**Operations and Supply Chain Management**
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## Lecture - 35
## Introduction to Supply Chain Management

In this lecture, we formally define Supply Chain Management, introduce the various concepts, and discuss relevant issues in supply chain management. What we have seen so far in the earlier 34 lectures are principles and concepts in operations management. Essentially, things related to what happens within an organization, even though there were instances, where we have seen models, were multiple organizations or the role of multiple organizations, where captured. Now, we define supply chain management, and also try to position what we have seen in the previous lectures, in the overall context of supply chain management.

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We have already seen the slide in an earlier lecture. Let us quickly recap the importance of this slide, now this slide talks about the requirements of manufacturing. Let me read it, make an increasing variety of products, on shorter lead times with smaller runs and flawless quality, improve return on investment by automating and introducing new technology in process and materials so, that price can be reduced to meet local and foreign competition, mechanize keep schedules flexible, keep inventories low, keep

capital cost minimum, and keep the work force contended. This is a definition given by skinner in 1985. If we look at this definition very carefully, there is a role for manufacturing, there is a role to increase the variety of products, there is a need to produce them in very short lead times.

There is also a need to automate and bringing new technology in materials, to meet competition, and there is a requirement to keep the schedules flexible, and to keep the work force contended. So, most of these relate to principles and requirements of manufacturing, but there is also a role or different organizations or multiple organizations, with whom the manufacturing firm interacts to make these variety of products.

So, in order to be successful in the business, it is important to meet these requirements of manufacturing, and also do this with the partners, who are suppliers who are customers and who are other stake holders. So, that the overall performance of the organization, as well as its partners is made better, and this chain of interaction between the organization which makes these products, as well as the suppliers and customers is broadly the supply chain that we are talking about.

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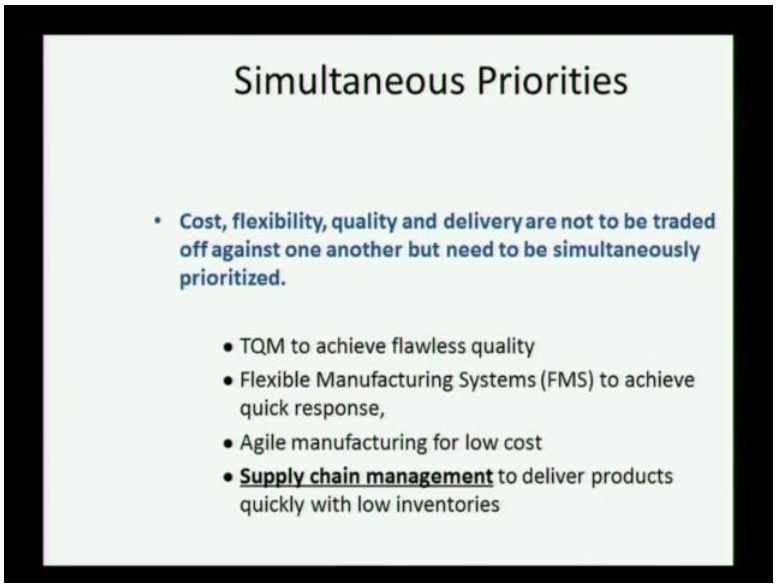


Researchers and practitioners have been talking about the requirements of manufacturing from the context of meeting customer expectation, from the context of reducing the cost of production, and the context of maximizing the profit. If required some time and over a

period of time, several methodologies have evolved to meet the requirements of manufacturing, four important aspects and concepts quality delivery and flexibility.

And it is also important to understand that these are not to be traded off against one another, but to be simultaneously prioritized, which means that like if an organization focuses on cost cutting, it cannot do it at the expensive reduced flexibility or reduced quality. One has to keep the other three at the same level and try and increase the four or try and increase all of them to the extent possible, but make sure that the performance with respect to any of these parameters does not come down, because more effort and emphasis is placed on one of them.

Broadly, let us look at some methodologies that have evolved in order to address these metrics or performance indicators of manufacturing or of a business. Total quality management evolved to achieve flawless quality, and to motivate people within the organization towards producing quality goods and services, as well as to maintain the overall quality in the organization. So, one of the metrics is quality and total quality management evolved as a methodology to meet the requirements of quality. Flexible manufacturing systems evolved to achieve quick response and flexibility.

Agile manufacturing, lean manufacturing and the forms of just in time manufacturing also look at minimizing the waste, so that the total cost of manufacturing is reduced. And supply chain management evolved over a period of time to deliver products, quickly and maintain low inventories. So, in some sense if an organization would be practicing or would be concentrating on all the four methodologies, that we talk about TQM, FMS, Agile, Lean manufacturing, and Supply Chain Management, so that cost flexibility quality and delivery are simultaneously achieved.

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Now, let us move to formal definition of supply chain. Several definitions for supply chain exist, one of them we are going to concentrate on, and this definition is as follows. Supply chain is a network of facilities and distribution options that performs the function of procurement of materials, transformation of these materials into intermediate and finished products and distribution of these finished products to the customers.

So, let me repeat it again, it is a network of facilities and distribution options that performs three tasks. One is procurement, second is manufacturing or transformation of these materials into products, and third is distribution, which is to deliver the manufactured products to the ultimate or end customer. This is the definition given by Lee and Billington, and is widely used in text books and in other research material.

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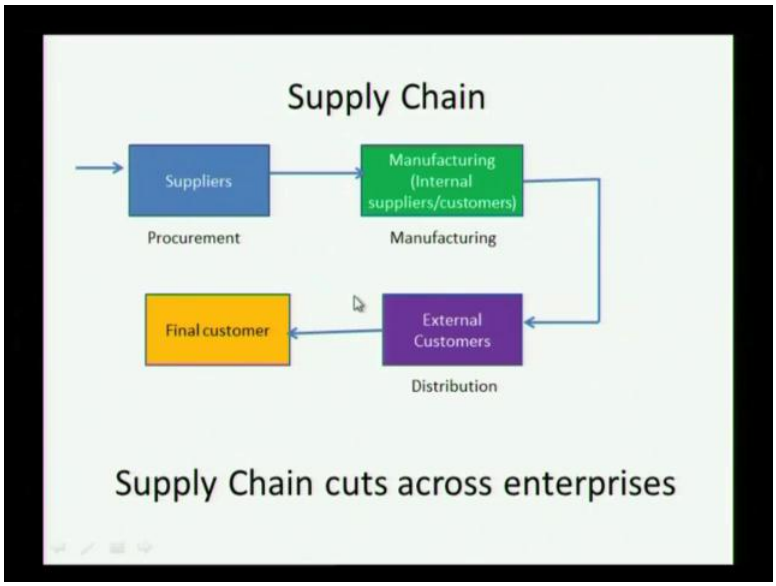


Now, we will quickly see who are the players in the supply chain. So one could think of 3 different or 4 different types of players in the supply chain. Now, there are a set of suppliers, which is shown first here, and then there is the manufacturing or the organization, which is central which is making the product that we are talking about. And then the produced goods are sent to customers through a channel, so it could be a distribution channel and from there it goes to the final customer. We could actually combine both these into a single thing called customer or distribution.

So, to fit in with the earlier definition of procurement, transformation of the products into manufactured goods, and to customers who are there. Now, the manufacturing that we show here, we also have written that the manufacturing has internal suppliers and customers. The transformation of the purchased item or products into manufactured products takes place in stages. And if we look at these stages we would realize that each stage acts as an internal supplier - customer within the overall manufacturing, which is shown in as internal suppliers and customers.

And then it moves to external customers, so from external suppliers, it moves to the internal suppliers and customers, and then it moves to the external customers and then it reaches the final customer. Now, we also see here the supply chain cuts across enterprises; there are lots of organizations many organizations who come under these suppliers. Even though, we have shown this as a single chain which just connects 3 or 4

entities, when we say suppliers here we mean a whole lot of suppliers that supply items to this manufacturing organization, so if we talk of a supply chain with respect to a single manufacturing organization.

Now, there is one organization here, there are many organizations here who are the suppliers, and there are many organizations here who may the final customers, and there would be few who would be in the distribution channel. So, if we are very specific with respect to this manufacturing organization, then you will have several nodes here as suppliers, who will be sending items to this.

And from here it will move towards several external customers, it will move this way to many people who are here, and then it will move this way to that. One can also observe that if we look at a overall supply chain, where these set of supplier may even be producing to more than one in this and so on; but ordinarily when we look at supply chain management, from the context of an organization, then we assume that there is a single organization here .

We have also seen that within this manufacturing, there are several stages where each stage will act as a supplier and customer to the next stage, as well as the previous stage respectively. So, supply chain cuts across enterprises, and an important thing to note here that it is not one company or organization here, it is not one distribution mechanism here or one customer here. This has several companies, several organizations that come here, and therefore supply chain is a network of suppliers, if we go back to the definition it is a network of facilities and distribution options.

Now, what are the reasons for us to look at supply chain holistically and supply chain, which is a network of organizations together and not concentrate on how an individual organization optimizes or increases the performance of the particular manufacturing unit. Now, the reason to look at supply chain holistically or as a network of these facilities and organizations are the following.

Now, the first one is shrinking product life cycles, traditionally product life cycle were longer, any product that came into the market survived in the market for a long time, but with increase in computers and electronic goods. We realize that the product life cycles are shorter, and therefore it is necessary to bring out a new products in time, to bring out new products before the existing products become obsolete or to increase product variety

by bringing in new products, which would eventually make the older products progressively obsolete.

So, product life cycles are shorter, and there is a need to bring new products quickly. Now, when there is a need to bring new products quickly, we go back to previous slide we realize that if this entity which is the manufacturing has to bring out new products quickly. Then there is a definite role for this entity which has a set of suppliers, as well as there is a role for this set of entity who are the in between the ultimate customer and manufacturer.

Now, suppliers have to be ready to supply the items that are needed for these new products quickly, which means they will have to integrate and coordinate with the manufacturer. And once these manufactured products are ready for dispatch or to be sent to the customer, now the distribution channels have to be ready to do it quickly. So, there is the need to bring these various organizations together, and collectively plan and execute this activity, so that the profits for all of them are increased and maximized.

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In a similar manner, we also have shrinking time window for delivery, today once the order is placed the customer expectation is that the delivery will be quick. So, organizations cannot take additional time to deliver, and therefore have to produce things faster which also necessitates the same amount of thinking, where we have to interact with the suppliers, as well as the customers.

Non shrinking lead times, one would also observe that even though a technology through a flexible manufacturing and automation, brings down the time to manufacture a product, the rate at which manufacturing times or processing times reduce is not as high as the rate in which product life cycles change. So, we call this as non shrinking lead times, while we have shrinking time window for delivery. The rate of shrinkage here is much faster or higher than the shrinkage here, which means that one needs to take care of these aspects as well and make decisions holistically.

Also, there is ever increasing product variety which brings in newer people here, and which also brings in newer set of customers here. So, it is not that this set of people, who are in the suppliers is a finite set of suppliers it also keeps changing as the product volume and variety increases. Similarly the set of final customers here also changes as the product volume and variety increases. And therefore, there is a need to integrate all these into a single entity called the supply chain, and do the planning and coordination together.

So, that the overall profits of the chain or the overall profits of all the members of the chain increases and the performance gets better. Now, what are the additional problems that we need to look at? First and foremost is demand uncertainty, now the once one we get into multiple products, here we realize that as the product volumes and variety increases. We have already seen in earlier lectures that today's challenge is to meet the increased volume, and variety particularly increased variety.

So, as increased as variety increases, we also observe that the demand uncertainty also increases for a given variety. When, we aggregate the variants of a given product or we when we aggregate the demands of the various varieties of a similar product, it may be possible to have a forecast error which is smaller or it may be possible to have the total demand showing less variance. But, the moment we have more products and more variety, the demand variation increases, and the uncertainty in the demand, therefore increases. Now, this has to be addressed, and this can be addressed only when organizations come closer to each other.

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Now, the order to order lead time also increases, and there is also a responsiveness squeeze which makes organizations produce, and deliver things much faster. And there is also a constant need to improve the profits as well as to increase, the cash flow within the organization. So, these are reasons for which we need organizations to come together, to do the planning and coordination together, so that the overall objective is met for all of them.

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Now, what are the areas for improvement in a supply chain, the several areas of improvement in a supply chain? Now, if we are positioning ourselves as this entity, which is manufacturing or the organization, which is going to interact with a lot of suppliers as well as with a lot of customers. The important question is how do I improve my inbound logistics? Now in order to manufacture we need to get the material from several suppliers.

Now, this process of getting the material from suppliers to the organization is called inbound logistics. Inbound because they come into the organization and logistics is the area by which we look at transportation, and other issues related to transporting items from one place to another. So, the inbound logistics have to be better, so that the right amount of bought out items are made available to manufacturing. The next question that we should ask is how will the structure of the supply chain have an impact on the overall performance?

Now, most of the times we use this serial chain which we show here, through one supplier manufacturing and then the customer, but then we have other structures. We have network structures and other structures in supply chain which will have an impact on the overall performance. Now, what are the planning tools that can bring different organizations together? Now do we use information technology to bring them together? But, to what extent and how do we do that and what are the advantages of having information technology brought in? What are the things that we can share between companies and organizations to make the planning much better?

So, these questions come when organizations talk together or work together. The same supplier may be producing to the competitor of the manufacturing organization, and how do we take care of that dimension, when we do the overall planning also. Now, are there strategies to handle product variety and short product life cycle, and how do we do it through organizations coming together is an aspect that has to be looked at when we look at supply chain management.

Now, there are three aspects we spoke about in a supply chain, the three important things are procurement - buying items from suppliers, transformation or converting these items into finished products, and distribution which is to send the finished products to the ultimate customers. So, those three aspects are now written as inbound logistics, in house

logistics, and outbound logistics, as I mentioned inbound means items that come into the organization, which means they come from the suppliers.

So, inbound logistics is handled through supplier development and supply management. How do we create new suppliers? How do we develop the suppliers or ensure that the suppliers are able to give us the right quantity of items at the right time? In house logistics is the whole gamut of operations management that we have seen through the earlier lectures. Most of what we saw in the earlier lectures have to do with how an organization handles things, which are directly within the scope of the organization. Example, we saw forecasting, we saw aggregate planning, we saw scheduling, and we saw all other aspects.

So, all these aspects, so if we now go back to the previous lectures in this course, we understand that many of the things that we have seen, so far now, deal with what comes under in house logistics or what happens within a manufacturing enterprise. So, there could be scheduling, then master scheduling, materials requirement planning, layout inventory management within the organization. So, all these come under what are called in house logistics. Outbound logistics talks about, how do I distribute or how do I send the finished goods from manufacturing, to the end customer.

So, here the aspects are warehousing and distribution management, transportation some understanding of how we can optimize the costs with respect to distribution, and transportation, we will see some aspects of this as we move along in the remaining lectures in the course. And we have seen a little bit of outbound logistics, when we have seen location models that talk about how to locate warehouses, and finally send the products through these ware houses into the final customers. We will also be seeing some more aspects of warehouse location, and other location problems in the remaining lectures in this course.

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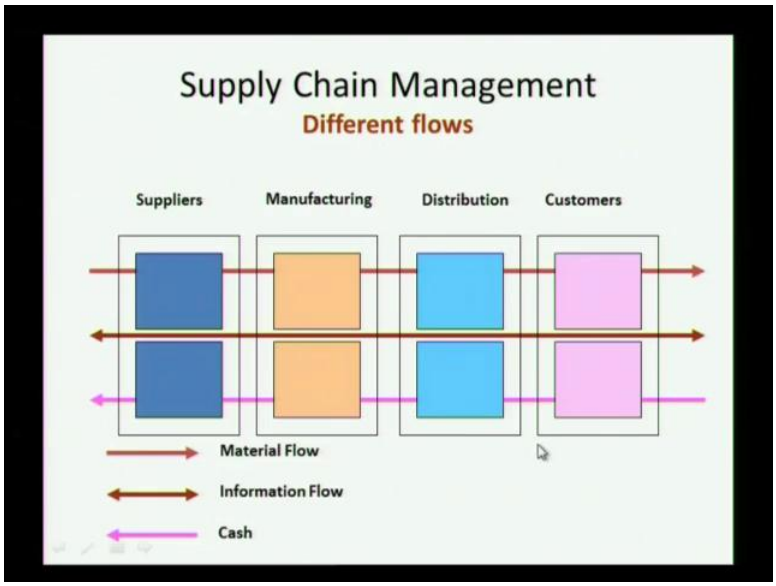


Now, this picture tells us the different layers or levels in the supply chain. You can see four of them, you can see suppliers, you can see manufacturing, you can see distribution, and you can see the final customer. So, these are four layers in the supply chain, as I also mentioned, if we are going to look at one organization or the organization, which is doing the manufacturing. There will be several suppliers, there will be few distribution channels, there could be few warehouses, and there will be many customers through which the product or products will flow.

Now, the material or product will flow from left to right, so from the suppliers to manufacturing, from manufacturing to distribution, and from distribution to the customers. Cash flow will happen in the opposite direction. The customers, who buy the product, will give cash to the distribution. Distribution would provide cash to manufacturing and manufacturing, would finally provide cash to the suppliers.

So, the cash will flow in the opposite direction compared to the material flow. Information flow which we were talking about for the first time will happen in both directions. We have already seen that the supply chain is successful or the overall business of an organization can be made better, through interacting with the suppliers and the customers, this we call as the supply chain management.

So, when the manufacturing starts interacting with the suppliers, there is a two way flow of information between the manufacturing and the suppliers. Manufacturing talks about

how much they want from the suppliers, what quantities, what items, and then the supplier talks to manufacturing by not only providing the material, which happens in this direction, but also providing information on the availability of these with the respect to the demands of the manufacturing.

So, there is a two way information flow between suppliers and manufacturing, and there is a two way information flow between manufacturing and distribution, and then between distribution and customers. So, information flows in both directions, unlike material flow and cash flow, which flow in one direction and opposite to each other. Now, the biggest challenge is while we know that we could we could get these two entities to talk to each other, supplier, manufacturing or the other two manufacturing distribution, and distribution to customer. There is information flow, how do we integrate them or bring all of them together, so that there is information flow right across the supply chain is an important challenge with respect to supply chain management.

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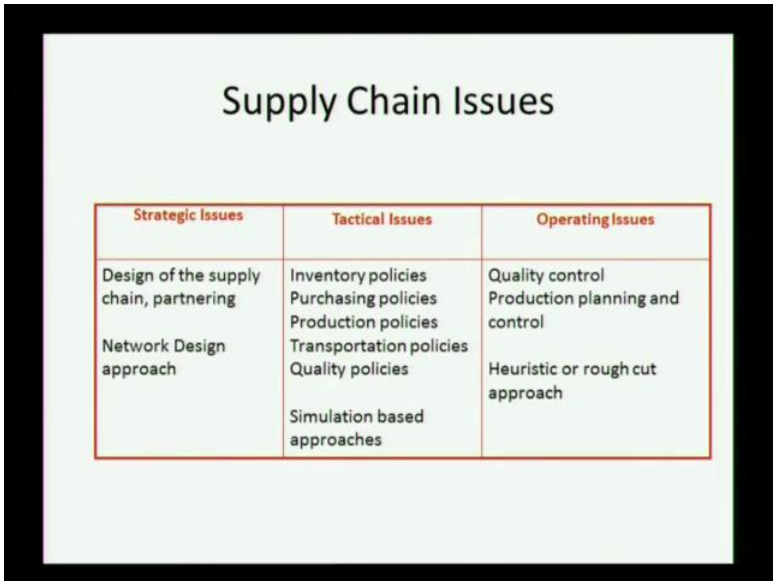


Now, when we look at supply chain what are the broad issues in supply chain? Broad issues in supply chain as usual can be categorized into strategic issues, tactical issues and operating or operational issues. Strategic issue are long issues that have long term impact or long term with respect to the time frame of the impact, tactical issues are usually medium term, and operational issues are very short term.

So, the supply chain issues can be categorized into strategic, tactical and operational. Some of the strategic issues are design of the supply chain, partnering, location and so on. So, design of the supply chain would talk about locating the various facilities, perhaps different products made in different countries, different items outsourced are bought from organizations which are located in different countries and so on.

And partnering, who are the partners, who are the suppliers, how do we select them, how do we develop them or how do we get them to meet our requirements and so on. So, these are some of the strategic issues, some of the tactical issues in a supply chain or what is the inventory policy across members of the supply chain, what are the purchasing policies across members of the supply chain.

What are the production policies, transportation policies, quality policies etcetera? Operating issues within each of them would be quality control, what are the quality aspects, production planning scheduling etcetera come under the operating issues. Now, each of these issues are handled through different methodologies, and these solution methodologies are given under each of these issues.

So, strategic issues are handled using what is called a network design approach, tactical issues are usually handled using simulation based approaches. And operational issues are usually handled using heuristic or rough cut or rule of thumb approaches. So depending on the nature of the issue a different solution approaches can also be used to address these issues.

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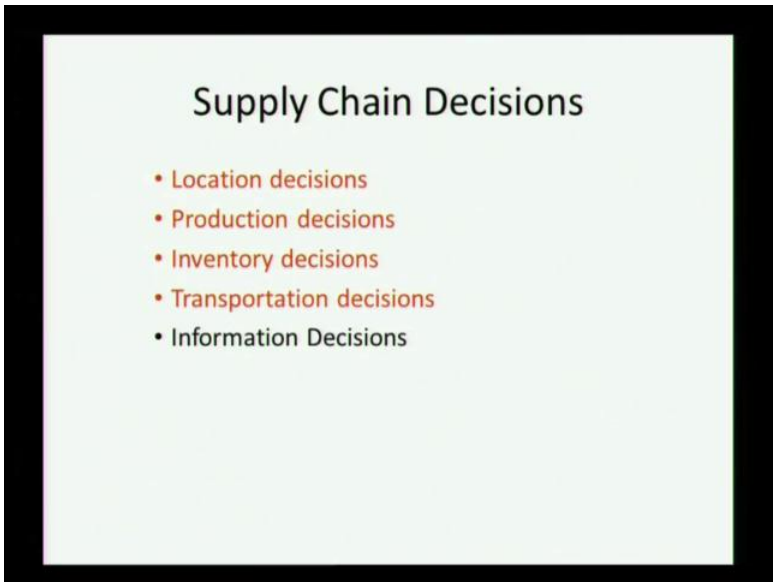


Then we move on to classification of supply chain decision making, the important classification given by Ram Ganeshan and Terry Harrison would broadly classify supply chain decisions into location decisions, production decisions, inventory decisions and transportation decisions. We also, they have also included information decisions as the fifth dimension, because information is the one that connects all the organizations, which are physically located, or physically away from each other.

So, we will look at five types of decisions in a supply chain - location decisions, production decisions, inventory decisions, transportation decisions and information decisions. Now, within an organization if you see we have already seen some aspects of production decisions, inventory decisions, and location decisions in the earlier lectures, where we have looked at production planning, scheduling, inventory, and location.

We are yet to see some of the transportation decisions or models related to transportation as well as some aspects of information decisions, which we will see as we move along in this course. Location decisions primarily talk about the geographic placement of production facilities, where do I place my production facilities.

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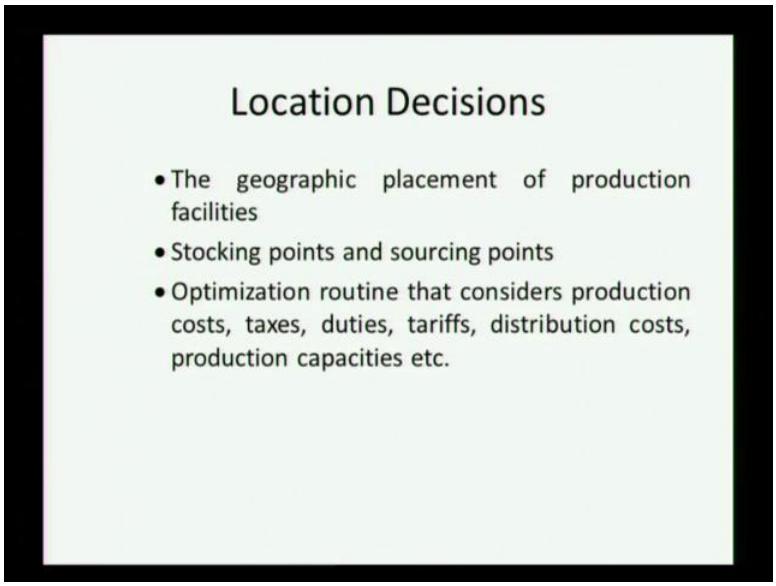


Where do I place my warehouses, where do place my stocking points, and who are my sourcing points, who are the companies for or organizations from which we are going to buy items. And finally, these are solved using optimization that considers production costs, taxes, because geographic placement across different countries, geographic placement across different states within a country. Involve different taxes duties tariffs distribution costs would change depending on the distance, and production capabilities would change with different plans.

So, we could think of a complex optimization routine that considers production costs taxes, duties, tariffs, distribution, cost production, capabilities or capacities etcetera to finally, arrive at location decisions.

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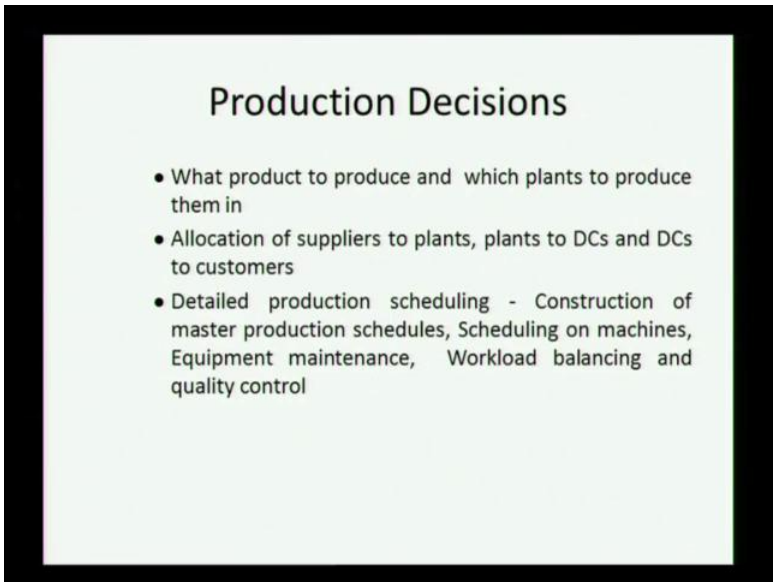


Production decisions are about which product to produce and which plants will produce these products. So production decisions would mean that the plants where production would take place are being chosen. And then the next level decision is to assign products to these plants, at first, of course to find out which products to produce and then assign these products to the plants.

And then how do we allocate suppliers to the plants, and how do we allocate plants to distribution centers and distribution centers to customers. Now, important solution methods include production scheduling, construction of master production schedule, machine scheduling, equipment maintenance work load balancing, and quality control. So, these are mostly things that are related to within an organization or in house once the decision to produce the products on the plants are made, and some of these we have already seen in the earlier lectures in this course.

Inventory decisions deal with three types of inventories, raw material inventory, semi-finished or work in progress inventory, and finished goods inventory. Now, we bring in a fourth dimension which is in process inventory between locations, because in a supply chain we are going to look at interactions between various organizations.

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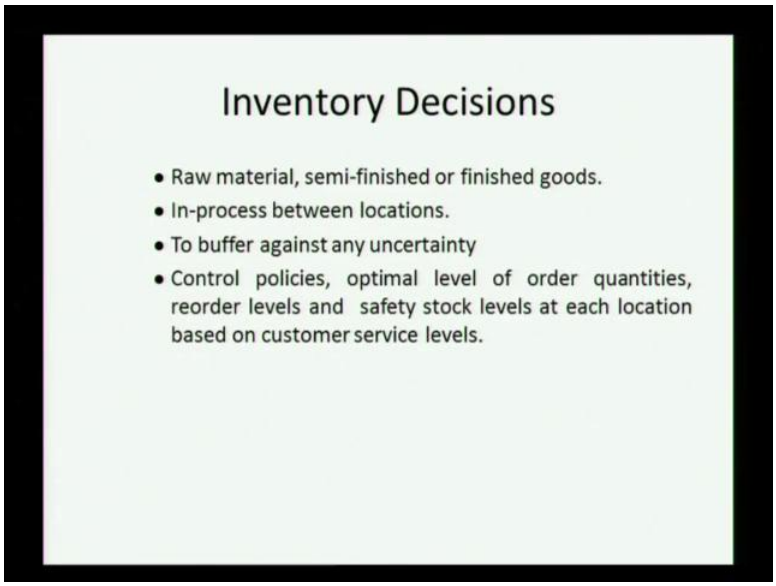


So, there could be inventory which is in transit or in process between locations also. Now inventory decisions are important to buffer against uncertainty. Now, the moment there is an uncertainty, one of the ways to reduce the uncertainty is to handle inventory. Traditionally inventory would mean physical items which are present. But, today inventory can be modeled as physical items, inventory could be time, inventory could be cash. The idea is to reduce the buffer or excess inventory, which we hold to handle uncertainty or to address the effect of uncertainty.

So, inventory decisions are about trying to hold minimum inventory, in terms of either units or time or cash to buffer against uncertainty. The solution methods would include control policies optimal level of order quantities, economic order formula and different order quantity or production quantity formulae, that we have seen in the previous lectures. Reorder levels computations that we have seen, safety stock levels and computations that we have seen, at each location based on given service levels.

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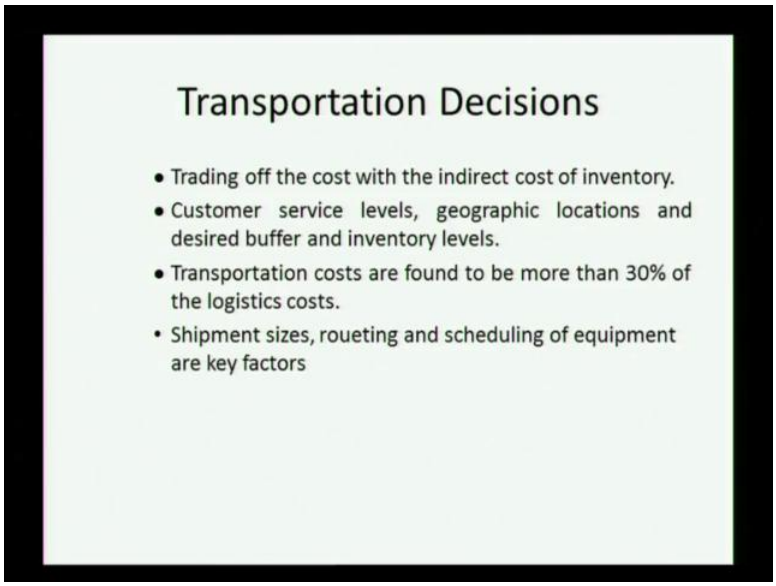


Transportation decisions are the tradeoff between cost of transportation with the indirect cost of inventory. Now, when the goods are made in the manufacturing facilities, now they have to be transported to the end customer - now many times they are transported through a distribution network or a distribution channel though in some instances direct sales to customers also exist.

So, when we have this transportation through distribution channels, the important question that arises is where do I locate the inventory? This physical inventory has to be located somewhere. And the question is how do we or where do we locate this inventory because there is a cost of transportation, and there is a cost of holding inventory. So, when inventory is held in a central place, we would realize that it is able to handle uncertainty better, but the cost of transportation would increase, because every time it has to be transported from a central place to different customers.

If on the other hand this inventory is not held in a central place, but it is decentralized and held in different places, then the cost of transportation may come down, but the amount of inventory that has to be held particularly to handle uncertainty will be higher. So, either way you will we will realize that between the two costs, which is cost of holding inventory as well as cost of transportation, one of them will be high and the other will be low and therefore, the question would be what would be the transportation decisions, such that the cost of trading off the inventory and transportation is maintained

well, or there is a good tradeoff between the two costs, or the sum of the two costs would be minimum. Now, what are the factors that would affect the level of inventory as well as the extent of transportation? Customer service levels are the first one, because the moment we have customer service levels and say that we have to meet the service level, higher the service level more the buffer inventory that is needed which we have seen earlier in this course. Geographic locations would determine the cost of transportation, from the place where the inventory is currently held to the place, where the inventory moves. Desired buffer and inventory levels will depend on the customer service levels, and also observe the transportation costs are higher and they contribute to more than 30 percent of the overall logistics costs.

And good transportation decisions can actually bring down, the total transportation cost other decisions would be shipment sizes routing and scheduling of equipment or product are some of the factors in transportation decisions.

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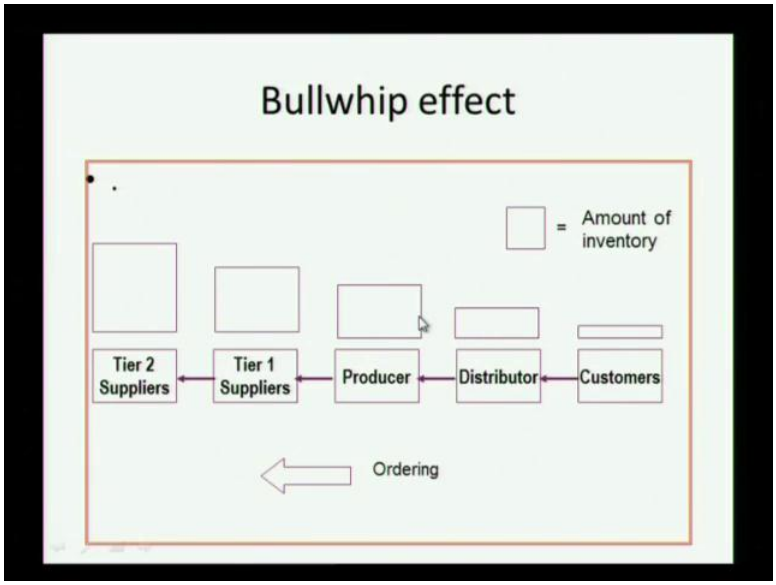


Now, we will briefly talk about something called the bullwhip effect, which is very specific to supply chain management, and we would look at this bullwhip effect in a little more detail in subsequent lectures. The bullwhip effect talks about the amount of inventory in the various stages of the supply chain, and generalizes that as we move to beginning of the supply chain or leftmost side of the supply chain, the overall inventory will be higher.

Bullwhip effect also talks about the fact that while the overall inventory would also be higher, it also talks about the fact that the variation in inventory would also be higher. A simple explanation to the bullwhip effect is that if there is a customer demand which is D, then the distributors will hold a demand will hold the quantity of slightly more than D, to take care of the demand fluctuation at the customer level.

So, the amount of inventory that these people would like to hold, or would like to have is a little more than D, and they do not produce, so they will buy from the people who produce. And because their requirement is little more than D, and the demand that they give to the producer is a little higher than their D, that they have, and the producer ends up producing a little more than what is demanded by the distributor.

So, therefore, the pressure is on the tier one suppliers, and tier two suppliers, to meet this requirement of the producer and they also end up increasing their demands a little bit, so that the uncertainty effect is captured. So, the uncertainty in demands of the customer finally, increases the demand on tier two suppliers, and more than that the amount of inventory that average inventory that the tier two supplier holds is very high.

So, this is called the bullwhip effect, where the average inventory held by various players in the supply chain increases as we move towards the left or as we move towards the supplier direction. The average inventory held will increase, and not only would the average inventory increase the variation would also increase, fluctuations will also increase. While, there will be times, this will be small, this will be large, and this could be small, this could be small, something else would be large, but the effect when we look at the average. As we move towards the left the average inventory will increase, and the inventory will fluctuate along the supply chain, this is called the bullwhip effect and we would later see methods or ways to reduce the bull whip effect. And one of the ways to reduce is by coordination, by sharing information and by bringing, these people closer to each other from an information point of view. Now what causes the bull whip.

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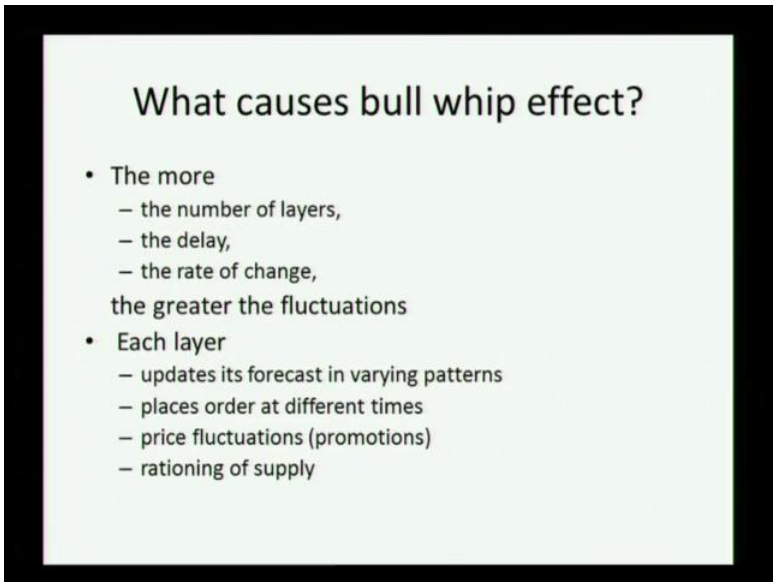


Effect? Some of these are more number of layers, higher the average inventory. Delay or time taken to move from one entity to another and the rate of change of the fluctuations, so more the fluctuations higher the inventory. Now, each because this happens, because each layer in the chain updates the forecast in varying patterns, places orders at different times there could also be price fluctuations which would determine the amount of inventory they would wish to have.

And these price fluctuations happen, because of promotion, product promotions, and there are times the rationing of supply also increases the inventory. Now, when there is rationing, which means when total supply is less than total demand, all the demand is not going to be met. And therefore, people would increase their demand notionally, so that if they are getting a proportionate increase of supply, then it makes thing better.

So, the moment there are instances where total supply is less than total demand, and rationing happens which means only a proportion of the demand is going to be met every player would automatically increase their demand. So, that the actual quantity that they get can increase, so all these result in excess inventory in the system, which causes what is called bullwhip effect.

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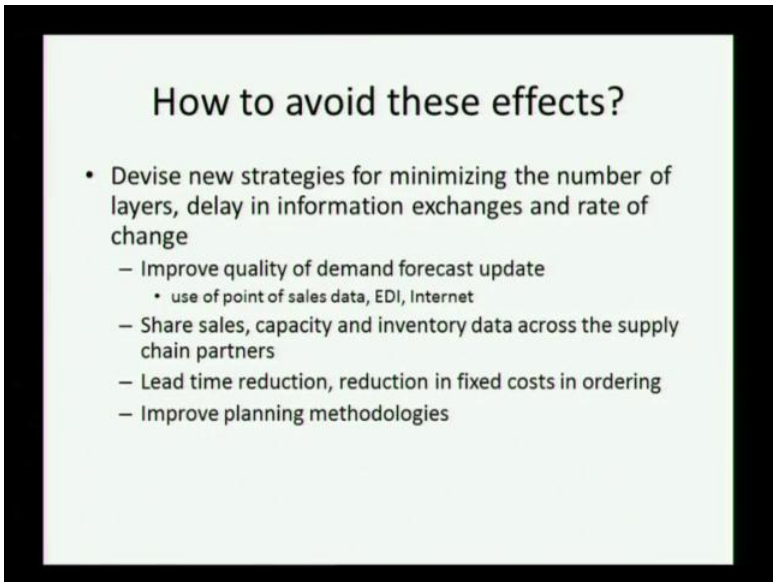


The several ways of avoiding the bullwhip effect. Some of which are use point of sale data, rather than forecasts, electronic data interchange, and use the internet to help in sharing information between or among the players in the supply chain. So, what are the data that can be shared sales data, capacity data, inventory data, they all can be shared which would effectively bring down the lead time, and will reduce the costs of ordering, and therefore it would bring down the bullwhip effect.

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Now, how do we plan better and how do we keep inventories low? Now some of the points are here - getting help from reducing lead times. Now, the moment we bring down the lead time which is either the external lead time or internal lead time, now what is the external lead time? External lead time is the time taken for items to come from the supplier to the manufacturing, which is external to the organization. Internal lead time is the time taken for manufacturing, which happens within an organization.

So, when we try to reduce the lead time, automatically the inventory that we hold will come down. Now, enabling or getting enabled through IT solutions, now IT solutions would help us reduce, this lead time, because more information is available and accurate information is available. And this can be done both internally and externally. Internal IT solutions talk about management information systems, they talk about ERP solutions within an organization.

And external IT solutions is how we get the ERP's of the partnering organizations to share information directly, or through the net and so on. So IT solutions internally and externally help them. Build market and business intelligence ideas and have better manufacturing planning systems like Just in Time manufacturing, which talks about reduced inventory and different kinds of planning, to have the reduced inventory. So, these are ways by which organizations can plan better and reduce the inventory, so that the bullwhip effect is also reduced. Now, what are the planning issues in supply chain, so that organizations come together and plan?

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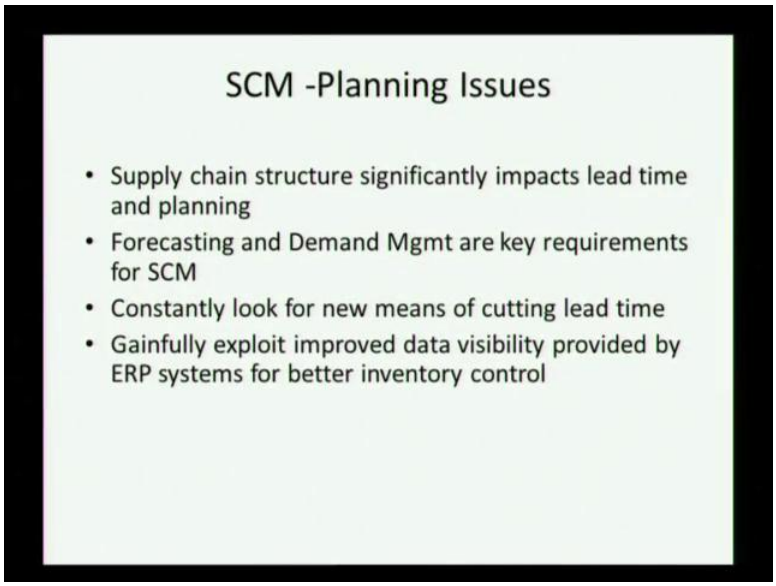


So, supply chain structure impacts the lead time and the planning. How the supply chain is structured, how many entities or organizations are there at each layer, and the extent to which these organizations cooperate with each other is about the structure, which would help in effective planning. Forecasting and demand management are key requirements for supply chain. So we should have good forecasting systems, which are reliable and show less variation. And we should depend more on demands than on forecasts, constantly look for new means of cutting lead times, exploit data visibility provided by ERP systems or use information technology to help in the planning.

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It is also necessary to understand that there is not only one type of supply chain, there could be different types of supply chain, so that is listed by the heading which says one size does not fit all. The same supply chain cannot work for all organizations or different organizations, so there are two classifications broad classifications that have been made. One is called an efficient supply chain, and the other is called a responsive supply chain, and if you see carefully the products are now classified into two very broad types.

So, one needs to understand the profile of the product, before we look at what kind of supply chain strategies we are going to have for the product. So products are broadly classified as functional products and innovative products. And their supply chains are called efficient supply chain and responsive supply chain, functional products have efficient supply chain, and responsive supply chains are for innovative products. Now, how does one classify a product into a functional product or an innovative product is the next question, because only after that classification we talk about efficient supply chains and responsive supply chains.

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| Criterion | Functional | Innovative |
|---|---|---|
| Product life cycle | > 2 years | 3 months to 1 year |
| Contribution margin | 5% - 20% | 20% - 60% |
| Product variety | low (upto 20 variants per category) | high (often thousands of variants) |
| Average forecast error | 10% | 40% - 100% |
| Average stock out | 1% - 2% | 10% - 40% |
| Forced end of season markdown | 0% | 10% - 25% |
| Lead time for made to order | 6 months - 1 year | 1 day to 2 weeks |

*Source: Fisher (1997), What is the right supply chain for your product, HBR, Mar. - Apr. 1997.*

Now, there is a very important and article from how about business review written by Marshall Fisher in 1997, which is titled "what is the right supply chain for your product". And there the author provides a framework to be used, which can be used to classify products as functional and innovative or talks about what are the broad characteristics of functional products, and what are broad characteristics of innovative products?

Against several criteria and some of these criteria are product life cycle, contribution margin, variety average forecast error, stock out forced end of season markdown, lead time, for made to order. Now, if you look at product life cycles, functional products have longer life cycles, suggested figure would be greater than 2 years, while innovative products have shorter life cycles. Contribution margins are lower for functional products, larger for innovative products, variety is low for functional products, high for innovative products forecast errors are lower for functional products, which means we get better forecast for these products.

Whereas, forecast errors are higher for innovative products, which means the forecast accuracy is relatively lower, for innovative products, average stock out is very less for functional products, stock outs are very large for innovative products. End of the season markdowns are higher, which means more products are available for forced sale or through promotions discounts and so on.

And lead time for made to order is large for functional products, and very small for innovative products. So, through this broad classification it is possible to identify weather a product fits into the functional category, or it fits into the innovative category, and depending on the functional product and innovative product. We talk about efficient supply chain and responsive supply chain, with efficient supply chain focusing more on cost minimization, and responsive supply chain focusing more on customer delivery.

Both the aspects of cost minimization and customer delivery are important to both the supply chains, but then we understand that, as we move towards a different type of a supply chain which is either efficient or responsive there will be a lot more emphasis on cost minimization, in an efficient supply chain and delivery or customer delivery in the responsive supply chain.

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Several other strategies can be used to design efficient supply chains, some of these strategies are continuous replenishment program using EDI links, which is electronic data interchange links. To be able to capture point of sale data for accurately updating the forecast, and we would have also understand the higher the forecast accuracy better the forecast less will be the inventory. The important aspect of getting the organizations together is to reduce the total cost of the supply chain, so that individual organizations benefit by that cost of the supply chain will come down if the inventory at the various levels of the supply chain are regulated.

Now, to understand that, we saw some aspects of the bullwhip effect. So, if the inventory in the supply chain reduces, then the cost would reduce, and inventory will reduce if forecasts are made better and more accurate. And therefore, there is a lot of emphasis on capturing point of sale data to accurately update the forecast, partner with organizations, which is essential aspect of supply chain, both on the left side or inbound side or the supplier side and the right side or the outbound side or the customer side.

Now, integrate systems between organizations to benefit from data visibility, and data sharing, and develop robust inventory control mechanisms to fix reorder points and reorder levels, so that the overall inventory comes down. So, what we have seen in this lecture is how organizations should come together, and work together and form a supply

chain, so that the total cost of the supply chain reduces and the delivery from the supply chain is made better.

How we can do that is through information technology and by understanding the various aspects in terms of location, production inventory and transportation decisions. We also saw the need for doing this through shrinking product life cycles, and the constant need to reduce the cost. And we also saw the two major classifications as functional depending on the type of the product as an efficient supply chain, and a responsive supply chain. Other aspects of supply chain management, we will see in the next lecture.