (APT).

$$APT = \frac{\text{Cost of goods sold}}{\text{Accounts Payable}}$$

Financial Measures Of Performance

- ◆ ROA can be written as the product of two ratios – **PROFIT MARGIN** and **ASSET TURNOVER**.

$$ROA = \frac{\text{Earnings before interest}}{\text{Sales Revenue}} (\text{Profit Margin})$$

$$\times \frac{\text{Sales Revenue}}{\text{Total Assets}} (\text{Asset Turnover})$$

Financial Measures Of Performance

- ◆ Cash-to-cash (C2C) cycle **roughly measures the average amount time from when cash enters the process as COST to when it returns as COLLECTED REVENUE.**

$$\begin{aligned} \text{C2C} = & - \text{days payable (1/APT)} \\ & + \text{days in inventory (1/INVT)} \\ & + \text{days receivable (1/ART)} \end{aligned}$$

Cash 2 Cash as a Measurement of Lean Operations

Desired Results of Cash-to-Cash Cycle

Drivers of Supply Chain Performance

There are two types of SC performance drivers namely:

1. Logistical Drivers
2. Cross Functional Drivers

Drivers of Supply Chain Performance

The three logistical drivers are:

◆ Facilities

◆ Inventory

◆ Transportation

Drivers of Supply Chain Performance

The three cross functional drivers are:

- ◆ Pricing
- ◆ Information
- ◆ Sourcing

Drivers of Supply Chain Performance

◆ Pricing

- **How much a firm will charge for the goods and services that it makes available in the supply chain.**

A Framework for Structuring Drivers

A Framework for Structuring Drivers

◆ What is a Framework?

- **The structure that forms a support or frame for Supply Chain Drivers.**

A Framework for Structuring Drivers

◆ **Role in the Competitive Advantage**

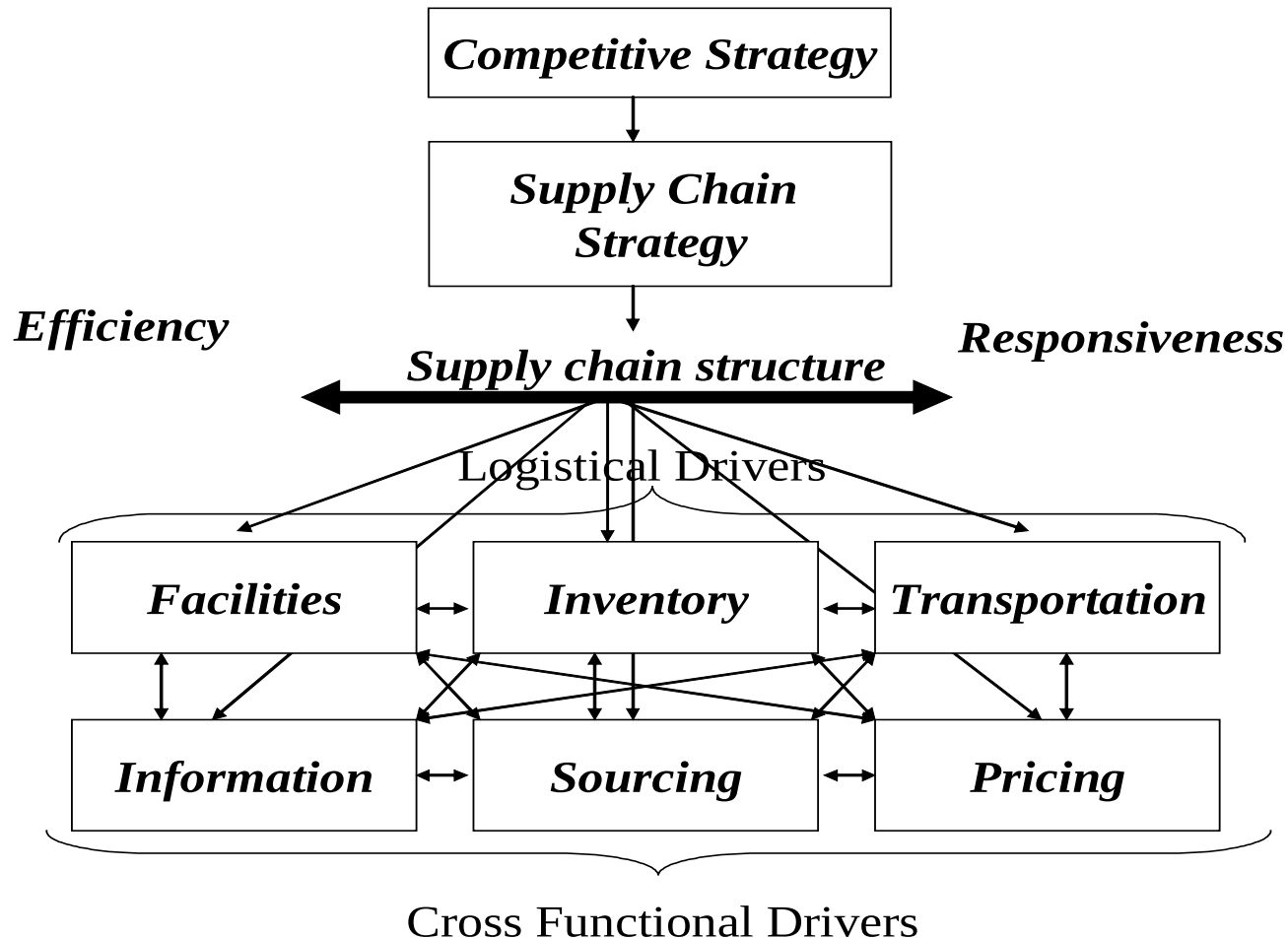
- ◆ **It actually provides competitive advantage in two dimensions namely:**
 - **Economies of scale (efficiency priority)**
 - **Larger number of smaller facilities (responsiveness priority)**

A Framework for Structuring Drivers

◆ Role in the competitive strategy

1. Competitive Strategy
2. Supply Chain Strategy (should balance between Efficiency and Responsiveness through SC Structure)
3. Supply Chain Structure
4. Logistical Drivers
5. Cross Functional Drivers

A Framework for Structuring Drivers



Facilities: Role in the supply chain

- The “where” of the supply chain
- Manufacturing or storage
(warehouses)**

Facilities: Role in the competitive strategy

Components of Facilities Decisions

- ◆ 1. Location
 - Centralization (efficiency) vs. decentralization (responsiveness)
 - Other factors to consider (e.g., proximity to customers)
- ◆ 2. Capacity (flexibility versus efficiency)
- ◆ 3. Manufacturing methodology (product focused versus process focused)

Components of Facilities Decisions

- ◆ **4. Warehousing methodology (SKU storage, job lot storage, cross-docking)**
- ◆ **5. Overall trade-off: Responsiveness versus efficiency**

Inventory: Role in the Supply Chain

- ◆ 1. Inventory exists because of a mismatch between supply and demand
- ◆ 2. Source of cost and influence on responsiveness

Inventory: Role in the Supply Chain

◆ 3. Impact on:

- **Material flow time: time elapsed between when material enters the supply chain to when it exits the supply chain**
- **Throughput**
 - » **rate at which sales to end consumers occur**
 - » **$I = DT$ (Little's Law)**
 - » **$I = \text{inventory}; D = \text{throughput}; T = \text{flow time}$**

Example – Nordstrom

Components of Inventory Decisions

◆ 1. Cycle inventory

- Average amount of inventory used to satisfy demand between shipments
- Depends on lot size

◆ 2. Safety inventory

- Inventory held in case demand exceeds expectations
- Costs of carrying too much inventory versus cost of losing sales

Components of Inventory Decisions

◆ 3. Seasonal inventory

- Inventory built up to counter predictable variability in demand
- Cost of carrying additional inventory versus cost of flexible production

◆ 4. Overall trade-off: Responsiveness versus efficiency

- More inventory: Greater responsiveness but greater cost
- Less inventory: Lower cost but lower responsiveness

Transportation: Role in the Supply Chain

- ◆ Moves the product between stages in the supply chain
- ◆ Impact on responsiveness and efficiency
- ◆ Faster transportation allows greater responsiveness but lower efficiency
- ◆ Also affects inventory and facilities

- ◆ Example: Laura Ashley

Components of Transportation Decisions

- ◆ Mode of transportation:
 - Air, truck, rail, ship, pipeline, electronic transportation
 - Vary in cost, speed, size of shipment, flexibility
- ◆ Route and network selection
 - Route: path along which a product is shipped
 - Network: collection of locations and routes
- ◆ In-house or outsource
- ◆ Overall trade-off: Responsiveness versus efficiency

Information: Role in the Supply Chain

- ◆ The connection between the various stages in the supply chain – allows coordination between stages.

Information:

Role in the Competitive Strategy

- ◆ Allows supply chain to become more efficient and more responsive at the same time (reduces the need for a trade-off)
- ◆ Information technology
- ◆ What information is most valuable?
- ◆ Example: Andersen Windows

Components of Information Decisions

- ◆ Push (MRP) versus pull (demand information transmitted quickly throughout the supply chain)
- ◆ Coordination and information sharing
- ◆ Forecasting and aggregate planning
- ◆ Enabling technologies
 - EDI
 - Internet
 - ERP systems
 - Supply Chain Management software
- ◆ Overall trade-off: NONE!

Sourcing: Role in the Supply Chain

- ◆ Set of business processes required to purchase goods and services in a supply chain
- ◆ Supplier selection, single vs. multiple suppliers, contract negotiation

Components of Sourcing Decisions

- ◆ In-house versus outsource decisions
- ◆ Supplier evaluation and selection
- ◆ Procurement process
- ◆ Overall trade-off: Make vs. Buy

Pricing: Role in the Supply Chain

- ◆ Pricing determines the amount to charge customers in a supply chain
- ◆ Pricing strategies can be used to match demand and supply

Pricing: Role in the Competitive Strategy

- ◆ Firms can utilize optimal pricing strategies to improve efficiency and responsiveness
- ◆ Low price and low product availability; vary prices by response times
- ◆ Example: Amazon.com

Components of Pricing Decisions

- ◆ Pricing and economies of scale
- ◆ Everyday low pricing versus high-low pricing
- ◆ Fixed price versus menu pricing
- ◆ Overall trade-off: Increase the firm profits vs. customer retention/value

Challenges/Obstacles to Achieving Strategic Fit

- ◆ Increasing variety of products
- ◆ Decreasing product life cycles
- ◆ Increasingly demanding customers
- ◆ Fragmentation of supply chain ownership
- ◆ Globalization
- ◆ Difficulty executing new strategies



Learning Objectives

1. Identify the key factors to be considered when designing a distribution network.
2. Discuss the strengths and weaknesses of various distribution options.
3. Understand how online sales have affected the design of distribution networks in different industries.
4. Distribution Network in practice.

The Role of Distribution in the Supply Chain

- *Distribution* – The steps taken to move and store a product from the supplier stage to the customer stage in a supply chain.
- Drives profitability by directly affecting supply chain cost and the customer experience.
- Choice of distribution network can achieve supply chain objectives from low cost to high responsiveness.

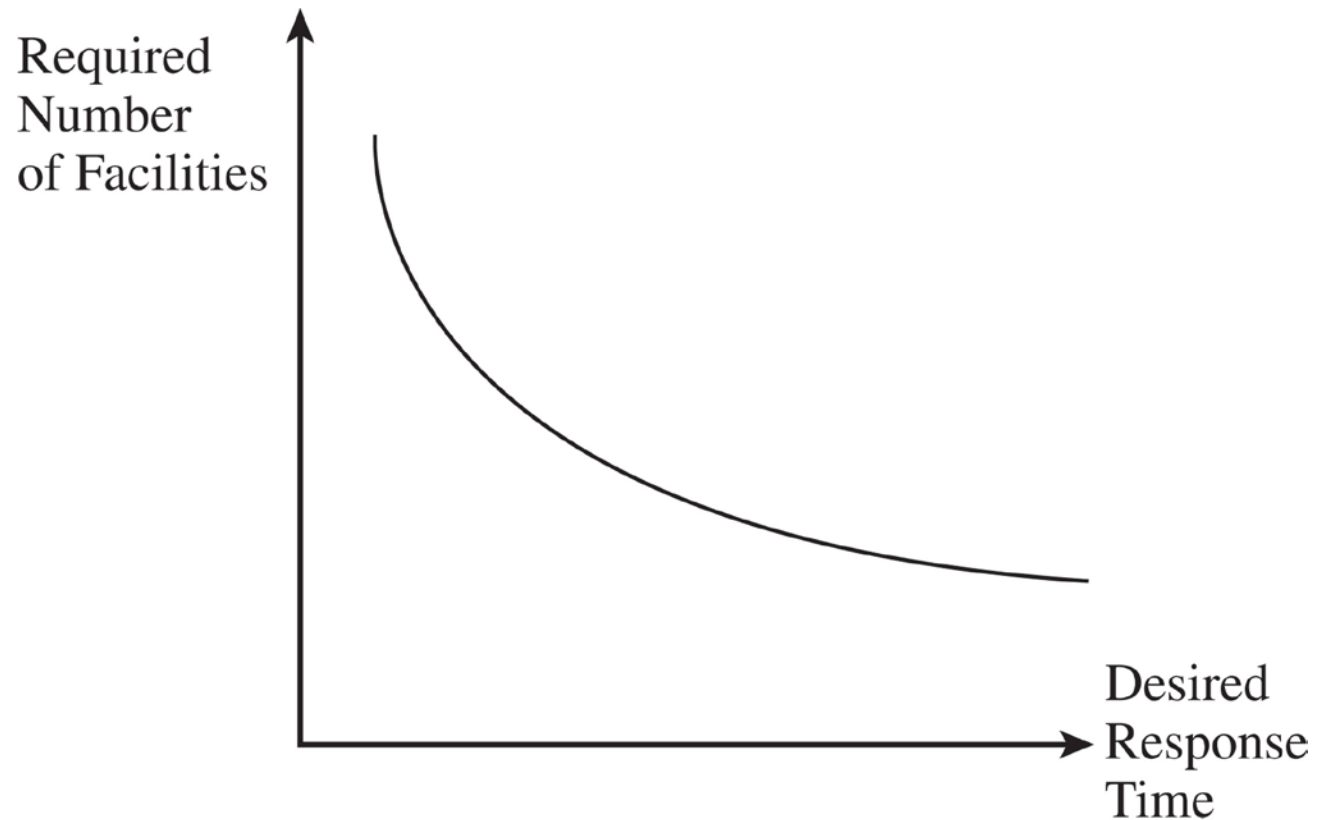
Factors Influencing Distribution Network Design

- Distribution network performance is evaluated along two dimensions:
 1. Customer needs that are met.
 2. Cost of meeting customer needs.
- Evaluate the impact on customer service and cost for different distribution network options.
- Profitability of the delivery network determined by revenue from met customer needs and network costs.

Factors Influencing Distribution Network Design

- Elements of customer service influenced by network structure:
 - Response time
 - Product variety
 - Product availability
 - Customer experience
 - Order visibility
 - Returnability

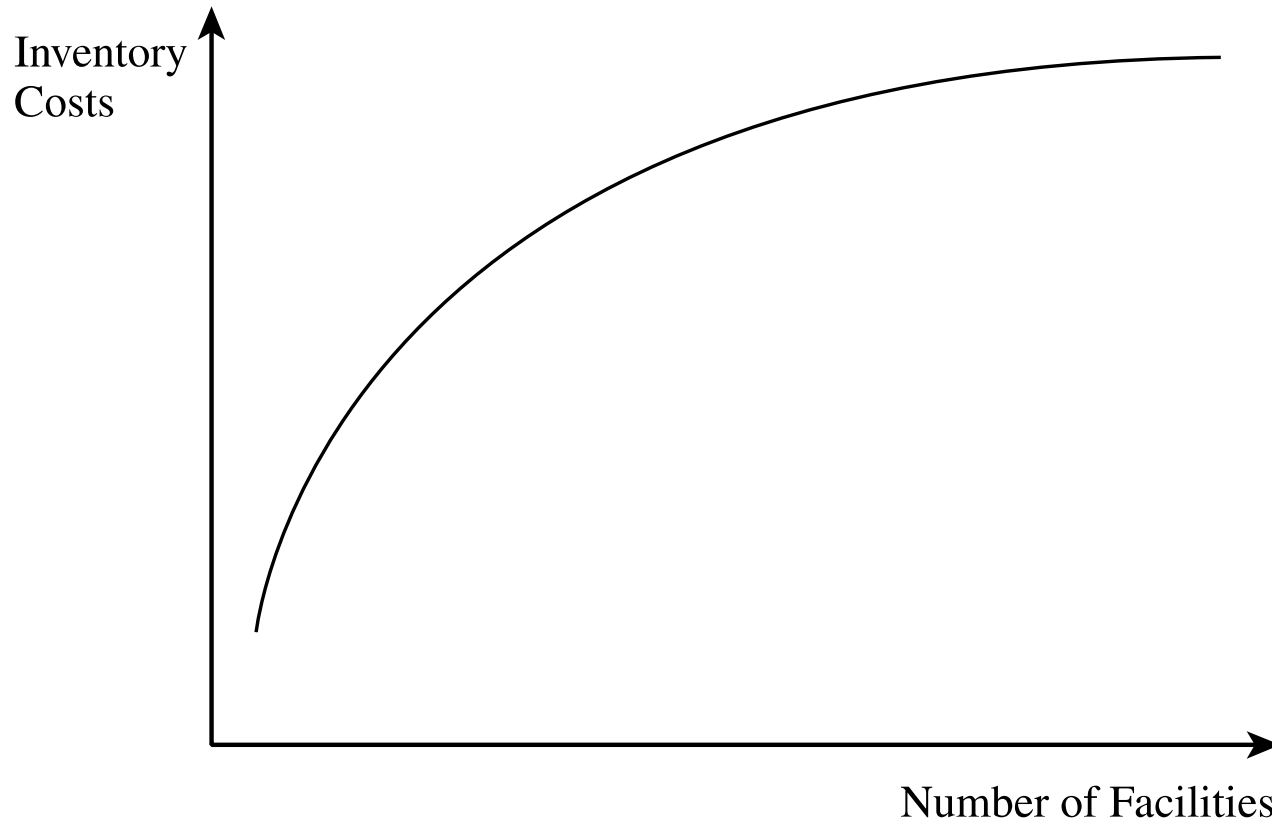
Desired Response Time and Number of Facilities



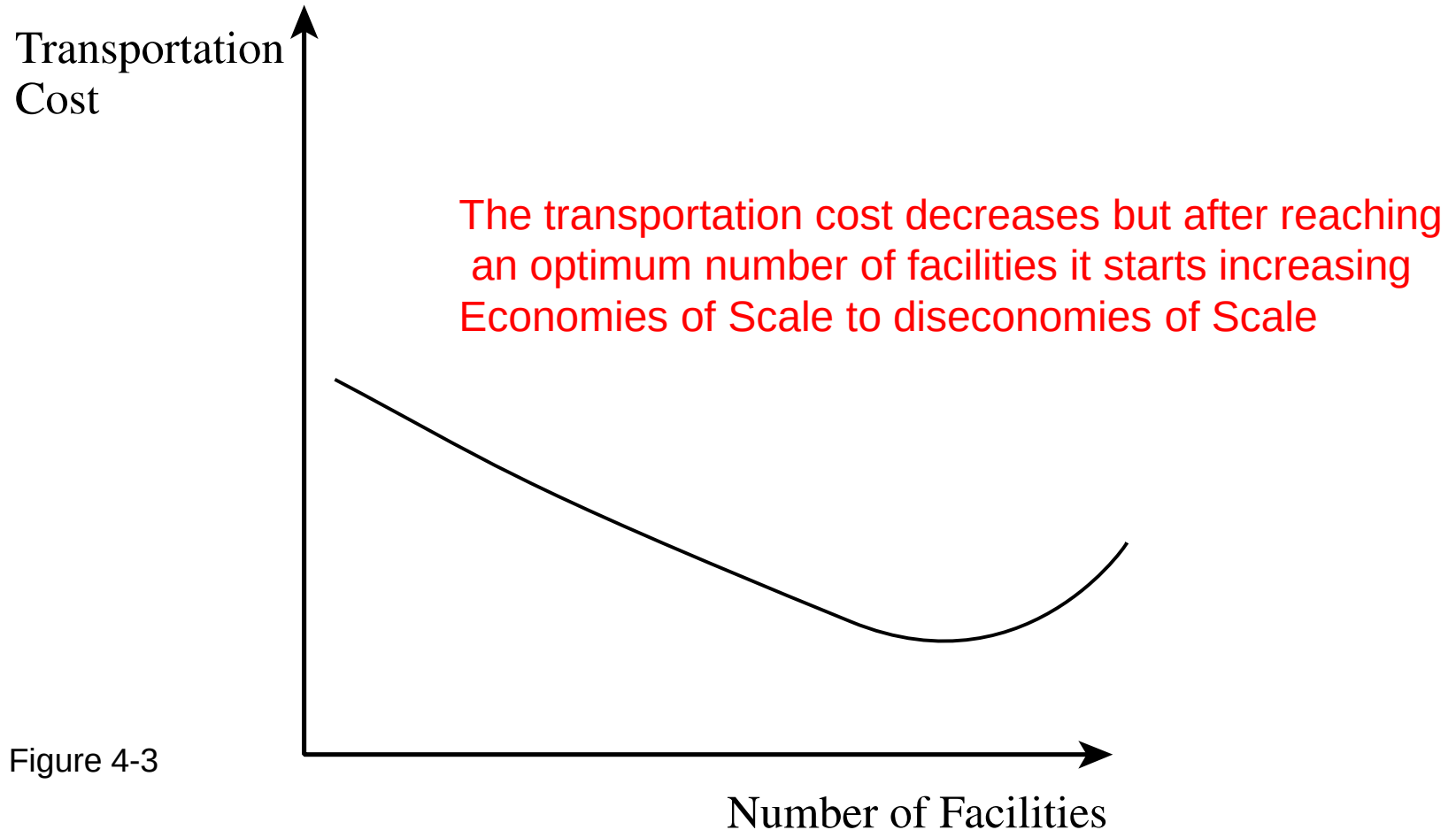
Desired Response Time and Number of Facilities

Firms that target customers who can tolerate a long response time require only.

Inventory Costs and Number of Facilities



Transportation Costs and Number of Facilities



Facility Costs and Number of Facilities

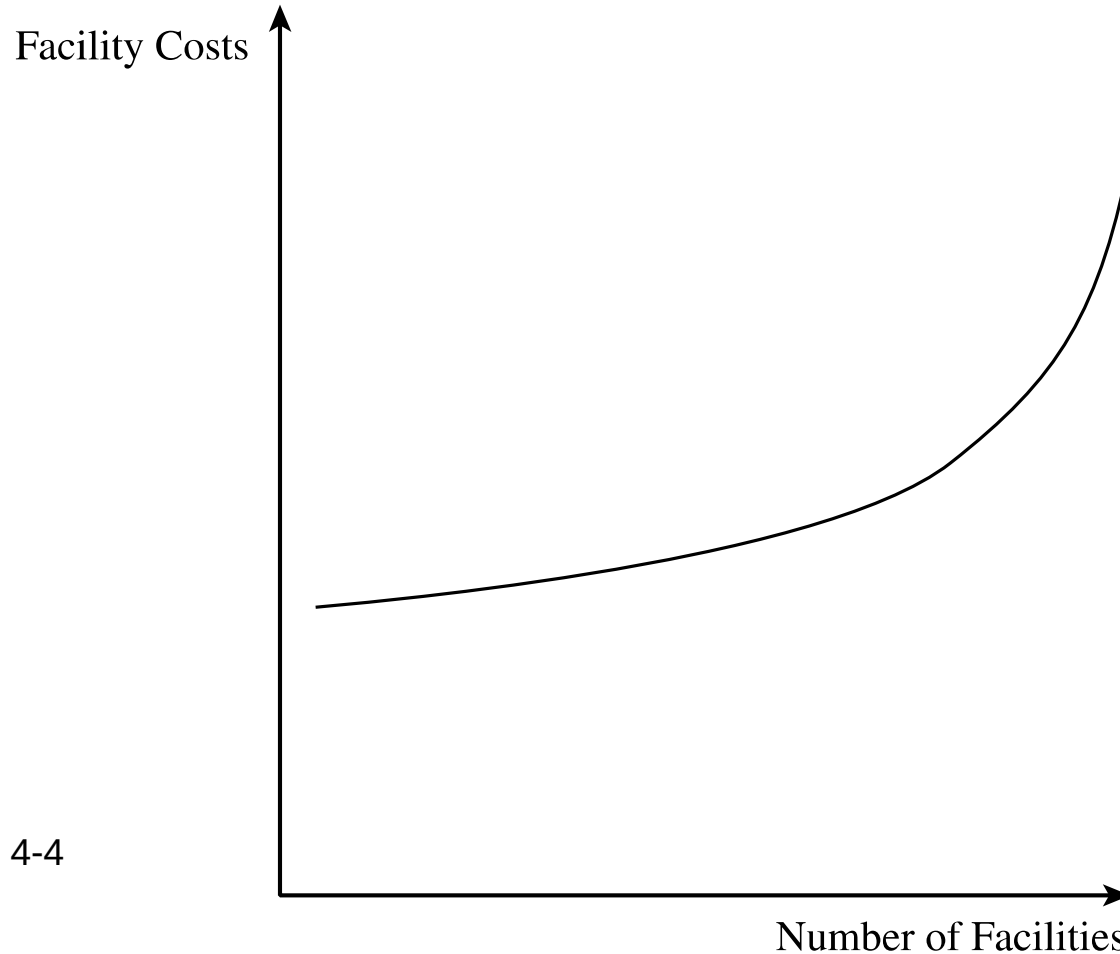


Figure 4-4

Number of Facilities

Logistics Cost, Response Time, and Number of Facilities

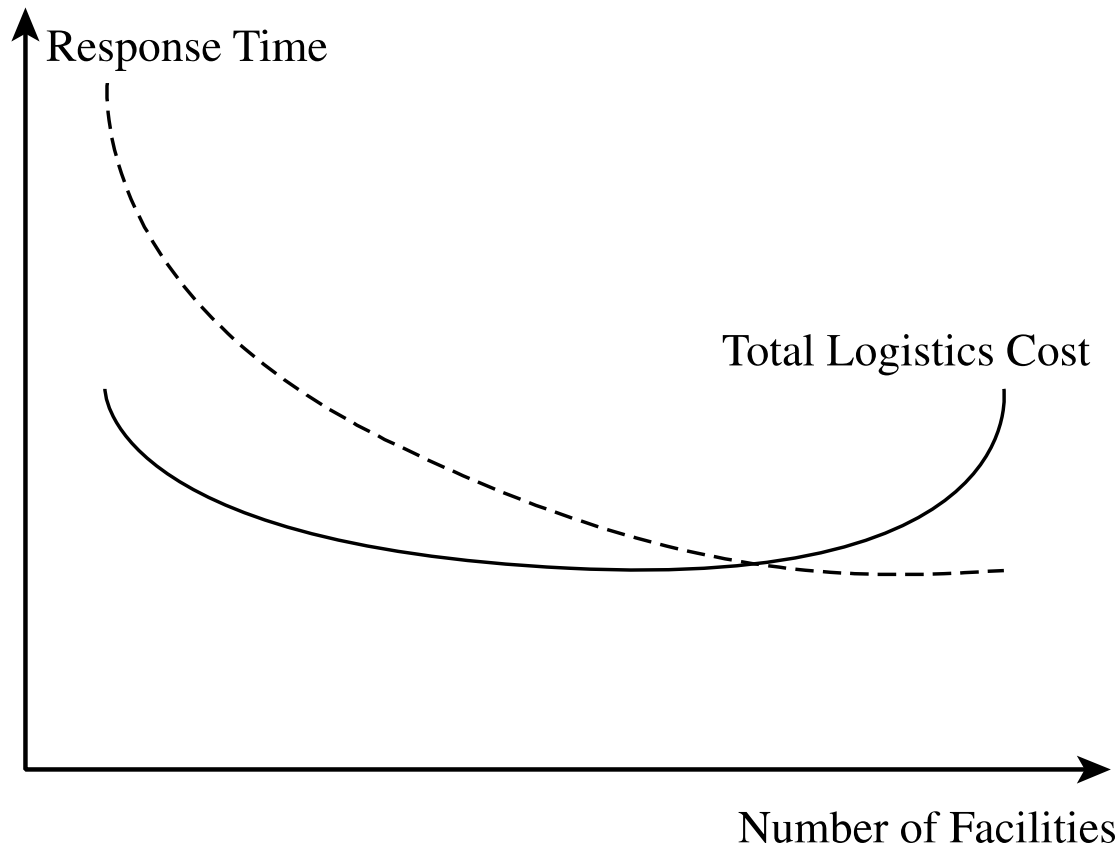


Figure 4-5

Number of Facilities

Design Options for a Distribution Network

- Distribution network choices from the manufacturer to the end consumer.
- Two key decisions:
 1. Will product be delivered to the customer location or picked up from a prearranged site?
 2. Will product flow through an intermediary (or intermediate location)?

Design Options for a Distribution Network

- One of six designs may be used:
 1. Manufacturer storage with direct shipping
 2. Manufacturer storage with direct shipping and in-transit merge
 3. Distributor storage with carrier delivery
 4. Distributor storage with last-mile delivery
 5. Manufacturer/distributor storage with customer pickup
 6. Retail storage with customer pickup

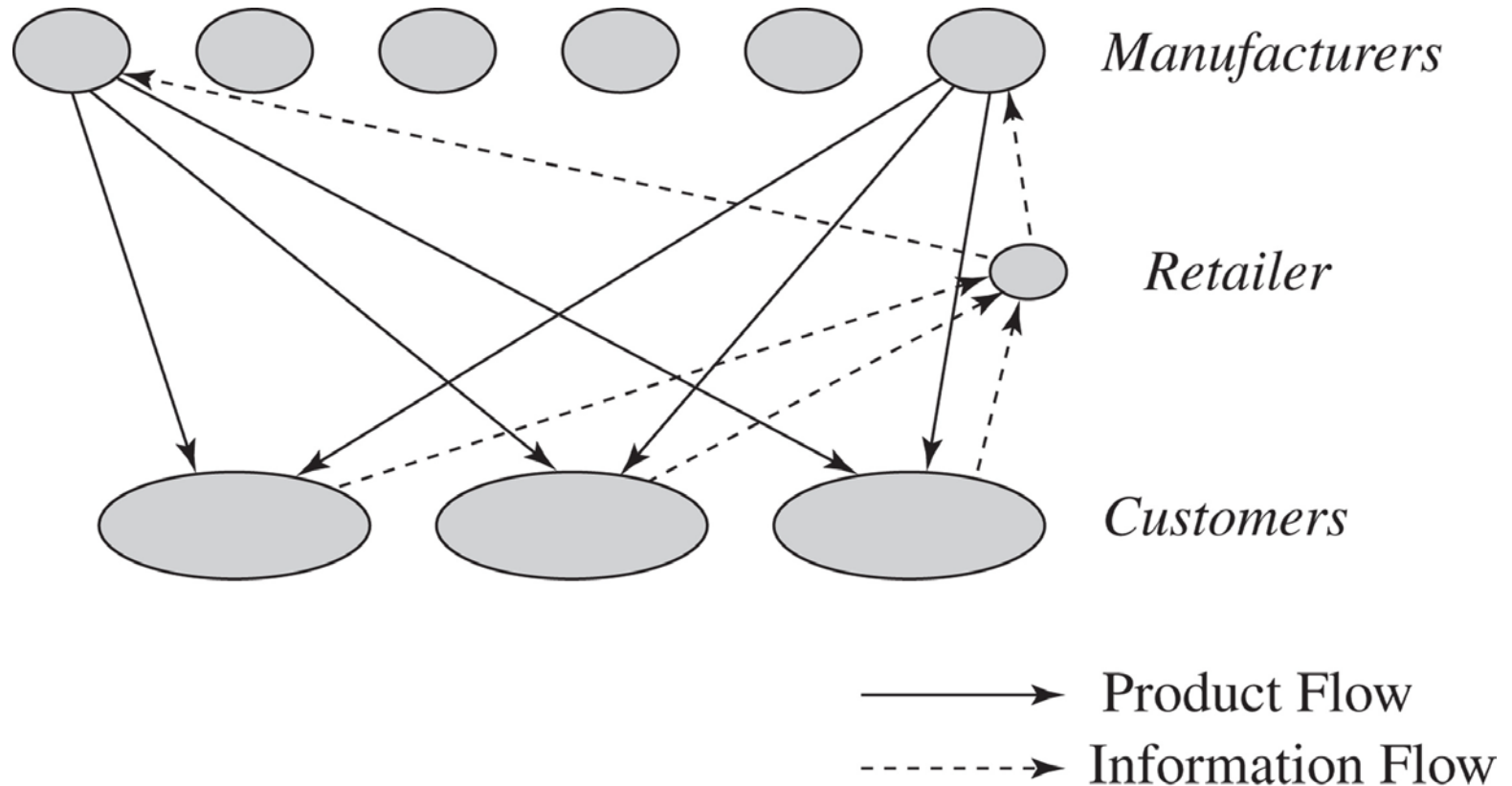
Manufacturer Storage with Direct Shipping

- In this option, product is shipped directly from the manufacturer to the end customer, bypassing the retailer (who takes the order and initiates the delivery request). This option is also referred to as **drop shipping**.

Manufacturer Storage with Direct Shipping

- Online retailers such as e-bags and Nordstrom.com use drop shipping to deliver goods to the end consumer. e-bags does not hold any inventory of bags and has them drop shipped directly from the manufacturer to the customer.

Manufacturer Storage with Direct Shipping



Manufacturer Storage with Direct Shipping

- The biggest advantage of drop shipping is the ability to centralize inventories at the manufacturer.
- A manufacturer can aggregate demand and provide a high level of product availability with lower levels of inventory than individual retailers.
- The benefits from centralization are highest for **high value, low volume items** with unpredictable demand.
- The decision of Nordstrom to drop-ship low volume shoes satisfies these criteria.

Manufacturer Storage with Direct Shipping

- Also, bags sold by e-bags tend to have **high value and low relatively volume** per SKU.
- The inventory benefits of aggregation are small for items with predictable demand and low value. Thus, drop shipping would not offer a significant inventory advantage to an online grocer selling a staple item like detergent.

Manufacturer Storage with Direct Shipping

- **Transportation costs** are high with drop shipping because the average outbound distance to the end consumer is large and package carriers must be used to ship the product.
- **Package carriers** have high shipping costs per unit compared to truckload(TL) or less-than-truckload (LTL) carriers.
- **With drop shipping**, a customer order with items from several manufacturers will involve multiple shipments to the customer. This loss in aggregation in outbound transportation further increases cost.

Manufacturer Storage with Direct Shipping

- Supply chains save on the **fixed cost** of storage facilities when using drop shipping because all inventories are centralized at the manufacturer.
- There can be some **savings of handling costs** as well because the transfer from manufacturer to retailer no longer occurs.
- **Handling costs** can be significantly reduced if the manufacturer has the capability to ship orders directly from the production line.

Manufacturer Storage with Direct Shipping

- A good **information infrastructure** is needed so that the retailer can provide product availability information to the customer even though the inventory is located at the manufacturer.
- The customer should also have visibility into **order processing** at the manufacturer even though the order is placed with the retailer.
- Drop shipping will generally require significant investment in the **information infrastructure**. The information infrastructure requirement is somewhat simpler for direct sellers like Dell because two stages (retailer and manufacturer) do not need to be integrated.

Manufacturer Storage with Direct Shipping Network

Cost Factor	Performance
Inventory	Lower costs because of aggregation. Benefits of aggregation are highest for low-demand, high-value items. Benefits are large if product customization can be postponed at the manufacturer.
Transportation	Higher transportation costs because of increased distance and disaggregate shipping.
Facilities and handling	Lower facility costs because of aggregation. Some saving on handling costs if manufacturer can manage small shipments or ship from production line.
Information	Significant investment in information infrastructure to integrate manufacturer and retailer.

Manufacturer Storage with Direct Shipping Network

Service Factor	Performance
Response time	Long response time of one to two weeks because of increased distance and two stages for order processing. Response time may vary by product, thus complicating receiving.
Product variety	Easy to provide a high level of variety.
Product availability	Easy to provide a high level of product availability because of aggregation at manufacturer.
Customer experience	Good in terms of home delivery but can suffer if order from several manufacturers is sent as partial shipments.
Time to market	Fast, with the product available as soon as the first unit is produced.
Order visibility	More difficult but also more important from a customer service perspective.
Returnability	Expensive and difficult to implement.

In-Transit Merge

Cost Factor	Performance
Inventory	Similar to drop-shipping.
Transportation	Somewhat lower transportation costs than drop-shipping.
Facilities and handling	Handling costs higher than drop-shipping at carrier; receiving costs lower at customer.
Information	Investment is somewhat higher than for drop-shipping.

In-Transit Merge

Service Factor	Performance
Response time	Similar to drop-shipping; may be marginally higher.
Product variety	Similar to drop-shipping.
Product availability	Similar to drop-shipping.
Customer experience	Better than drop-shipping because only a single delivery has to be received.
Time to market	Similar to drop-shipping.
Order visibility	Similar to drop-shipping.
Returnability	Similar to drop-shipping.

Manufacturer Storage with Direct Shipping & In-Transit Merge

- Under this option, inventory is not held by manufacturers at the factories but is held by distributors / retailers in intermediate warehouses and package carriers are used to transport products from the intermediate location to the final customer.
- Information and product flows when using distributor storage with delivery by a package carrier.

Distributor Storage with Carrier Delivery

Cost Factor	Performance
Inventory	Higher than manufacturer storage. Difference is not large for faster moving items but can be large for very slow-moving items.
Transportation	Lower than manufacturer storage. Reduction is highest for faster moving items.
Facilities and handling	Somewhat higher than manufacturer storage. The difference can be large for very slow-moving items.
Information	Simpler infrastructure compared to manufacturer storage.

Distributor Storage with Carrier Delivery

Service Factor	Performance
Response time	Faster than manufacturer storage.
Product variety	Lower than manufacturer storage.
Product availability	Higher cost to provide the same level of availability as manufacturer storage.
Customer experience	Better than manufacturer storage with drop-shipping.
Time to market	Higher than manufacturer storage.
Order visibility	Easier than manufacturer storage.
Returnability	Easier than manufacturer storage.

Distributor Storage with Last Mile Delivery

Cost Factor	Performance
Inventory	Higher than distributor storage with package carrier delivery.
Transportation	Very high cost given minimal scale economies. Higher than any other distribution option.
Facilities and handling	Facility costs higher than manufacturer storage or distributor storage with package carrier delivery, but lower than a chain of retail stores.
Information	Similar to distributor storage with package carrier delivery.

Distributor Storage with Last Mile Delivery

Service Factor	Performance
Response time	Very quick. Same day to next-day delivery.
Product variety	Somewhat less than distributor storage with package carrier delivery but larger than retail stores.
Product availability	More expensive to provide availability than any other option except retail stores.
Customer experience	Very good, particularly for bulky items. Slightly higher than distributor storage with package carrier delivery.
Time to market	Less of an issue and easier to implement than manufacturer storage or distributor storage with package carrier delivery.
Order visibility	Easier to implement than other previous options.
Returnability	Harder and more expensive than a retail network.

Manufacturer or Distributor Storage with Customer Pickup

Cost Factor	Performance
Inventory	Can match any other option, depending on the location of inventory.
Transportation	Lower than the use of package carriers, especially if using an existing delivery network.
Facilities and handling	Facility costs can be high if new facilities have to be built. Costs are lower if existing facilities are used. The increase in handling cost at the pickup site can be significant.
Information	Significant investment in infrastructure required.

Manufacturer or Distributor Storage with Customer Pickup

Service Factor	Performance
Response time	Similar to package carrier delivery with manufacturer or distributor storage. Same-day delivery possible for items stored locally at pickup site.
Product variety	Similar to other manufacturer or distributor storage options.
Product availability	Similar to other manufacturer or distributor storage options.
Customer experience	Lower than other options because of the lack of home delivery. Experience is sensitive to capability of pickup location.
Time to market	Similar to manufacturer storage options.
Order visibility	Difficult but essential.
Returnability	Somewhat easier given that pickup location can handle returns.

Retail Storage with Customer Pickup

Cost Factor	Performance
Inventory	Higher than all other options.
Transportation	Lower than all other options.
Facilities and handling	Higher than other options. The increase in handling cost at the pickup site can be significant for online and phone orders.
Information	Some investment in infrastructure required for online and phone orders.

Retail Storage with Customer Pickup

Service Factor	Performance
Response time	Same-day (immediate) pickup possible for items stored locally at pickup site.
Product variety	Lower than all other options.
Product availability	More expensive to provide than all other options.
Customer experience	Related to whether shopping is viewed as a positive or negative experience by customer.
Time to market	Highest among distribution options.
Order visibility	Trivial for in-store orders. Difficult, but essential, for online and phone orders.
Returnability	Easier than other options because retail store can provide a substitute.

Comparative Performance of Delivery Network Designs

	Retail Storage with Customer Pickup	Manufacturer Storage with Direct Shipping	Manufacturer Storage with In-Transit Merge	Distributor Storage with Package Carrier Delivery	Distributor Storage with Last-Mile Delivery	Manufacturer Storage with Pickup
Response time	1	4	4	3	2	4
Product variety	4	1	1	2	3	1
Product availability	4	1	1	2	3	1
Customer experience	Varies from 1 to 5	4	3	2	1	5
Time to market	4	1	1	2	3	1
Order visibility	1	5	4	3	2	6
Returnability	1	5	5	4	3	2
Inventory	4	1	1	2	3	1
Transportation	1	4	3	2	5	1
Facility and handling	6	1	2	3	4	5
Information	1	4	4	3	2	5

Key: 1 corresponds to the strongest performance and 6 the weakest performance.

Delivery Networks for Different Product/ Customer Characteristics

	Retail Storage with Customer Pickup	Manufacturer Storage with Direct Shipping	Manufacturer Storage with In-Transit Merge	Distributor Storage with Package Carrier Delivery	Distributor Storage with Last-Mile Delivery	Manufacturer Storage with Pickup
High-demand product	+2	−2	−1	0	+1	−1
Medium-demand product	+1	−1	0	+1	0	0
Low-demand product	−1	+1	0	+1	−1	+1
Very low-demand product	−2	+2	+1	0	−2	+1
Many product sources	+1	−1	−1	+2	+1	0
High product value	−1	+2	+1	+1	0	+2
Quick desired response	+2	−2	−2	−1	+1	−2
High product variety	−1	+2	0	+1	0	+2
Low customer effort	−2	+1	+2	+2	+2	−1

Key: +2 = very suitable; +1 = somewhat suitable; 0 = neutral; −1 = somewhat unsuitable; −2 = very unsuitable.

Distribution Networks in Practice

1. The ownership structure of the distribution network can have as big an impact as the type of distribution network.
2. It is important to have adaptable distribution networks.
3. Product price, commoditization, and criticality affect the type of distribution system preferred by customers.
4. Integrate the Internet with the existing physical network.

Learning Objectives

1. Understand the role of network design in a supply chain.
2. Identify factors influencing supply chain network design decisions.
3. Develop a framework for making network design decisions.
4. Use optimization for facility location and capacity allocation decisions.
5. Effect of IT /IS on SCM Network Design
6. Practical Issues

Network Design Decisions

- Searches for answers for Facility Role, Facility location, Capacity allocation, Market and supply allocation, Strategic factors, Technological factors, Macroeconomic factors, Political, Infrastructure factors, Competitive factors, Customer response time and local presence and Logistics / facility costs **in a supply chain.**

Network Design Decisions

- Supply Chain Network Design
Decisions include the assignment of Facility role, location of manufacturing, storage or transportation related facilities and the allocation of capacity and markets to each facility.

Network Design Decisions

Classification

- Facility role
 - What role should each facility play?,
 - What processes are to be performed at each facility?
- Facility location
 - Where should facilities be located?
- Capacity allocation
 - How much capacity should be allocated at each facility?
- Market and supply allocation
 - What markets should each facility serve?
 - Which supply sources should feed each facility?

Network Design Decisions :Significance and Impact

- Network Design decisions have a significant impact on performance because they determine the supply chain configuration and set constraints within which other supply chain drivers can be used either to decrease supply chain cost or increase responsiveness.

Facility role : Significance and Impact

- Decisions concerning the role of each facility are significant because they determine the amount of flexibility the supply chain has in changing way it meets the demand.

Facility Location: Significance and Impact

- Facility location decisions have a strong and long term impact on the performance of supply chain because it is strategically expensive to shutdown a facility or move it to a different location.
- A good location decision should keep the costs down with reasonable high responsiveness.

Facility Location: Significance and Impact

- In contrast a poorly located facility makes it very difficult for a supply chain to perform close to the efficient frontier.

Capacity allocation : Significance and Impact

- Capacity Allocation decisions also have significant impact on supply chain performance.
- Capacity allocation can be easily altered as compared to location, capacity allocation tends to stay stable for years.
- Allocating too much capacity would lead to poor utilization and idle inventory as a result higher costs. Allocating too little capacity would lead to poor responsiveness and if demand is filled from distant facility than higher costs.

Conclusion: Significance and Impact

- Network design decisions must be revisited as a firm grows or when two companies merge.
- As redundancies and differences in markets served by either of the two separate firms consolidation some facilities and changing the location and role of others can help reduce cost and improve responsiveness.

Possible strategic roles

Kasra Ferdows suggests possible strategic roles for various facilities in a global supply chain network.

1. Off shore Facility: Low cost facility for export production.
2. Source Facility: Low cost facility for global production.
3. Server Facility: Regional Production Facility.

Possible strategic roles

4. Contributor Facility: Regional production facility with development skills.
5. Output Facility: Regional production facility built to gain local skills.
6. Lead Facility: Facility that leads in development and process technologies.

Factors Influencing Network Design Decisions

1. Strategic factors
2. Tactical & Operational factors
3. Technological factors
4. Macroeconomic factors
 - Tariffs and tax incentives
 - Exchange-rate and demand risk
 - Freight and fuel costs
5. Political

Factors Influencing Network Design Decisions

6. Infrastructure factors

7. Competitive factors

- Positive externalities between firms
- Locating to split the market

8. Customer response time and local presence

9. Logistics and facility costs

1. Strategic Factors

- A firm's competitive strategy has a significant impact on network design with in supply chain e.g.
 - Apparel and manufacturing to china, Zara has apparel facility in Portugal and Spain to provide quick response.
- Convenience stores aim to provide easy access to customers as a part of competitive strategy.

1.Strategic Factors

- Firms focusing on cost leadership (Efficiency) tend to find the lowest cost location for their manufacturing facilities, even if that means locating very far from the markets they serve.
- Firms focusing on responsiveness (Agility) tend to locate facilities closer to the market and may select a high-cost location if this choice allows the firm to quickly react to changing market needs.

1.Strategic Factors

- Global Supply Chain networks can best support their strategic objectives with facilities in different countries playing different roles.e.g.
 - Nike has mass production facilities in china and indonesia and innovative-high responsiveness and high priced facilities in korea and taiwan.
- Kira Ferdows suggests possible strategic roles for various facilities in a global supply chain network.

2. Operational & Tactical

- Market Advertisement and Progressive campaign
- Market Reach
- Product Type
- Network Size
- Transportation Costs
- Seasonal effects

3. Technological Factors

- If production technology displays significant economies of scale, a few high-capacity locations are the most effective.
- In contrast, if facilities have lower fixed costs, many local facilities are preferred because this helps lower transportation costs.

4. Macro Economic Factors

- **Macroeconomic Factors.** *Macroeconomic factors* include:
 - Taxes, tariffs, exchange rates, and other economic factors that are not internal to an individual firm.
 - If a country has very high tariffs, companies either do not serve the local market or set up manufacturing plants within the country to save on duties.
- High tariffs lead to more production locations within a supply chain network, with each location having a lower allocated capacity.

5. Political Factors

- Companies prefer to locate facilities in politically stable countries where the rules of commerce are well defined.
- Countries with independent and clear legal systems allow firms to feel that they have recourse in the courts should they need it.
- This makes it easier for companies to invest in facilities in these countries. Political stability is hard to quantify, so a firm makes an essentially subjective evaluation when designing its supply chain network.

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6. Infrastructure Factors

- The availability of good infrastructure is an important prerequisite to locating a facility in a given area.
- Poor infrastructure adds to the cost of doing business from a given location.
- Key infrastructure elements to be considered during network design include availability of sites, labor availability, proximity to transportation terminals, rail service, proximity to airports and seaports, highway access, congestion, and local utilities.

7. Competitive Factors

- Companies must consider competitors' strategy, size, and location when designing their supply chain networks.
- A fundamental decision firms make is whether to locate their facilities close to competitors or far from them.
- How the firms compete and whether external factors such as raw material or labor availability force them to locate close to each other influence this decision.

Competitive Factors

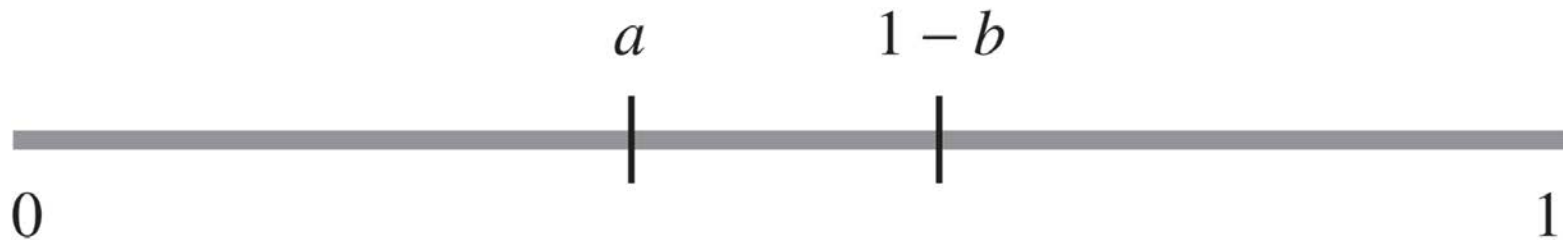
- Positive externalities between firms:
 - Collocation benefits all as it increases demand and benefits all the players like the mechanics workshops along the highways.
 - Convenience stores, apparel outlets in the city.
 - What positive externalities you can think of in the Pakistani Context with respect to Global Supply Chains or any local SC?
 - Suzuki developed Supply Chain of Vendors in Pakistan followed by other automobile manufacturers.

Competitive Factors

- In the absence of Positive externalities between firms, firms opt to capture the largest share of the market.
 - Collocation benefits all
- Locating close to each other to split the market , market segment is between line 0 and 1, customer closest to the firm and the equidistant customer is split evenly between the two firms.
 - Locate to capture largest market share

Competitive Factors

Figure 5-1



- Locating to split the market
 - Locate to capture largest market share.
 - If total demand is 1, Firm 1 locates at point a , Firm 2 locates at point b , the demand at the two firms, d_1 and d_2 is given by:

$$d_1 = a + \frac{1 - b - a}{2} \quad \text{and} \quad d_2 = \frac{1 + b - a}{2}$$

8. Customer Response Time & Local Presence

- Firms that target customers who value a short response time must locate close to them.
- If a firm is delivering its product to customers, use of a rapid means of transportation allows it to build fewer facilities and still provide a short response time.
- This option, however, increases transportation costs. Moreover, there are many situations where the presence of a facility close to a customer is important.

9. Logistics and Facility Costs.

- **Logistics and facility costs incurred within a supply chain change as the number of facilities, their location, and capacity allocation is changed.**
- **Companies must consider inventory, transportation, and facility costs when designing their supply chain networks. Inventory and facility costs increase as the number of facilities in a supply chain increase.**
- **Transportation costs decrease as the number of facilities is increased.**

9. Logistics and Facility Costs.

- Increasing the number of facilities to a point where inbound economies of scale are lost increases transportation cost.
- The supply chain network design is also influenced by the transformation / Operation occurring at each facility.
- When there is a significant reduction in material weight or volume as a result of processing, it may be better to locate facilities closer to the supply source rather than the customer.

9. Logistics and Facility Costs.

- Total logistics costs are a sum of the inventory, transportation, and facility costs.
- The facilities in a supply chain network must at least equal the number that minimizes total logistics costs.
- A firm may increase the number of facilities beyond this point to improve the response time to its customers.
- This decision is justified if the revenue increase from improved response outweighs the increased cost from additional facilities.

Framework for Network Design Decisions

- **The four phases in the framework for network design decisions:**
 - **Phase I: Define a Supply Chain Strategy/Design**
 - **Phase II: Define the Regional Facility Configuration**
 - **Phase III: Select Desirable Sites**
 - **Phase IV: Location Choices**

Phase I: Define a Supply Chain Strategy

- The objective of the first phase of network design is to define a firm's supply chain strategy.
- The supply chain strategy specifies what capabilities the supply chain network must have to support a firm's competitive strategy.
- Phase I starts with a clear definition of the firm's competitive strategy as the set of customer needs that the supply chain aims to satisfy.

Phase I: Define a Supply Chain Strategy

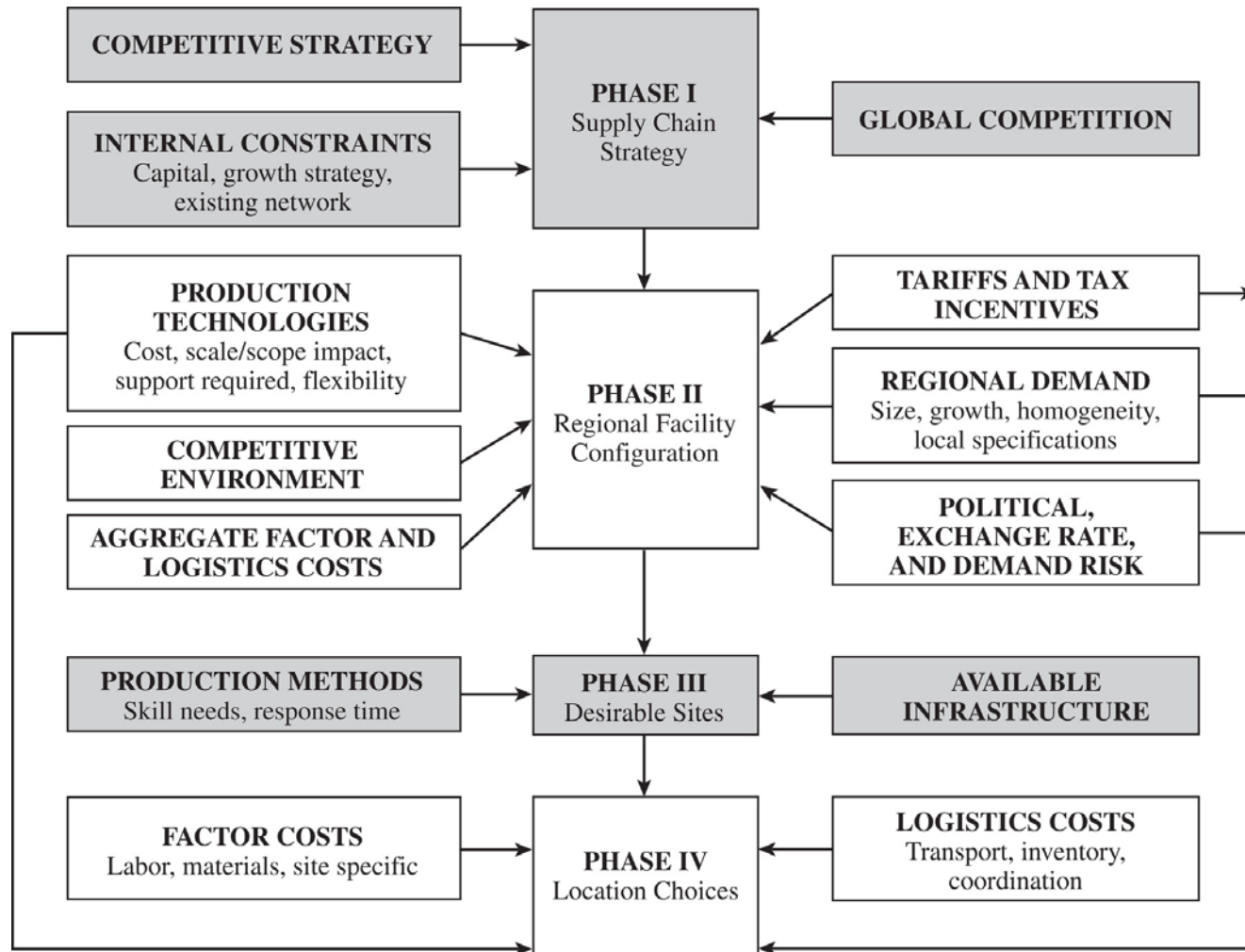
- Based on the competitive strategy of the firm, an analysis of the competition, any economies of scale or scope, and any constraints, managers must determine the supply chain strategy for the firm.

Framework for Network Design Decisions

- **Phase I: Define a Supply Chain Strategy/Design**
 - Clear definition of the firm's competitive strategy
 - **Forecast the likely evolution of global competition**
 - Identify constraints on available capital
 - **Determine growth strategy**

Framework for Network Design Decisions

Figure 5-2



Phase II: Define the Regional Facility Configuration

- The objective of the second phase of network design is to identify regions where facilities will be located, their potential roles, and their approximate capacity. An analysis of Phase II is started with a forecast of the demand by country.
- Such a forecast must include a measure of the size of the demand as well as a determination of whether the customer requirements are homogenous or variable across different countries.

Phase II: Define the Regional Facility Configuration

- The next step is for managers to identify whether economies of scale or scope can play a significant role in reducing costs given available production technologies.
- Next, managers must identify demand risk, exchange rate risk, and political risk associated with different regional markets.
- They must also identify regional tariffs, any requirements for local production, tax incentives, and any export or import restrictions for each market.

Phase II: Define the Regional Facility Configuration

- The next step is for managers to identify whether economies of scale or scope can play a significant role in reducing costs given available production technologies.
- Next, managers must identify demand risk, exchange rate risk, and political risk associated with different regional markets.
- They must also identify regional tariffs, any requirements for local production, tax incentives, and any export or import restrictions for each market.

Phase II: Define the Regional Facility Configuration

- The regional configuration defines the approximate number of facilities in the network, regions where facilities will be set up, and whether a facility will produce all products for a given market or a few products for all markets in the network.

Framework for Network Design Decisions

- **Phase II: Define the Regional Facility Configuration**
 - Forecast of the demand by country or region.
 - Economies of scale or scope.
 - Identify demand risk, exchange-rate risk, political risk, tariffs, requirements for local production, tax incentives, and export or import restrictions.
 - Identify competitors.

Phase III: Select a Set of Desirable Potential Sites

- The objective of Phase III is to select a set of desirable sites within each region where facilities are to be located.
- The set of desirable sites should be larger than the desired number of facilities to be set up so that a precise selection may be made in Phase IV.
- Sites should be selected based on an analysis of infrastructure availability to support the desired production methodologies.

Phase III: Select a Set of Desirable Potential Sites

- *Hard infrastructure requirements* include the availability of suppliers, transportation services, communication, utilities, and warehousing infrastructure.
- *Soft infrastructure requirements* include the availability of skilled workforce, workforce turnover, and the community's receptivity to business and industry.
- In Pakistani context what do you see which is your strength? Or we have balance between hard and soft infrastructure?

Phase IV: Location Choices

- The objective of this phase is to select a precise location and capacity allocation for each facility.
- Attention is restricted to the desirable sites selected in Phase III.
- The network is designed to maximize total profits, taking into account the expected margin and demand in each market, various logistics and facility costs, and the taxes and tariffs at each location.

Models for Facility Location and Capacity Allocation

- The aim of the SC Manager should be to Maximize the overall profitability of the supply chain network while providing customers with the appropriate responsiveness.
- Revenues comes from the sale of the product, where as costs arise from facilities, labor, transportation, material and inventory.

Models for Facility Location and Capacity Allocation

- The profits of the firm are also affected by taxes and tariffs. IDEALLY, PROFITS after TAX should be maximized when designing a Supply Chain Networks.
- Many trade-offs during network design e.g, building many facilities to serve local markets reduces transportation costs and provides a faster response time , but increases the facility and inventory costs.

Network Design Models

- Managers use network design models in two different situations.
- First, these models are used to decide on locations where facilities will be established and the capacity to be assigned to each facility.
- Managers must make this decision considering a time horizon over which locations and capacities will not be altered (typically in years).

Network Design Models

- Second, these models are used to assign current demand to the available facilities and identify lanes along which product will be transported.
- Managers must consider this decision at least on an annual basis as demand, prices, and tariffs change.
- In both cases, the goal is to maximize the profit while satisfying customer needs.

Models for Facility Location and Capacity Allocation

- Network design models used to decide on locations and capacities and to assign current demand to facilities.

Models for Facility Location and Capacity Allocation

- Important information required and should be available for making design decision
 1. Location of supply sources and markets
 2. Location of potential facility sites
 3. Demand forecast by market
 4. Facility, labor, and material costs by site
 5. Transportation costs between each pair of sites
 6. Inventory costs by site and as a function of quantity
 7. Sale price of product in different regions
 8. Taxes and tariffs
 9. Desired response time and other service factors

Models for Facility Location and Capacity Allocation

- Given the above 9 important information factors either GRAVITY MODELS or NETWORK OPTIMIZATION MODELS MAY BE USED TO DESIGN THE NETWORK.
- WE DESIGN THE MODELS ACCORDING TO THE PHASE OF THE NETWORK DESIGN FRAMEWORK AT WHICH EACH MODEL IS LIKELY TO BE USEFUL.

Models for Facility Location and Capacity Allocation

- ***Installing the Solver add-in***
- To follow the exercises from this part of the presentation, you will need to use the “Solver” add-in for Microsoft.
- Excel. When installed, it appears in the “Analysis” toolbar under the “Data” tab.

Uncertainty

- ◆ **Uncertainty** is a term used in subtly different ways in a number of fields, including physics, philosophy, statistics, economics, finance, insurance, psychology, sociology, engineering, and information science.
- ◆ It applies to predictions of future events, to physical measurements already made, or to the unknown.

Uncertainty Concepts

1. Although the terms are used in various ways among the general public, many specialists in decision theory, statistics and other quantitative fields have defined uncertainty, risk, and their measurement as:
 1. **Uncertainty:** The lack of certainty, A state of having limited knowledge where it is impossible to exactly describe the existing state, a future outcome, or more than one possible outcome.
 2. **Measurement of Uncertainty:** A set of possible states or outcomes where probabilities are assigned to each possible state or outcome – this also includes the application of a probability density function to continuous variables.

Uncertainty Concepts

4. **Risk:** A state of uncertainty where some possible outcomes have an undesired effect or significant loss.
 - Pure Risk : negative outcome
5. **Business risks** implies uncertainty in profits or danger of loss and the events that could pose a risk due to some unforeseen events in future, which causes business to fail.
 - Business risks can be classified by the influence by two major risks: **internal risks** & **external risks**.

◆ As the title indicates, you would be taking into account :

1. globalization
2. international trade, commerce
3. exchange rates
4. strategic planning and financial planning along with Impact of Globalization on Supply Chain Networks
5. The Off-shoring Decision: Total Cost

Discounted Cash Flow Analysis

$$\text{Discount factor} = \frac{1}{1+k}$$

$$NPV = C_0 + \sum_{t=1}^T \left(\frac{1}{1+k} \right)^t C_t$$

where

$C_0, C_1, \dots, C_T$ is a stream of cash flows over T periods

NPV = the net present value of this stream of cash flows

k = rate of return

- Compare NPV of different supply chain design options
- The option with the highest NPV will provide the greatest financial return

NPV Example: Naimatkada Logistics

- ◆ How much space to lease in the next three years for Demand = 100,000 units.
 - ◆ Requires 1,000 sq. ft. of space for every 1,000 units of demand or 1 unit of demand needs 1 sq, ft, of space
 - ◆ Revenue = Rs14 per unit of demand
 - ◆ Decision is whether to sign a three-year lease or obtain warehousing space on the spot market
 - ◆ Three-year lease: cost = Rs.10 per sq. ft.
 - ◆ Spot market: cost = Rs12 per sq. ft.
- $k = 0.1 = 10\%$

NPV Example: Trips Logistics

For leasing warehouse space on the **spot** market:

Expected annual profit = Revenue-Cost

$$= 100,000 \times \text{Rs}14 - 100,000 \times \text{Rs}12 = \text{Rs}200,000$$

Cash flow = Rs.200,000 in each of the next three years

$$\begin{aligned} NPV(\text{no lease}) &= C_0 + \frac{C_1}{1+k} + \frac{C_2}{(1+k)^2} \\ &= 200,000 + \frac{200,000}{1.1} + \frac{200,000}{1.1^2} = \text{Rs.}547,107.4 = \text{Rs.}547,107 \end{aligned}$$

NPV Example: Naimatkada Logistics

For leasing warehouse space with a three-year lease:

Expected annual profit = $100,000 \times \text{Rs}14 - 100,000 \times \text{Rs} 10 = \text{Rs}.400,000$.

Cash flow = \$200,000 in each of the next three years.

$$\begin{aligned} NPV(\text{no lease}) &= C_0 + \frac{C_1}{1+k} + \frac{C_2}{(1+k)^2} \\ &= 400,000 + \frac{400,000}{1.1} + \frac{400,000}{1.1^2} = \text{Rs}.10,94,215 \end{aligned}$$

The NPV of signing the lease is $\text{Rs} 10,94,215 - \text{Rs}547,107 = \text{Rs} \text{Rs}.547,108$ higher; therefore, the manager decides to sign the lease.

However, uncertainty in demand and costs may prompt the manager to rethink his decision.

Representations of Uncertainty

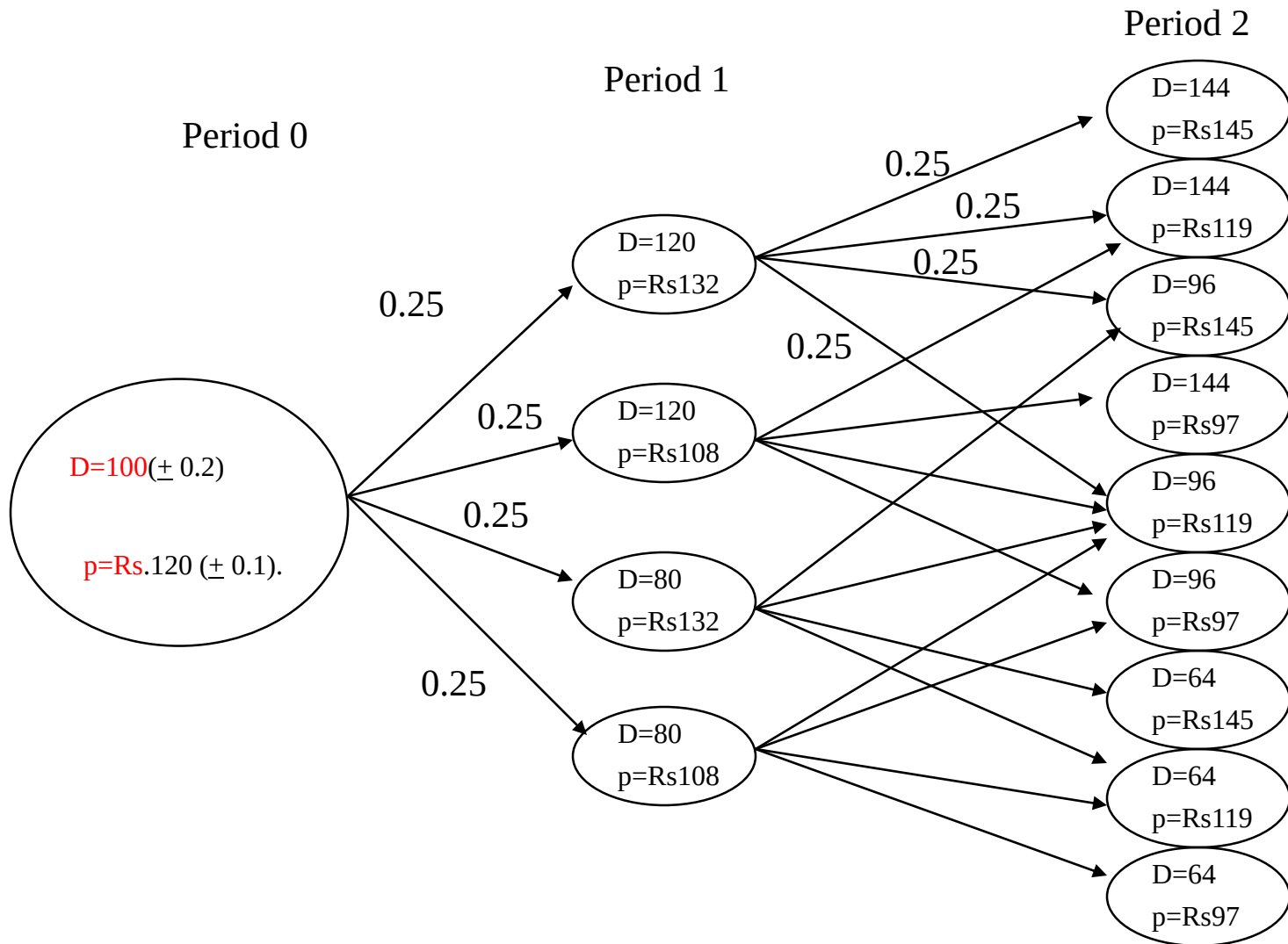
- ◆ A set of possible states or outcomes where probabilities are assigned to each possible state or outcome – this also includes the application of a probability density function to continuous variables.
- ◆ Probability: Theory from which we consider the Binomial Representation of Uncertainty.
 - Additive
 - Multiplicative
- ◆ Other Representations of Uncertainty
 - Classical Set Theory, Fuzzy set theory, Fuzzy measure theory, Rough Set theory

Binomial Representations of Uncertainty

- ◆ When moving from one period to the next, the value of the underlying factor (e.g., demand or price) has only two possible outcomes – up “u” or down “d”.
- ◆ The underlying factor moves up by a factor $u > 1$ with probability p , or down by a factor $d < 1$ with probability $1-p$.
- ◆ Assuming a price P in period 0, for the multiplicative binomial, the possible outcomes for the next four periods:
 - Period 1: Pu , Pd
 - Period 2: Pu^2 , Pud , Pd^2
 - Period 3: Pu^3 , Pu^2d , Pud^2 , Pd^3
 - Period 4: Pu^4 , Pu^3d , Pu^2d^2 , Pud^3 , Pd^4

Binomial Representations of Uncertainty

- ◆ In general, for multiplicative binomial, period T has all possible outcomes $Pu^t d^{(T-t)}$, for $t = 0, 1, \dots, T$.
- ◆ From state $Pu^a d^{(T-a)}$ in period t , the price may move in period $t+1$ to either:
 - $Pu^{a+1} d^{(T-a)}$ with probability p , or
 - $Pu^a d^{(T-a)+1}$ with probability $(1-p)$



Binomial Representations of Uncertainty

- ◆ For the additive binomial, the states in the following periods are:
 - Period 1: $P+u, P-d$
 - Period 2: $P+2u, P+u-d, P-2d$
 - Period 3: $P+3u, P+2u-d, P+u-2d, P-3d$
 - Period 4: $P+4u, P+3u-d, P+2u-2d, P+u-3d, P-4d$
- ◆ For mathematically inclined, in general for the additive binomial, **period T has all possible outcomes $P+tu-(T-t)d$, for $t=0, 1, \dots, T$**

-
- ◆ The degree of demand and price uncertainty has a significant influence on the appropriate portfolio of long- and short-term warehousing space that a firm should carry.
 - ◆ If price and demand vary over time in a global network, flexible production capacity can be reconfigured to maximize profits in the new environment.
 - ◆ In reality, demand and prices are highly uncertain and are likely to fluctuate during the life of any supply chain decision.
 - ◆ The multiplicative binomial cannot take on negative values and can be used for factors like demand, price, and exchange rates that cannot become negative.

-
- ◆ If uncertainty is ignored, a manager will always sign long-term contracts because they are typically cheaper and avoid all flexible capacity because it is more expensive.
 - ◆ Decision trees with DCFs can be used to evaluate supply chain design decisions given uncertainty in prices, demand, exchange rates, and inflation.
 - ◆ In a complex decision tree, there are thousands of possible paths that may result from the first period to the last.
 - ◆ Simulation models require a higher setup cost to start and operate compared to decision tree tools.

Evaluating Network Design Decisions Using Decision Trees

- ◆ A manager must make many different decisions when designing a supply chain network.
- ◆ Many of them involve a choice between a long-term (or less flexible) option and a short-term (or more flexible) option.
- ◆ If uncertainty is ignored, the long-term option will almost always be selected because it is typically cheaper.
- ◆ Such a decision can eventually hurt the firm, however, because actual future prices or demand may be different from what was forecasted at the time of the decision.
- ◆ **A decision tree is a graphic device that can be used to evaluate decisions under uncertainty.**

Decision Tree Methodology

1. Identify the duration of each period (month, quarter, etc.) and the number of periods T over the which the decision is to be evaluated.
2. Identify factors such as demand, price, and exchange rate, whose fluctuation will be considered over the next T periods.
3. Identify representations of uncertainty for each factor; that is, determine what distribution to use to model the uncertainty.
4. Identify the periodic discount rate k for each period.
5. Represent the decision tree with defined states in each period, as well as the transition probabilities between states in successive periods.
6. Starting at period T , work back to period 0, identifying the optimal decision and the expected cash flows at each step. Expected cash flows at each state in a given period should be discounted back when included in the previous period.

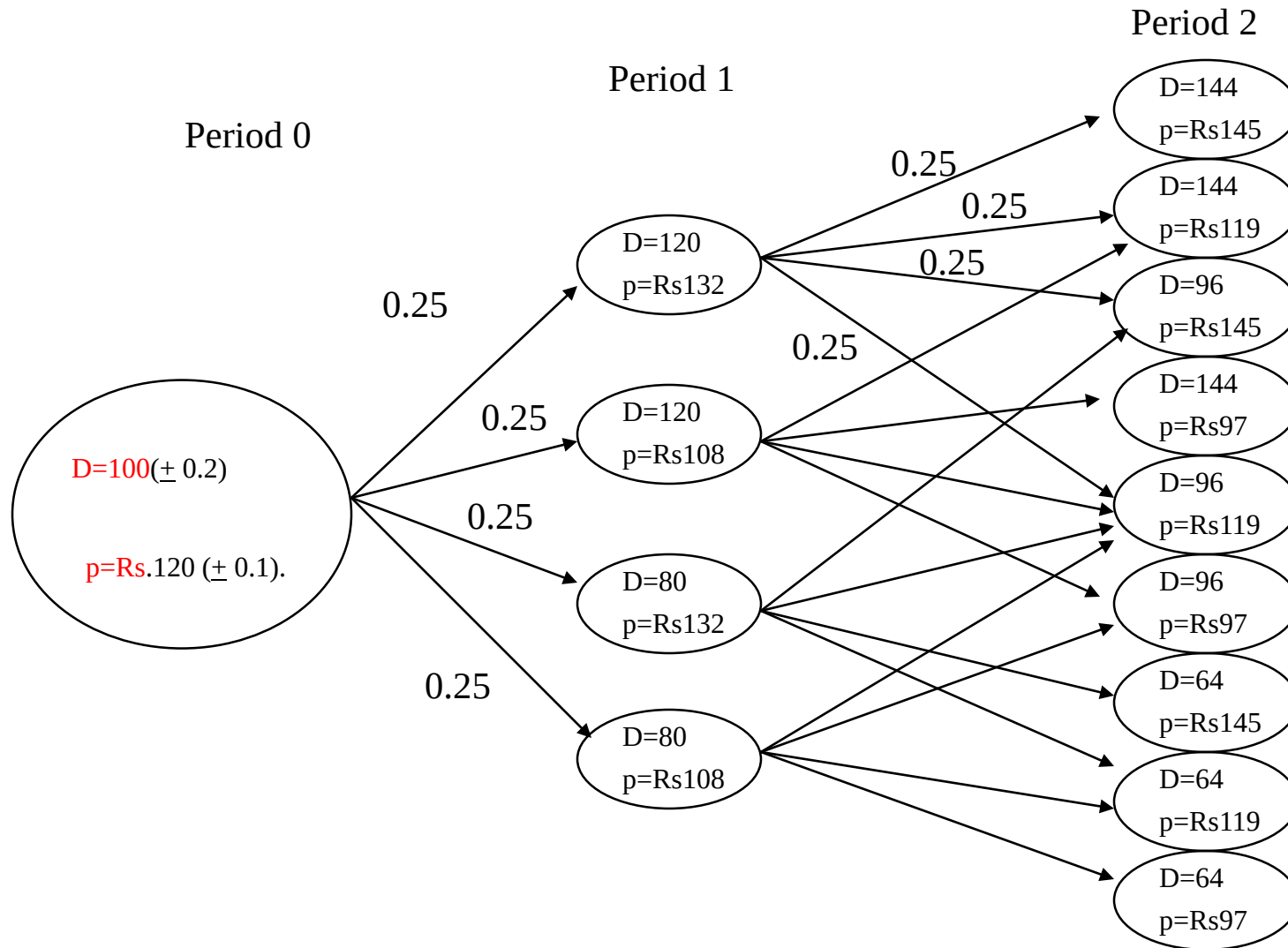
Decision Tree Methodology: Subakraftar Rasad Logistics

- ◆ Decide whether to lease warehouse space for the coming three years and the quantity to lease.
- ◆ Long-term lease is currently cheaper than the spot market rate.
- ◆ The manager anticipates uncertainty in demand and spot prices over the next three years.
- ◆ Long-term lease is cheaper but could go unused if demand is lower than forecast; future spot market rates could also decrease.
- ◆ Spot market rates are currently high, and the spot market would cost a lot if future demand is higher than expected.

Subakraftar Rasad Logistics: Three Options

1. Get all warehousing space from the spot market as needed.
2. Sign a three-year lease for a fixed amount of warehouse space and get additional requirements from the spot market.
3. Sign a flexible lease with a minimum change that allows variable usage of warehouse space up to a limit with additional requirement from the spot market.

Subakraftar Logistics Decision Tree (Fig. 6.2) : SPOT PRICE



Subakraftar Rasad Logistics Example

Node	Revenue	Cost	Profit
D=144,p=145	Rs.1,75,68,000	$144,000 \times 145 = 2,08,80,000$	Rs.-33,12,000
D=144,p=119	Rs.1,75,68,000	$144,000 \times 119 = 1,71,36,000$	Rs.432,000
D=144,p=97	Rs.1,75,68,000		Rs.36,00,000
D=96, p=145	Rs. 1,17,12,000		Rs.22,08,000
D=96,p=119	Rs. 1,17,12,000		
D=96,p=97	Rs. 1,17,12,000		
D=64,p=145	Rs.78,08,000		
D=64,p=119	Rs.78,08,000		
D=64,p=97	Rs.78,08,000		

Evaluating Flexibility Using Decision Trees

- ◆ Decision tree methodology can be used to evaluate flexibility within the supply chain
- ◆ Suppose the manager at **Subakraftar Rasad** Logistics has been offered a contract where, for an upfront payment of Rs.10,00,000, the company will have the flexibility of using between 60,000 sq. ft. and 100,000 sq. ft. of warehouse space at Rs100 per sq. ft. per year. Trips must pay Rs60,00,000 for the first 60,000 sq. ft. and can then use up to 40,000 sq. ft. on demand at Rs100 per sq. ft. as needed.
- ◆ Using the same approach as before, the expected profit of this option is Rs.56,72,500 (DO NOT READ FIGS)
- ◆ The value of flexibility is the difference between the expected present value of the flexible option and the expected present value of the inflexible options
- ◆ The three options are listed in Table 6.7, where the flexible option has an expected present value Rs.836,100 greater than the inflexible lease option (including the upfront Rs.10,00,000 payment)

PakBangla Road Vehicle: Evaluation of Supply Chain Design Decisions Under Uncertainty

- ◆ Dedicated Capacity of 1,000 in the **Pakistan** and 500 in **Bangladesh**
 - Period 2 Evaluation
 - Period 1 Evaluation
 - Period 0 Evaluation
- ◆ Flexible Capacity of 1,000 in the **Pakistan** and 500 in **Bangladesh**
 - Period 2 Evaluation
 - Period 1 Evaluation
 - Period 0 Evaluation

Evaluating Facility Investments: Road Vehicles

Plant	Dedicated Plant		Flexible Plant	
	Fixed Cost	Variable Cost	Fixed Cost	Variable Cost
PK 100,000	Rs 10 million/yr.	Rs 1500 / tire	Rs100 million / year	Rs 150 / tire
BD 50,000	4 million Takas / year	1200 takas / tire	40 million takas / year	120 takas / tire

PK. Expected Demand = 100,000;

BD Expected Demand = 50,000

1 BD TK = 1.25 PK RS

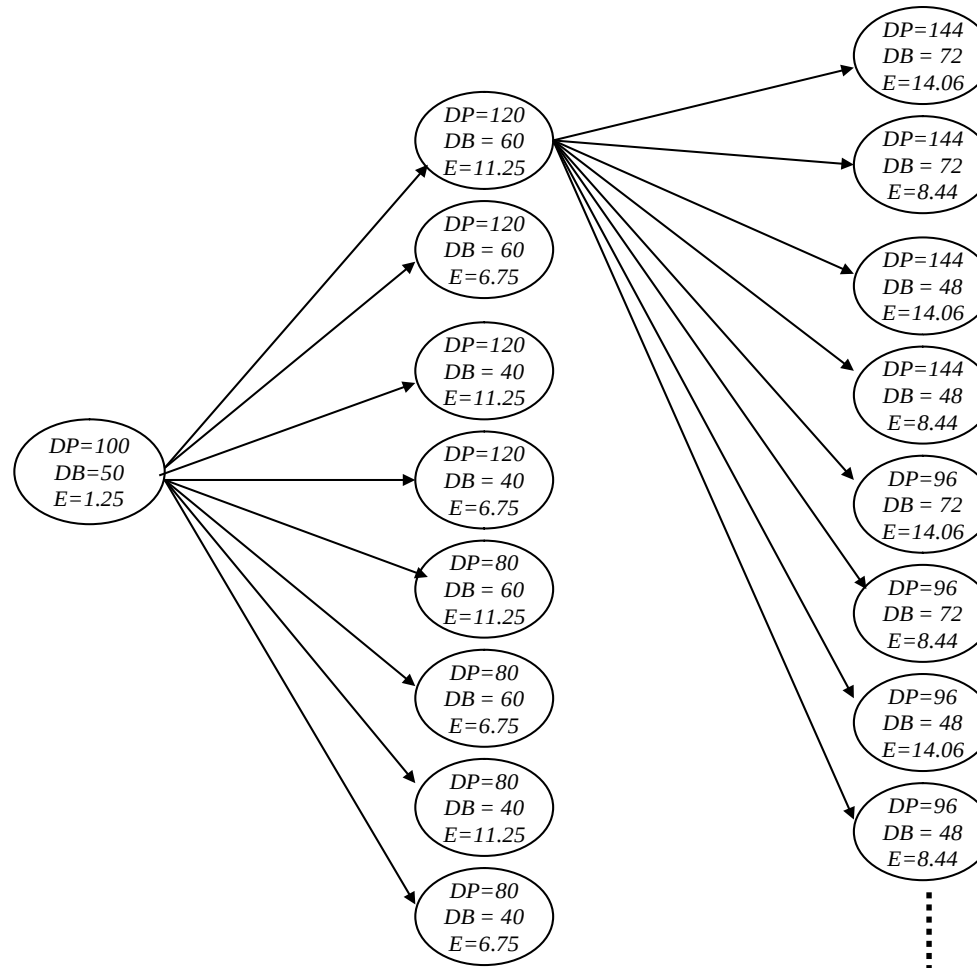
Demand goes up or down by 20 percent with probability 0.5 and exchange rate goes up or down by 25 per cent with probability 0.5.

Road Vehicles

Period 0

Period 1

Period 2



Making Global Supply Chain Design Decisions Under Uncertainty in Practice

1. Combine strategic planning and financial planning during global network design.
2. Use multiple metrics to evaluate global supply chain networks.
3. Use financial analysis as an input to decision making, not as the decision-making process.
4. Use estimates along with sensitivity analysis.

Learning Objectives

1. Understand the role of forecasting for both an enterprise and a supply chain.
2. Identify the components of a demand forecast.
3. Forecast demand in a supply chain given historical demand data using time-series methodologies.
4. Analyze demand forecasts to estimate forecast error.

Role of Forecasting in a Supply Chain

- The basis for all planning decisions in a supply chain
- Used for both push and pull processes
 - Production scheduling, inventory, aggregate planning
 - Sales force allocation, promotions, new production introduction
 - Plant/equipment investment, budgetary planning
 - Workforce planning, hiring, layoffs
- All of these decisions are interrelated

Characteristics of Forecasts

1. Forecasts are always inaccurate and should thus include both the expected value of the forecast and a measure of forecast error.
2. Long-term forecasts are usually less accurate than short-term forecasts.
3. Aggregate forecasts are usually more accurate than disaggregate forecasts.
4. In general, the farther up the supply chain a company is, the greater is the distortion of information it receives.

Components and Methods

1. Qualitative

- Primarily subjective
- Rely on judgment

2. Time Series

- Use historical demand only
- Best with stable demand

3. Causal

- Relationship between demand and some other factor

4. Simulation

- Imitate consumer choices that give rise to demand

Components of an Observation

Observed demand (O) = systematic component (S)
+ random component (R)

- Systematic component – expected value of demand
 - **Level** (current deseasonalized demand)
 - **Trend** (growth or decline in demand)
 - **Seasonality** (predictable seasonal fluctuation)
- Random component – part of forecast that deviates from systematic component
- Forecast error – difference between forecast and actual demand

Basic Approach to Effective Forecasting

The following basic, six-step approach helps an organization perform effective forecasting:

- **1.** Understand the objective of forecasting.
- **2.** Integrate demand planning and forecasting throughout the supply chain.
- **3.** Understand and identify customer segments.
- **4.** Identify the major factors that influence the demand forecast.
- **5.** Determine the appropriate forecasting technique.
- **6.** Establish performance and error measures for the forecast.

Time-Series Forecasting Methods

- Three ways to calculate the systematic component:

- ***Multiplicative***

$$S = \text{level} \times \text{trend} \times \text{seasonal factor}$$

- ***Additive***

$$S = \text{level} + \text{trend} + \text{seasonal factor}$$

- ***Mixed***

$$S = (\text{level} + \text{trend}) \times \text{seasonal factor}$$

Static Methods

Systematic component = (level + trend) × seasonal factor

$$F_{t+l} = [L + (t + l)T]S_{t+l}$$

where

- L = estimate of level at $t = 0$
- T = estimate of trend
- S_t = estimate of seasonal factor for Period t
- D_t = actual demand observed in Period t
- F_t = forecast of demand for Period t

Estimate Level and Trend

Periodicity $p = 4$, $t = 3$

$$\bar{D}_t = \begin{cases} \left[D_{t-(p/2)} + D_{t+(p/2)} + \sum_{i=t+1-(p/2)}^{t-1+(p/2)} 2D_i \right] / (2p) & \text{for } p \text{ even} \\ \sum_{i=t-[(p-1)/2]}^{t+[(p-1)/2]} D_i / p & \text{for } p \text{ odd} \end{cases}$$

$$\begin{aligned} \bar{D}_t &= \left[D_{t-(p/2)} + D_{t+(p/2)} + \sum_{i=t+1-(p/2)}^{t-1+(p/2)} 2D_i \right] / (2p) \\ &= D_1 + D_5 + \sum_{i=2}^4 2D_i / 8 \end{aligned}$$

Estimating Seasonal Factors

$$S_i = \frac{\sum_{j=0}^{r-1} \bar{S}_{jp+1}}{r}$$

Adaptive Forecasting

- The estimates of level, trend, and seasonality are adjusted after each demand observation.
- Estimates incorporate all new data that are observed.

Adaptive Forecasting

$$F_{t+1} = (L_t + lT_t)S_{t+1}$$

where

L_t = estimate of level at the end of Period t

T_t = estimate of trend at the end of Period t

S_t = estimate of seasonal factor for Period t

F_t = forecast of demand for Period t (made Period $t - 1$ or earlier)

D_t = actual demand observed in Period t

$E_t = F_t - D_t$ = forecast error in Period t

Steps in Adaptive Forecasting

- Initialize
 - Compute initial estimates of level (L_0), trend (T_0), and seasonal factors ($S_1, \dots, S_p$)
- Forecast
 - Forecast demand for period $t + 1$
- Estimate error
 - Compute error $E_{t+1} = F_{t+1} - D_{t+1}$
- Modify estimates
 - Modify the estimates of level (L_{t+1}), trend (T_{t+1}), and seasonal factor (S_{t+p+1}), given the error E_{t+1}

Moving Average

- Used when demand has no observable trend or seasonality.

Systematic component of demand = level

Time Series Models

Forecasting Method	Applicability
Moving average	No trend or seasonality
Simple exponential smoothing	No trend or seasonality
Holt's model	Trend but no seasonality
Winter's model	Trend and seasonality

Selecting the Best Smoothing Constant

	A	B	C	D	E	F	G	H
1	Period t	Demand D_t	Level L_t	Forecast F_t	Error E_t	Squared Error	Absolute Error A_t	% Error
2	0		2017.9					
3	1	2024	2021.2	2017.9	-6.1	37	6.1	0.3%
4	2	2076	2050.8	2021.2	-54.8	3003	54.8	2.6%
5	3	1992	2019.0	2050.8	58.8	3463	58.8	3.0%
6	4	2075	2049.3	2019.0	-56.0	3135	56.0	2.7%
7	5	2070	2060.5	2049.3	-20.7	429	20.7	1.0%
8	6	2046	2052.7	2060.5	14.5	210	14.5	0.7%
9	7	2027	2038.8	2052.7	25.7	658	25.7	1.3%
10	8	1972	2002.7	2038.8	66.8	4459	66.8	3.4%
11	9	1912	1953.6	2002.7	90.7	8218	90.7	4.7%
12	10	1985	1970.6	1953.6	-31.4	985	31.4	1.6%
13		2017.9			87	2,460	42.5	2.1%
14	$\alpha =$	0.54						

Solver Parameters

Set Target Cell:

Equal To: ☐ Max ☒ Min ☐ Value of:

By Changing Cells:

Subject to the Constraints:

Buttons: Solve, Close, Options, Add, Change, Delete, Reset All, Help

Figure 7-5

Forecasting Demand at Tahoe Salt

- Moving average
- Simple exponential smoothing
- Trend-corrected exponential smoothing
- Trend- and seasonality-corrected exponential smoothing

Learning Objectives

1. Understand the role of forecasting for both an enterprise and a supply chain.
2. Identify the components of a demand forecast.
3. Forecast demand in a supply chain given historical demand data using time-series methodologies.
4. Analyze demand forecasts to estimate forecast error.

Aggregate Planning (AP)

- 1. Understand the Role of Aggregate Planning in Supply Chain.**
2. Understand the importance of aggregate planning as a supply chain activity.
- 3. Describe the information needed to produce an AP (**Aggregate Plan Problem**).**
4. Explain the basic trade-offs to consider when creating an aggregate plan (**AP Strategies**).
- 5. Formulate and solve basic aggregate planning problems using Microsoft Excel.**

Learning Objectives 1

1. Identify the decisions that are best solved by aggregate planning.

Role of Aggregate Planning in a Supply Chain

- Capacity has a cost and lead times are often long.
- So a company needs to decide about :
 - Capacity levels, production levels, outsourcing and promotions well before demand is known.
 - Anticipate demand and Determine how to meet this demand.
 - Invest in a plant with large capacity for peak demand.
or
 - Invest in a plant with small capacity with large inventory warehouses to continue production in low demand.
- These types of questions are answered by
Aggregate planning.

Role of Aggregate Planning in a Supply Chain

- Aggregate planning:
 - Is a process by which a company determines **ideal** levels of capacity, production, subcontracting, inventory, stock-outs, and pricing over a specified time horizon.
 - Goal is to maximize profit, while fulfilling demand.
 - Decisions made at an aggregate or a product family (not SKU) level for example an AP in an automobile plant would determine the total production level in plant the total number of autos not the units of individual SKU (**STOCK KEEPING UNIT**).
 - How can a firm best use the facilities it has?

Role of Aggregate Planning in a Supply Chain

- Aggregate planning:
 - Traditionally AP was limited to the ENTERPRISE.
 - Currently AP includes Supply Chain Management.
 - It requires inputs from entire Supply Chain and the results impact the entire Supply Chain.
 - Collaborative Demand Forecasts forms one of the most important inputs for AP.
 - Constraints of the Upstream Supply Chain Partners the suppliers directly impact the Supply Chain.
 - Has a direct influence and consequence on production plans and helps to plan supply and demand in a Supply Chain.

Role of Aggregate Planning in a Supply Chain

- The AP 's main objectives is to specify operational parameters over the time horizon.
 - Production rate: The number of units to be completed per unit time (such as per week per month).
 - Workforce: The number of workers/units of capacity needed for production.
 - Overtime: amount of over production planned.
 - Machine capacity level: the number of units of machine capacity needed for production.

Role of Aggregate Planning in a Supply Chain

- The AP 's main objectives is to specify operational parameters over the time horizon.
 - 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.
- AP serves as a broad blueprint for operations and establishes the parameters within which short term production & distribution decisions are made.

Role of Aggregate Planning in a Supply Chain

- The AP allows the Supply Chain to alter capacity allocations and change supply contracts.
 - Ideally whole Supply Chain Process should be coordinated with the planning process.
 - If a manufacturer has planned to increase in production over a given period of time then the supplier, transporter and warehouse must be informed about this plan so as to update their own plans.
 - Ideally, all stages of the Supply Chain should work together on an aggregate plan.
 - If all stages plan independently then supply chain results in shortages and oversupply in the supply chain.

Module 2: The Aggregate Planning Problem

- The objective of the AP is to satisfy demand in a way that maximizes the profit for the firm. We can formally state the 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.
- **To create an aggregate plan a company must specify the planning horizon for the plan.**

Mod 2: The Aggregate Planning Problem

- Specify the planning horizon (typically 3-18 months).
- Specify the duration of each period.
- Specify key information required to develop an aggregate plan.
- In general, aggregate planning takes place over months or quarters.
- The company specifies key required information to produce an aggregate plan.

Information Needed for an Aggregate Plan

An aggregate **planner** requires the following:

- Aggregate demand forecast F_t for each Period t over T periods
- Production costs:
 - Labor costs, regular time (Rs./hr) and overtime (Rs./hr)
 - Subcontracting costs (Rs./hr or Rs./unit)
 - Cost of changing capacity – hiring or layoff (Rs./worker), adding or reducing machine capacity (Rs./machine)
- Labor/machine hours required per unit
- Inventory holding cost (Rs./unit/period)
- Stock out or backlog cost (Rs./unit/period)
- Constraints – overtime, layoffs, capital available, stockouts, backlogs, from suppliers

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 customer service levels.
- Backlog/stockout quantity: Used to determine customer service levels.
- Machine capacity increase/decrease: Used to determine if new production equipment should be purchased or idled.

Outputs of Aggregate Plan

- The quality of an AP has a significant impact on the profitability of a firm.
- A poor aggregate plan can result in lost sales and lost profits if the available inventory and capacity are unable to meet demand.
- A poor aggregate plan can result in lost sales, lost profits, excess inventory, or excess capacity there by raising costs.
- Therefore, AP is a very important tool in helping a Supply Chain maximize profitability.

Module 3: Aggregate Planning Strategies

- Trade-off between capacity, inventory, backlog/lost sales.
- 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.
- Tailored or hybrid strategy – a combination of strategies.

Chase Strategy

1. Vary machine capacity or hire and lay off workers as demand varies.
2. Often difficult to vary capacity and workforce on short notice.
3. Expensive if cost of varying capacity is high.
4. Negative effect on workforce morale.
5. Results in low levels of inventory.
6. Used when inventory holding costs are high and costs of changing capacity are low.

Time Flexibility Strategy

1. Use excess machine capacity.
2. Workforce stable, number of hours worked varies.
3. Use overtime or a flexible work schedule.
4. Flexible workforce, avoids morale problems.
5. Low levels of inventory, lower utilization.
6. Used when inventory holding costs are high and capacity is relatively inexpensive.

Level Strategy

1. Stable machine capacity and workforce levels, constant output rate.
2. Inventory levels fluctuate over time.
3. Inventories carried over from high to low demand periods.
4. Better for worker morale.
5. Large inventories and backlogs may accumulate.
6. Used when inventory holding and backlog costs are relatively low.

Lecture 27

1. Aggregate Planning Using Linear Programming
2. Aggregate Planning in Excel
3. Role of IT in Aggregate Planning
4. Implementing Aggregate Planning in Practice
5. Summary of Learning Objectives & Modules

Module 4. Aggregate Planning Using Linear Programming

- ABCXYZ COOLERS
 - Highly seasonal demand
 - Develop a forecast

Month	Demand Forecast
January	1,600
February	3,000
March	3,200
April	3,800
May	2,200
June	2,200