

Module 4: Supply Chain Management

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Lesson 4-1: Supply Chains and Their Complexities

Module 4.1.1. Introduction to Supply Chain Management

A supply chain consists of the links through which goods and services get transformed and flow from raw materials to finished products delivered to end users.



Christopher, 1992



(pixabay.com, n.d.)

Let's start with a very basic definition of a supply chain. What exactly is a supply chain? A supply chain is, if you were to think of a chain, it's the different links in that. It starts from the very basic raw material, and it goes all the way to having the product in the hand of the customer and then even talking about the disposal of that product after the customer has used it. We're talking about the complete chain going from purchase of raw material to distribution of the product, to the recycling, or to the disposal of the product toward the end.

EXAMPLE

SUPPLY CHAIN OF PEANUT BUTTER



(van Staveren, 2013)



Let's take a specific example of a supply chain for peanut butter. Peanut butter, if you think about it, where does it start? It starts with growing the peanuts. The farmer needs to purchase seeds, fertilizer. They need to have irrigation, so they need irrigation services in order to get the water for growing the peanuts. Next, the peanuts are bought maybe by a wholesaler. They could be bought directly by the company that's going to make the peanut butter. It could be many different ways in which a peanut butter manufacturer might purchase those peanuts, either directly or through a wholesaler. What is happening if there's a wholesaler is there's one more tier being added to that supply chain, one more link being added to that supply chain if you think about it that way. The peanut butter manufacturer has their own facilities. They may outsource some of it. They may do everything themselves in terms of the crushing of the peanuts, to making the peanut butter all by themselves, and then they send it out for sales. The sales, again, could be direct sales. The company could be selling peanut butter to you as a customer through online selling source, or they could be selling through a retail channel. They could also be selling it through a channel like a wholesaler that is going to purchase from them and then going to sell to retailers. There may be some consolidation there, another link, another tier being added there. Finally, you could have bulk purchases of the peanuts in terms of the catering facilities that companies have or universities have that use the peanut butter in the products that they make for you. If you think about this particular supply chain, we're talking about from a farm to a fork; getting it from the fields to the fork on your table, that would be the complete supply chain for peanut butter.

SUPPLY CHAIN COMPLEXITY RELATED TO DEMAND

Globalization of options for customers

Availability of multiple distribution channels

Shrinking life-cycles of products

Expanding opportunities from advancements in

Information systems

The Internet

Data analytics



Now that we have a definition of supply chain and we've seen what that means, let's see why this topic has become so important in the past four or five decades. There are two aspects to this, why the complexity has increased. One is the complexity in the demand and why that has increased in the last four or five decades. Customers today, if you think about buying things for yourself, you have a lot of choices of buying any product. You can buy it from all over the world pretty much, you don't have to worry about it coming from the country in which you're living in. Companies are able to sell across borders. Countries have relaxed any restrictions on material being passed from one place to the other, and so the market is very global. There are multiple distribution channels. You can walk into a store and try something or you can buy it online, you can get the benefit of user reports when you're buying something and you can base it on that. You don't really even have to go to a store to experience something, you can rely on other people's experience with that product in order to make that purchase. The life cycle of products has become much shorter. What is happening is, with the increasing pace of change in technology, products are being renovated every day. You're getting new products every day. You're getting newer types of cell phones, newer types of tablet computers, and that is changing much more quickly. In terms of the complexity of demand for a company's product, companies find it very hard to even forecast what's going to cannibalize what products demand, and so on and so forth. If you think about these three areas, these three areas are impacted by the changes that have happened in the next point that we're talking about here, which is information systems, has a much bigger impact. The Internet has a much bigger impact. Nowadays, the use of big data in terms of being able to forecast what is

needed by customers has a huge impact on how customers sell products to you. What you can see is these three aspects are making managing demand much more complex for any supply chain, for that purpose.

SUPPLY CHAIN COMPLEXITY RELATED TO SUPPLY

- Increase in outsourcing
- Rise in global sourcing
- Creation of complex networks
- Intensifying pace of change
- Intensifying focus on social and environmental impacts



Looking at it from the other side, it's going to be similar from a supply side in some sense because the three things that we talked about, the Internet and data analytics and information systems are having an impact on the supply side as well. In that sense, there are some opportunities that companies have in terms of sourcing from suppliers. There's been an increase in outsourcing simply because companies are able to keep better tabs on their suppliers. They can take what would have been a risky purchasing decision in the past is no longer risky because they can have a tighter control over their suppliers in some sense because they can share real-time information and they can see what's going on and they can be flexible if there's any kind of an issue with the supply chain. There's a rise in global outsourcing for the same reason. If you think about outsourcing has increased, but offshoring has also increased. Again, it's because of things like the Internet and having information systems that can keep track of your suppliers that offshoring has increased. Of course, the time that it takes for a material to get delivered over shipping lines has not decreased that much, but that's something that companies have to still deal with. Complex networks in the sense that companies are buying and selling to the same company. For example, Apple computers or Apple iPhones could be used in cars, in airplanes, they could be having an alliance with a car manufacturer or an airline manufacturer. I'll put it on the opposite side, Apple might get into making cars themselves, so they might have a buy-sell relationship with the same company. In that sense, the complexity of the network has become much higher. The

pace of change has changed from a customer's perspective, but from a producer's perspective, they have to keep an eye on technology, what is getting obsolete. Things that are changing really quickly have an impact. Nokia is a company that we no longer talk about because they were the ones that failed to keep up with the smartphone technology. That's where it makes a difference in terms of complexity of the supply chain and how companies have to incorporate that in making the long-term decisions. Finally, companies today are talking about their triple bottom line. Customers are demanding that companies report on their triple bottom line. What does that mean? Companies not only have to worry about financial performance, they also have to think about the impact that their operations are having socially and environmentally. Where are they buying their raw material from? What are the conditions in the countries from where they're buying their raw material from is having a meaningful impact on how they can sell their product. Similarly, in terms of the environment, what are they doing in terms of the waste and disposing of the waste that is coming from their facilities is something that customers are paying much more attention to. In that sense, it's adding a lot more that companies have to think about when they think about, we're going to source this from a particular supplier in a particular country, and what is that going to mean for not only our financial performance but in terms of what are we going to be able to tell our customers as to where their product is coming from.

Module 4.1.2. Managing The Supply Chain

SUPPLY CHAIN MANAGEMENT I

Managing a supply chain is about managing the flows of goods and services through the chain as well as the flows of associated information and financial transactions.

(Mentzer et al., 2001)

The performance of a supply chain is determined by its ability to match demand and supply.

Overstocking costs: holding, discounting, scrapping, obsolescence

Understocking costs: lost sales, damaged reputation

So let's talk about managing the supply chain after we've got a definition of supply chains now. So, managing a supply chain, if you were to think about it, it's the idea that you want to grow the size of the pie for the whole supply chain. You want to make the supply chain such that you get higher profits for the whole supply chain, so that everyone can share. Everyone in the supply chain, all the companies in the supply chain can share in their profit. But coming down to a more formal definition, managing a supply chain is about managing the flows of goods and services. But it's also about managing the flows of associated information and financial transactions. So what does that mean? When we talked about supply chains, we talked about simply the goods going from raw materials and being distributed and going to the customer, and then we talked about the disposal of the product. But if you think about it more closely, there's also information that is involved here. What do we mean by that? Information in the sense of day-to-day, what are the changes in the orders that have to be made, what is the customer demand and how is it changing? And you also have to think about it from a long term perspective, in terms of when companies are developing new products, how do they share information in terms of developing the new products? Finally, with financial transactions, how is the increase in that pie, if we can call it that, the increase in the total profit of the supply chain. How is that going to get shared across the different partners in that supply chain is something that supply chain management discusses talks about. So in that sense, supply chain management is a much larger topic, we can talk about many of these different aspects of the supply chain from not just managing

the flow of goods and services. But also managing, for example, the intellectual property rights, also managing, for example, how the patent protection is in different countries from where things are being sourced. And those things also have an impact on supply chain management, as well as how our company is going to have contracts that take the benefits of the supply chain and pass it to each of the players. The performance of the supply chain is going to get determined by how good it is, matching the demand and supply. So the idea being that, you have product when it's needed, where it's needed, and in the quantities that it's needed and the quality that is needed. So we're talking about matching demand and supply from a very basic perspective.

Module 4.1.3. Reasons for and Risks of Outsourcing

OUTSOURCING

I

Passing on an organizational activity completely or partially to an external supplier

(Barthélemy, 2003)

Core activities

Production, research and development, marketing

Supporting activities

Logistics, plant maintenance, information systems

For global markets

Production closer to consumption

(Gottfredson et al., 2005; Venkatraman, 2004)

When we talk about supply chain management, one of the most fundamental decisions that is involved in supply chain management is this decision that companies have to make. Should we make something ourselves or should we buy it from outside? So it's the make or buy decision and the make or buy decision could be about many different types of activities that the company might be involved in. So you have the core activities of a company, so if you're talking about a cell phone manufacturer R&D for manufacturing that cell phone is a core activity. The assembly of the cell phones is a core activity and the marketing, if it's a branded cell phone is a core activity. And companies have to think about whether they're going to outsource any of these activities, no, it was unheard of that companies would outsource R&D. But given our current developments and information technology that has become a possibility. So companies are doing that and of course companies can outsource their marketing and their assembly, so a lot of companies are doing that. When you talk about outsourcing, you could be thinking about the supporting activities, so it's not just whatever the core activity of that company is. But it could be for example their payroll maintenance, it could be their logistics, their distribution, even distribution of within their own plans. If they have an assembly plant in a different part of the country and they have a finishing plant in a different part of the country, they might even outsource their logistics. So you have third party logistics that are taking care of the logistics aspects of it. And then you have the information systems maintenance being outsourced to the experts in doing that. You could be thinking about outsourcing in terms of a way of entering a global

market, so if you want to get into the. If you are a US company wanting to get into the car market in India or in China or in Vietnam, you might outsource in the sense that you might partner with somebody who's already there. And use that in terms of making products for that market, so you are outsourcing because you want the production to be closer to consumption in that sense.

CONVENTIONAL REASONS FOR OUTSOURCING

- Access to specialized knowledge
- Volume-based costs
- Capacity restrictions – management and/or work force



Now let's take a look, let's unpeel the onion of outsourcing a little more and see why do companies outsource. So at a very basic level, at a very, in a very traditional sense, why did companies outsource, why did they used to outsource? And it was basically because you wanted to access something that a supplier is able to do better than you are. Right, so you're getting access to some kind of specialized knowledge if you're talking about distribution. You are going to a UPS or a FedEx because they know how to do these things, they do it on a day to day basis. You may be outsourcing one of the reasons for outsourcing could also be volume, you simply don't have the volume if you are a car manufacturer. You make many different types of cars, only a few of those or a small percentage of the cars may need a particular component. Let's take, for example, sunroof and you don't have enough volume to make that sunroof yourself. So you say, I'm just going to purchase it from somebody who's who's making this in larger volumes. And it has a cost advantage based on that, it could be because of, you want to keep your company size small. You don't, you want to keep it manageable, you don't want to have a large company to manage, so, because of that, you might outsource the activities that you could.

CONVENTIONAL RISKS OF OUTSOURCING

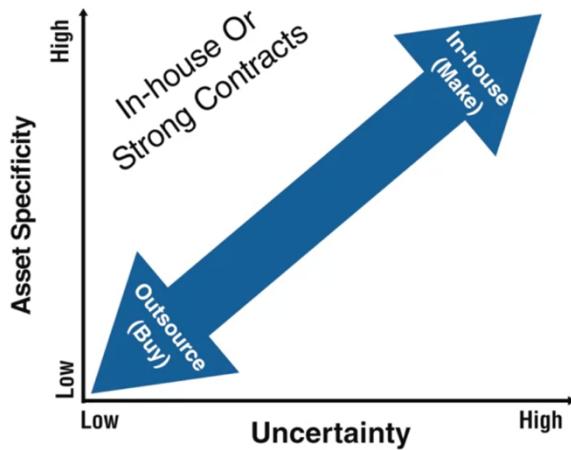
- Dependence
- Loss of core activities
- Quality risks



So, those are the reasons that companies typically outsource, of course, when you talk about outsourcing from that sense, from the conventional sense. There were the typical risks of outsourcing, one of the easiest ones that you can think of is you become dependent on the company that you outsource to. So if the manufacturing plant or the manufacturing facility of that company has to shut down because of a strike because of. If you're offshoring to that country because, if there's political disturbance in that country. That might shut down your dependence on that particular manufacturing plant or the country as a supplier, is going to cause trouble for you as a manufacturer. You are scared, you are going to be aware of not wanting to outsource your core activities, right? So if you're a car manufacturer and you're thinking about the engine, that's a core activity. And if there's some proprietary technology that has got to do with that particular aspect of your product, like the engine of the car, you'll say, well, I don't want to lose that core activity. I don't want to give it to somebody because it might get copied, also, I want to keep it in house because that's something that I want to learn more about and develop more. So I want to keep that core activity in house and not outsource it and something that we can all relate to in terms of, what if I give the production of this to a supplier? What about the quality, are they going to pay as much attention as I, as a company, whereas my company would to the quality of that component? And that's something that you think about from an outsourcing perspective, whether the supplier is going to pay that much attention to the quality of the product that they're selling to you.

Module 4.1.4. Transaction Cost Economics

TRANSACTION COST ECONOMICS THEORY WILLIAMSON, 1985, 2002, 2008



There's this framework that has existed for some time now that you can apply in order to make an outsourcing decision. If you think about it, it's a two-by-two matrix. On the y-axis we have asset specificity and on the x-axis we have uncertainty. Going on the vertical is asset specificity and on the horizontal is uncertainty. If you think about what is asset specificity, first of all? Asset specificity is a level of dependency that can be there. What do we mean by that? In order to make a particular product for you, if a supplier has to set up something that's very specific to you as a buyer, it's called asset specific. They have to build assets to be able to supply that product to you, there is a high degree of asset specificity then. It should be very logical that when there is a high level of asset specificity, you should be thinking about making that in-house, because why should a supplier put up a manufacturing plant specifically for you if that particular technology is specific for you. You can think about it another way, when there is high degree of asset specificity, there's not going to be much that the supplier is going to gain in terms of volumes because they are only making it for you in a specific way. If you think about asset specificity being high, you're already being pushed towards making something in-house. On the other extreme, if you think about asset specificity being low, it's easy to think of, well then you should outsource. If it's something that is very generic that the supplier has to make for you and probably that supplier is making it for other buyers as well. For example tires for economy cars. Tires for economy cars are something that no car manufacturing company would make themselves. They would be willing to outsource them and get them manufactured from tire manufacturers. When

you think of low asset specificity, the decision then goes towards outsourcing. If you think of this as a two-by-two matrix on the x-axis having uncertainty, so when you have low asset specificity and low uncertainty, the decision is to outsource. On the other extreme, when you have high uncertainty, high asset specificity, the decision should be to make yourself make in-house. The question then arises, what about the other two boxes on this two-by-two? Low uncertainty, high asset specificity. There, you could be either making it in-house or you could be outsourcing it. But because there's going to be a high degree of asset specificity, you want good intellectual property protection, you want strong contracts in order to protect the interests of the buyer so that they don't get copied. Also, you want to protect the interests of the supplier because if they're setting up something that is going to be specific to this particular buyer, they want to be able to make sure that they keep getting the orders that justify the setting up of those assets.

Module 4.1.5. Make or Buy or Partner

SELECTION FRAMEWORK

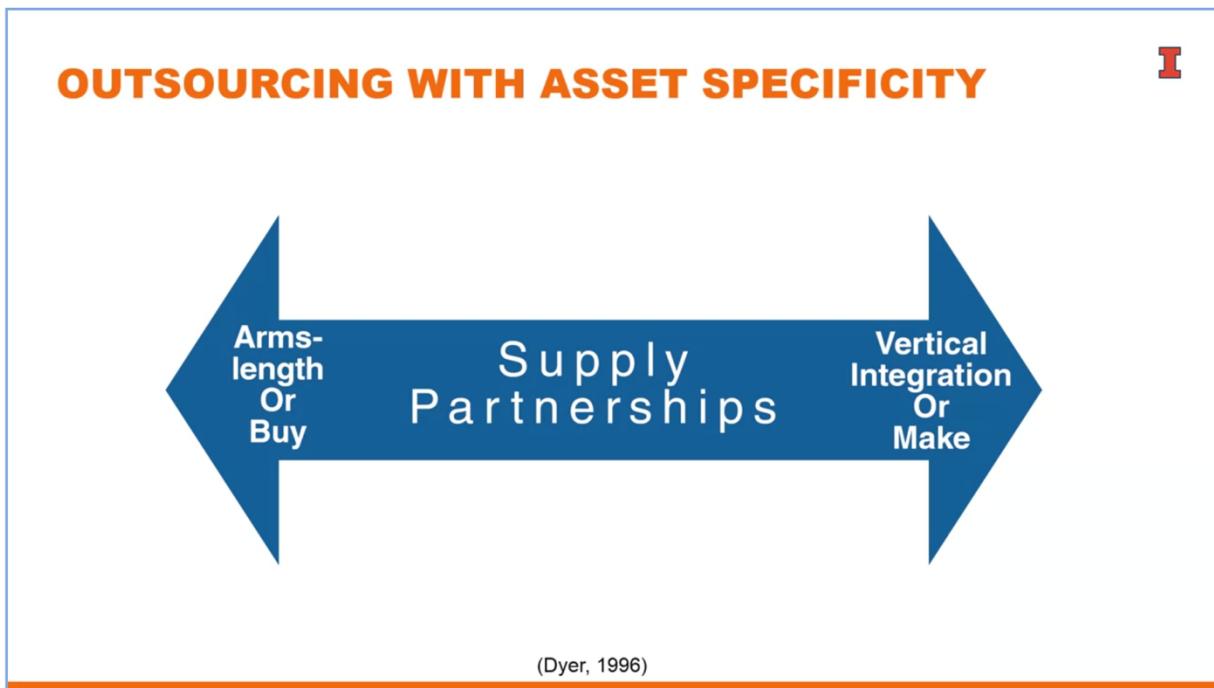
		Decision	
		Buy	Make
Decision Criteria	Coordination	Codified knowledge Distinct tasks	Tacit knowledge Learning-by-doing
	Strategic Control	Common production assets and R&D	Unique production assets and R&D
	Intellectual Property	Strong protections Clean technical borders	Weak protections Fuzzy technical borders

Hayes and Wheelwright, 1984.; Hayes et al., 2005



Take a look at another, a more simplified framework, so it's getting a little less theoretical here and this is coming from manufacturing strategy. So this is a framework that has been applied more to manufacturing companies. And here you have the three decision criteria, coordination, strategic control and intellectual property. And if coordination is going to be hard, so if coordination is going to be hard because that the kind of knowledge that needs to be shared between buyer and supplier, if the buyer cannot specify, codify what they need from the supplier, then the obvious decision there is going to be you make the product yourself. You're not going to be able to specify things to the supplier, so you make the product yourself on the other hand, if you can codify what is needed, if the knowledge is codified or quantifiable, then you're going to say, well let's just send the drawings to the supplier and they can make it for us. Similarly, if the task, if it's a component that can be easily separated from all the other things that are going into making a particular product. If that's easily separable, then you're going to buy if it's going to be a distinct task that's needed, worse is if it is a component that's not easily separable, that is very intrinsic to your product, then you are going to rely on making it. If there's learning by doing, if we have to work towards how this component is going to fit into your product, then you are going to tend towards making it yourself or you should tend towards making it yourself control the second criteria. This should be something that is intuitive because if you want to control and it's something that you want to keep control yourself, you would make it yourself. So if there are unique production assets and there's unique research and development

that's involved, you want to make the product yourself. On the other hand, if it's common, if it's a technology that is going to get used by many different buyers of that same product, then there's going to be somebody else out there who can do it better than you. So you're going to outsource that you're going to buy that from that outsource company intellectual property. We talked about this earlier a little bit and if intellectual property can be easily protected, then you're going to tend towards buying something. But if intellectual property, if the boundaries are not very clear and it's not very clear as to how you can protect your intellectual property or if you're buying from a particular country that does not have very good protections for intellectual property, you might tend toward making it yourself. So those are some practical ways for thinking about a make or buy decision. These are the different criteria that you should think about.



We talked about buying and making as two different extremes of a continuum. But if you think about it nowadays, what companies are doing is that they are moving towards the middle of this continuum and I call the supply partnerships because it's partnering with a buyer. Or thinking about it from a different perspective, it's something that you would do on your own, that you would give to a buyer and you probably would have some kind of information exchange, some kind of partnership active partnership so that you can get the benefits of both. So if you think about it, what we're saying here is you're trying to get the benefits of that specialist knowledge of the supplier. But at the same time you're saying, well there might be some things that we can do better together or there might be controlled that I don't want to lose and therefore I'm getting into this partnership, I'm putting in an effort to get into this partnership. Now, partnerships can also be on a

continuum it could be simply that you have a contract for what quantity that company has to sell to you and what quantity you are committing to purchase or it could be on the other extreme a supplier alliance. It could be an alliance with one supplier in saying that we commit to not only buying this product from you, but also to developing new products by working with you. So that could also be on one end of the continuum or other when you're talking about a supply chain partnership or a supply partnership, in fact, when you think of a company like Apple, you rarely think of the company doing well because of its supply chain.

OUTSOURCING AND SUPPLY CHAIN MANAGEMENT AT APPLE



Tim Cook took charge of supply chain in 1998

Left: (Marchive, 2011) Right: (Song, 2013)



I

Replaced own factories with contract manufacturing

Reduced suppliers and negotiated and partnered with the remaining

Reduced warehouses and inventory

Cut the production lead time

Improved inventory turns

You probably think of Apple doing well because of its innovation because of the new products that it comes up with. But in fact Apple owes a lot of its success to managing partnerships with suppliers and managing inventories. Tim Cook, who took charge of the supply chain in 1998 came in and made a big change to their supply chain. In fact he's known for saying that you treat your supply chain like a dairy if it's going beyond its use by date, you're in trouble. So he used to always talk about it from that point of view, and he did a lot of things in order to help the turnaround at Apple, he did a lot of things to manage its supply chain, better, to manage its inventories better. And which got Apple back on the trajectory to growth and doing much better as it has continued.

IN-VIDEO QUESTION 9

Roughly what percentage of Toyota's trucks and cars are outsourced?

Roughly what percentage of Boeing's 787 Dreamliner jet was outsourced outside the U.S.?



(flickr.com/taymazvalley, 2015)

All right, let's take a pause here and think about two companies that you may know of that you may have heard of and just think about what kind of outsourcing do they do? So Toyota is one company. So think about what kind of outsourcing this Toyota do, what percentage of their trucks and cars are outsourced. And second what I'd like you to think about Boeing's Dreamliner project and what percentage of that particular airplane when they were developing that airplane was outsourced and what was outsourced outside the US. So two different questions here.

IN-VIDEO INSIGHTS

Outsourcing at Toyota

70%

Outsourcing of Boeing's 787
Dreamliner jet outside the U.S.

35%



So here are the answers to those two questions. Toyota outsources approximately 70% off its cars and trucks. So they make they assemble the cars and trucks based on assemblies subassemblies that they get from different suppliers. And what is different about Toyota outsourcing 70% is even then within the US If you look at cars that are manufactured in the US. If you look at the top 10 cars manufactured in the US. Their cars, their five of those cars out of those 10 cars are Toyotas, which means what they outsource, but they outsourced to local suppliers, they outsource from local suppliers and and get their that get their materials from them. On the other hand, if you look at at Boeing and their Dreamliner project, their Dreamliner 787 was offshore. So it was outsourced outside the US to the extent of 35%. Now this may not mean much to you other than the previous project? The 747 was outsourced to the extent of only 5%, so 5% to 35%. And and if you put these these things together, you're seeing that outsourcing and offshoring are are two completely different things, right? So outsourcing could be to to local suppliers. And it doesn't necessarily mean that you're outsourcing outside the country, offshoring means that that you're getting from distant places. The other thing that you might want to note about these two companies is Toyota has had some trouble in the recent years because that can be traced to quality problems from some of its outsource part. And in the case of of Boeing 787, this has been talked about a lot there were a lot of delays in there in that project and and some of that was blamed on offshoring their their part supplies and not keeping track of their suppliers, and that was blamed for the delay of the project. So it tells you about some of the risks of outsourcing that you can manage if you're managing your supply chain better.

Module 4.1.6. Matching Supply Chain to Conditions

BUILDING SUPPLY CHAINS

Align with Demand
and Supply Characteristics

		Demand Uncertainty	
		Low (Functional Products: groceries, food)	High (Innovative Products: fashion goods, computers)
Supply Uncertainty	Low (Stabilized Processes)	Efficient	Responsive
	High (Emerging Processes)	Risk-Hedging	Agile

(Lee, 2002; Fisher, 1997)



What I'd like you to take away from this is that there is not going to be a one size fits all kind of a solution when you talk about supply chain management. It's a complex problem, you have to think about many things. But here's another way of thinking about it, and another way of thinking about supply chain decisions. And the idea of this particular matrix here that we have, again, two by two is talking about aligning the objectives of the supply chain. So aligning the objectives among the different partners that are in the supply chain. So here on the two by two, we have supply uncertainty and demand uncertainty on the left side supply uncertainty if it's low and demand uncertainty if it's low. So you're talking about products like groceries, you want to focus on a supply chain that's more efficient. You're focusing on cost reduction, you're focusing on getting products that can be made at a much cheaper cost. Going down on the supply uncertainty, access going down to high uncertainty there you're focusing on hedging your risks. If there's high uncertainty, you're talking about building safety stock, you're talking about having multiple suppliers. What if one supplier has to close down do we have a second supplier from whom we can source? So you're talking about hedging your risks in whatever you where you can, you could be using inventory tactics like pulling the inventory for different areas in one place and being able to manage it better in that way. Let's move on to the other side of demand uncertainty. So if there's high demand uncertainty and there is low supply uncertainty, you should be looking for a responsive supply chain that relies on suppliers that may be co located, right? So you're

talking about fashion goods, you want your suppliers to be co located, so you can respond quickly to any change in demand. You could be thinking about mass customization techniques, making some products make the order and then making some products make to stock. So you're able to be responsive to your customers when you get different orders from them. And finally, if you are in a situation where the demand uncertainty is high and the supply uncertainty is high, you need to do a little bit of everything, right? You need to have a responsive supply chain, which means you have to have mass customization techniques, you need to have co located suppliers. But then if you're talking about co located suppliers, you may be trading off the risk if they are located right next to you. And if there's an environmental disaster in that area, then everything is going down. So in terms of risk hedging, you have to rely on other things. But when you're talking about high demand uncertainty and high supply uncertainty, you have what is called the age old supply chain, which is both responsive and at the same time trying to hedge against risks of any problems that might occur. So that is a basic overview of what supply chain management is all about.

Lesson 4-2: Supply Chain Partnership

Module 4.2.1. Variability in the Supply Chain

BULLWHIP EFFECT

The magnitude of demand volatility a company faces increases the further upstream it resides in the supply chain.

(Lee et al., 1997)



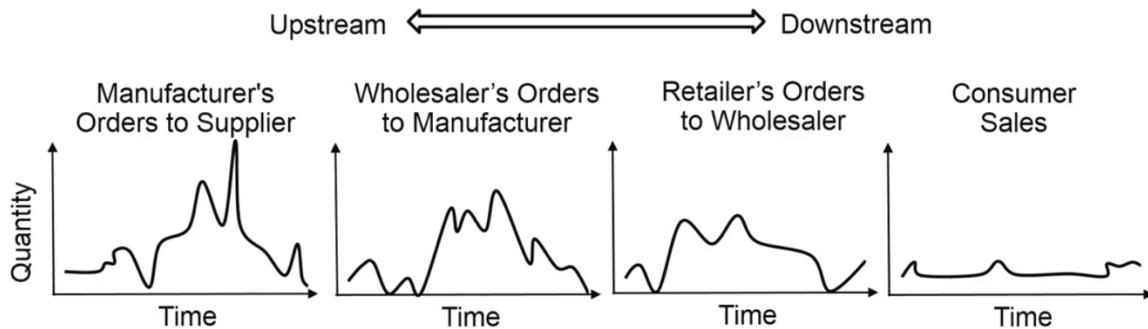
(commons.wikimedia.org/Thwongerry; Toobaz; Stern, 2010)



When you're thinking about supply chains and the many tiers in the supply chain, what happens is when you have more tiers in the supply chain, it's vulnerability to this bullwhip effect increases. You get this bullwhip effect occurring more and more unless you do something about it, when you have more and more layers in the supply chain, when you have more and more tiers in the supply chain. What exactly is the bullwhip effect? Let's take a small example here and see what it means.

SUPPLY CHAIN TIERS

I



(Lee et al., 1997)

You can think of any product and you have customers for that product, buying the product, and they will be some variability in the demand there. Over time, there's going to be some variability in what the customer purchases. They'll be purchasing from a retailer and the retailer in turn is going to place orders to the wholesaler. Now, the retailer will have some information about day-to-day sales and is going to incorporate that information and pass on the orders to the retailer based on that. Think about this, customer buys every day, many times in a day or customers buy many times in the day. A retailer probably places orders to the wholesaler in a normal sense, in a conventional sense, maybe once a week, maybe once every three days. There's going to be some periodic difference between when customers buy and when retailers place orders to the wholesaler. If you keep going further upstream, the retailer has to buy from a wholesaler, and the wholesaler has to buy from a manufacturer. What you're seeing here is what happens in reality. It's that the variability in demand, and the variability in the order quantity becomes much higher as you move upstream in the supply chain. That's what is called the bullwhip effect. The idea is that, because there's a time lag between when the customers actually purchase and the order gets placed to the retailer and then to the wholesaler and the manufacturer. As well as there's a time lag in how the product flows back from the manufacturer all the way to the consumer, this bullwhip effect seems to occur.

REASONS FOR OSCILLATIONS



I

- Order batching
- Quantity discounts
- Lead times
- Demand signal processing
- Trade promotions
- Sales force incentives
- Rationing and shortage games



Let's take a closer look at the bullwhip effect and why does it happen? Because it's a very important purpose of supply chain management to try and reduce this bullwhip effect. We try to reduce it by things that we do in supply chain management.

Let's take a look at why it does occur. A few reasons for it, one is batching of orders, retailer batches orders. They wait 3-4 days or seven days. They might have a regular cycle of ordering supplies from the wholesaler. Same thing with the wholesaler ordering from their supplier. You keep going upstream in the supply chain and the same thing happens. There's batching of orders based on some time period that they may think of. Quantity discounts. These are things that are common in all kinds of products. If you buy more, you're going to get a quantity discount. What that does is that creates artificial demand. That might create some misinformation, so a retailer might buy more, because of a quantity discount and that can be some misinformation. That can cause more variation in the demand going upstream. Lead times. The fact that it takes some time for a product to go from the manufacturer all the way to the retailer and then to the customer means that every stage has to plan for a lead time. They have to think about how to cover that lead time, the safety stock for that lead time. That creates them having more inventory than they actually think they need for the needed demands. They have some other safety stock, and that can cause more variation in the orders that they place. Demand signal processing. The idea that when a wholesaler sees a spurt in demand from a retailer, they may process it as an actual increase in demand when it's actually that the retailer is trying to take advantage of some discount, or is trying to maybe hedge against some expected shortage, or is expecting a really high demand

for that particular week and it's not going to expect that in the times after that week. If that is not clarified to the wholesaler and further to the manufacturer, they may process that spurt in demand in a different way. Trade promotions. The same idea as quantity discounts, trade promotions are you buy four cases, and I'll give you a fifth one for free. What that does is creates these artificial buckets in which retailers buy. They'll buy 12 when they need only 10. They'll try to think about it in multiples of four because they're going to get the fifth one as free. That will create more variation in how they place orders. Incentives for the sales force. Same kind of thing as discounts. If you sell more this month, you're going to get a bonus and that's going to cause artificial demand to get created. It will create some artificial demand that might get adjusted in the coming weeks and months and that's going to create fluctuations. It's going to go up and down because of those artificial spurts in demand that you're causing based on the incentives. Having an expected shortage. Therefore, you might stock more of a particular product based on what you're expecting. Or there might be a supplier who's giving less material than is being ordered based on some forecasts that they have of they may be able to get a price increase in the future so they're holding the material even though they do have the material to sell. Again, that might cause misinformation because the retailer might think, when I order 100, I get only 80, how about if I order 120 and then I'll be able to get the exact quantity that I need and that might cause some misinformation. What happens because of all these things is you have situations going back to this picture here. You have these situations where you might have a lot of stock at some point in time and at the same time on, at other times, you will have a situation where it goes down to zero inventory and you have orders that are being not filled for your customers. Both of these situations can arise, and these arise because of things that we do in the normal course of business, day-to-day course of business. These are oscillations of variations that come because of our normal ways of doing business. Next, let's look at some of the things that can happen that actually make this variation even worse.

EXTERNAL DISRUPTIONS ACCENTUATING BULLWHIP

Order changes

Customer changes to order quantities, delivery dates, and mix

Late and faulty deliveries

Supplier or transportation delays, defective or incorrect products



These are disruptions that can make the bullwhip effect even worse. Changes to orders. If customers are allowed to change orders until the last minute, then there's added fluctuation based on changed orders. There'll be added fluctuations in terms of the inventory when you have changed orders. Late deliveries, when you're talking about lead time as causing some of the bullwhip effect. You're also adding to that bullwhip effect when deliveries are not reaching in the time that they're supposed to and if there are quality issues. If you order 100 but only 80 are usable, then you try to adjust for that in your orders and then you try to make up for the yield loss that you're going to have and that's what can actually make the bullwhip effect even worse. Having a good quality management program or having a good forecast for your orders is always going to help

in terms of reducing the bullwhip effect.

INTERNAL DISRUPTIONS ACCENTUATING BULLWHIP

- Parts/component shortages
- Engineering changes
- New service or product introductions
- Data errors or communication errors



In terms of internal disruptions, that can make the bullwhip effect even worse. Shortages of components. If you have a shortage of components and then you start making other product because you have a shortage of components for one product, you're making product that's not being demanded that can cause the inventory of the wrong things to go up and when you need the capacity for making the right things, you don't really have it. Changes to products, changing in terms of engineering, changes to the products that you're making. If they are more frequent, they're only going to increase the variability in the supply, and that's going to make the bullwhip effect even worse. When you have new product introductions, you have less information about how the market is going to react to these new products and services. That can increase the variation in terms of having too much or too little, having overstock or running out of product. If there are errors in terms of the orders, instead of ordering 1,000 cases, if the order went in for 100 cases or the other way around, that's going to cause excess inventory for a temporary period of time or less inventory for a temporary period of time. You might compensate in the next order and that can be seen as a signal of increasing or decreasing demand, thereby increasing the variation in the demand and supply. Again, making the bullwhip effect even worse. These are the things that companies need to be aware of in terms of trying to reduce the bullwhip effect. There are some things that naturally occur, there are some things that are because of mistakes. Reducing the mistakes of those kinds helps reduce the bullwhip effect.

Module 4.2.2. Combatting Supply Chain Variability

COUNTERMEASURES FOR BULLWHIP (1 OF 2)

Substitute inventory with information

Increase visibility and cooperation

Combat reasons for order batching

Reduce order processing and setup costs

Reduce response time and increase delivery frequency



What are some of the countermeasures that companies take? What are some of the things that companies have done in order to reduce this bullwhip effect? The main idea is to use information exchange which is more efficient than simply trying to exchange information based on your order. Giving your supplier or giving your buyer more information than is being exchanged simply by the price of the product or by the quantity of the product that's being ordered. Moving beyond that. Not just giving a price if you are a supplier, but saying more about why that price is and what you're expecting in the future. In the same way for the buyer, giving an order and having more communication than that in terms of what are you expecting in terms of future orders, and not just relying on price and quantities to be the surrogates for that information, giving more than that. You try to reduce the reasons for order batching. You try to reduce the reasons why companies try to hold inventory. You reduce setup times. When you talk about quality management and lean manufacturing, we talk about the idea of reducing setup times, and among other things that also helps reduce the bullwhip effect. Simply because when you reduce the setup time, the process is more flexible for moving from one product to the other, and therefore you don't need to hoard inventory or hold inventory, and therefore you can reduce the bullwhip effect in that way. Reducing the lead time for products using combinations of make-to-stock and make-to-order, using mass customization, modular designs, where you can put things together based on customer orders, are things that can help with reducing the reasons for batching orders.

COUNTERMEASURES FOR BULLWHIP (2 OF 2)

Recognize variability enhancing policies

- Use everyday low pricing
- Use sell-through based promotions
- Use rolling horizons for sales incentives



Countermeasures for the bullwhip effect. Other countermeasures is reducing the use of the sales discounts that you give to customers. Reducing the idea of promotions that you give to customers and to your salespeople, or at least being aware of them. Sometimes, because it's an industry standard, you're not able to get completely rid of them, but at least if you're aware of them, then you can say that, well, we know that because we offered this, there might be a spurt in demand based on this deal that the customers are getting. That might not be a true signal of increasing demand. It's not a trajectory that's going to keep going that way, so take the increase in sales in this week with a grain of salt. Similarly, using rolling horizons for sales incentives, not just telling them based on end-of-month numbers, but looking at the last three months, the last six months can help in terms of not having that artificial spurt in demand when it's time for the bonuses.

BETTER MANAGE INVENTORY

- Point of sales data
- Forecasting and analytics
- Pooling inventories
- Part commonality
- Postponement
- Quality control
- Just in time (JIT)



If you can better manage inventory or reduce the need for having inventory, again, it all comes down to better ways in which you can keep your inventory or think about placing your orders. Point of sales data being transferred all the way to the manufacturer, the idea of Walmart, having their data from their registers getting consolidated and going to Procter & Gamble as their supplier, and them knowing what to expect and what to order, what's less on the shelves. Using combined forecasting and analytics. Using the power of big data. Pooling inventories, so having central warehouses in terms of a large country where you're supplying products to different areas, but if you are pooling the inventories for many different areas, that can reduce the need for total need for inventory. Common parts for products so that you have less that you need to plan for in terms of components. Postponement of finishing of the product. What is needed by the customer might be customized for the customer, but if you can make things and make-to-stock environment and then postponing the ultimate finishing for the customer can help. Last but not the least, the idea of quality control and just in time. Not having quality issues, so that your supply is more predictable. Forcing yourself to reduce setup times and getting into just-in-time deliveries can help you get better at managing the bullwhip effect.

IN-VIDEO QUESTION

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Additive manufacturing, recognized by its popular current version called 3D printing, has emerged as a disruptive technology in recent years. It enables the production of single customized units of products at relatively low total costs and in relatively less time.



How may this technology help reduce the bullwhip effect?

Time for a question here. If you think of this developing technology of additive manufacturing, what is also known as 3D printing. If you think about it, what that is talking about is being able to make whatever product you want from drawings for that product, and you can envision something like what we would see in Star Trek. You're talking about different molecules being transformed into a product and appearing in front of the customer when they need it. That technology, if you were to think about it, should have some impact on supply chains and how we think about supply chains. What I'd like you to do is take a minute and think about how would this technology help reduce the bullwhip effect? What would it do in terms of reducing the bullwhip effect?

IN-VIDEO INSIGHTS

Reduction of bullwhip from use of additive manufacturing

Production closer to customer, reducing lead times

Production from basic raw materials, reducing need for raw materials and components

Customization of end product, eliminating finished goods inventory

Reduced lead time



You would have thought of several things that something like 3D manufacturing would do. First thing is that it's producing the product right in the hands of the customer. The customer is actually printing out, is being able to manufacture the product right in their living room based on drawings, based on materials that you're getting, so it's going to reduce lead times. They think about a product, and they go and download drawings for it, they have the material ready for it, and they're able to make it. The other thing that this technology can bring is the idea of raw materials that can be used for many different products. You're not thinking about particular components, you're not thinking about specific types of raw materials, but you're thinking about more versatile raw materials that are being developed. In terms of keeping inventory of raw materials components, it reduces the need for that. In terms of planning for inventory, it reduces the need for doing that because you're simply not keeping inventory of too many components and raw materials. In terms of customizing for the customer, if there's the capability, if the capability develops for customers to add their little features to the product in addition to that drawing that they can download, then you can actually make the product exactly as the customer would want it. Finally, the idea of reduced lead time. You're not having a lead time for, if you need a product, you send the order, the supplier is going to process the order, and then they're going to put it in line for it to be manufactured, and it might take so many days for them to produce it and then the transit time for it to get to you. All of that is getting reduced when you're looking at the idea of additive manufacturing or 3D printing, where you are able to make the product in much less time. It would have a huge impact if this technology were to take off and land up in our living rooms so that we can make those products on our own.

Module 4.2.3. Alignment of Supply Chain Incentives

ALIGNMENT AMONG SUPPLY CHAIN PLAYERS (1 OF 2)

Key notions:

- Visibility
- Trust
- Design of incentives/contracts
- Leverage information technology
 - For tracking inventory
 - For sharing real-time information

(Narayanan and Raman, 2004)



The idea of Alignment Amongst Supply Chain Players is very important. Before we close off this idea of supply chains, we should think about what has alignment mean. Alignment simply means that all of the players in the supply chain are moving in the same direction, they have common objectives. Now companies, when they outsource and they build their supply chain, it's easy to overlook the fact that you're not communicating what the objectives are for you as well as for your suppliers and your buyers, and you're not exchanging that information, so it becomes important for you to do that. The way you can do that is if you talk more, if you communicate more, so what are the key ideas here; visibility, trusting your buyers and suppliers, and designing contracts, designing incentives such that everybody's objectives are aligned, they're going after the same types of things. Those are important aspects to think of as you are building your supply chain.

ALIGNMENT AMONG SUPPLY CHAIN PLAYERS (2 OF 2)

Example programs

Vendor Managed Inventory

Collaborative Planning, Forecasting and Replenishment



There's some programs that have become popular in the sense of aligning supply chains. Vendor managed inventory in supply chains, we like to use three letter acronyms, so VMI, so supply chain is SCN, VMI is vendor managed inventory. Vendor managed inventory simply means that as P&G, as the supplier for Walmart, P&G is managing the inventory in the warehouses or in the stores of Walmart, or in the stores of Sam's Club, so it's the supplier, this large supplier managing the inventories in the stores where the product is being sold. The other idea and not quite a three-letter acronym here we're talking about a four-letter acronym is CPFR. It's collaborating right from the stage of your forecasts, not just exchanging information about your daily sales, your weekly sales, but also in terms of forecasts, what do you expect as a retail store and talking to your supplier, to your large supplier and seeing what they expect. The advantage there is that you get the idea of consolidated information, you get the idea of planning for the future in a much better way when you have consolidated information across your suppliers and buyers.

BEYOND BULLWHIP SUPPLY CHAIN PERFORMANCE

Agility: Quick response to

- Short-term changes in demand and supply

- External disruptions

Adaptability: Alter supply chain design to

- Meet structural shifts in markets

- Follow technology and product lifecycles

(Lee, 2004)



Moving beyond the idea of the bullwhip effect, even if we can take care of the bullwhip effect or let's say that we don't have to worry about the bullwhip effect anymore, the idea that supply chains need to be agile and adaptable is becoming more and more prevalent in the academic literature as well as with practitioners. What do we mean by agility and adaptability? Here, the simple idea is that agile means being able to flex depending on how demand changes, so day-to-day changes, weekly changes in demand, and how a supply chain is able to flex to that, and adaptability means more in terms of a long-term. Talking to suppliers in terms of new product development, talking to suppliers in terms of what is coming in terms of anticipated demand. If these two components are being thought about, are being kept an eye on, it helps in general, for the supply chain performance of any company, of any supply chain. We're talking more generally than simply looking at the bullwhip effect, and more generally than looking at a particular type of supply chain, all types of supply chains would benefit from these two aspects.

DEVELOP RELATIONSHIPS WITH SUPPLIERS (1 OF 2)

Understand and respect supplier capabilities

Reduce supplier base and deepen relationships

Provide continuous feedback at all levels



Finally, to close off this lesson on supply chain management, you can think of contracts, you can think of incentives, you can think of trying to get your buyers and suppliers moving in the same direction based on things that you build structurally into your relationship with the supplier. But there's this other perspective of supply chain management that says, "There's nothing to beat the idea of building partnerships with supply chain." Building relationships with supply chains based on mutual respect. You select a supplier based on the idea that they're willing to work with you for a long-term, and then you basically have open books that you share with them, they share their cost structure with you, you share your new product development and it becomes a mutually beneficial relationship. What happens there is you're trying to get the benefit of the specialized knowledge of your suppliers, but at the same time, you're not trying to keep them distinct from you, you're sharing information with them and you're getting access to your information. There's the idea of having a supply chain relationship. Now what this means is that you reduce your supplier base. This idea actually goes counter to the idea of risk hedging. You say, "I'm going to have fewer suppliers for my core products and I'm going to work very closely with them. Not simply going to have multiple suppliers, because what if one supplier is not able to deliver, I go to the other one. I'm not going to think about it that way, I'm going to think about it more from working with that supplier." Providing continuous feedback at all levels, meaning at a day-to-day level in terms of continuous improvement of their processes, of things that go wrong. If I'm a buyer and if there are defects in the components that are coming in, I'm simply not saying, "You better send me better components," you're saying, "Well, let me work with you in terms of what is the problem with the components." Where are we either not communicating to you what our needs are or how we can help you with the

development of that component in terms of reducing the problems with that components. Providing the feedback to your supplier.

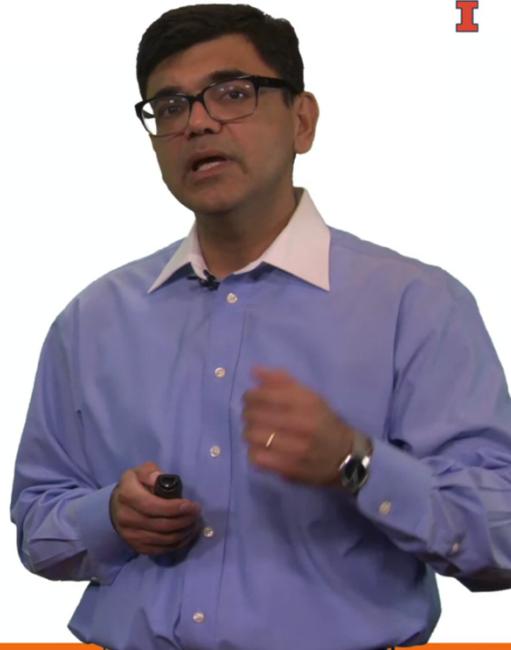
DEVELOP RELATIONSHIPS WITH SUPPLIERS (2 OF 2)

Cultivate and develop supplier capabilities

Share information systematically

Involve suppliers in quality management

(Liker and Choi, 2004)



Having better capabilities from your supplier, so even having supplier alliances, putting your suppliers together in terms of if you're buying the same component from multiple suppliers across the world, then putting them together and saying, "Let's learn from best practices from all the suppliers." Share information even across what would have been conventionally thought as competing suppliers to suppliers that are competing to sell a product to you, you're thinking of developing their capabilities based on cooperation between you and them and among the suppliers. Sharing information systematically and continuously all the time, and as we saw earlier, involving them in continuous improvement. Not just saying you need to have better quality and not just saying you need to have lower costs in terms of helping them of their quality, in terms of helping them in terms of their cost reduction, you work with them, you help them with their cost reduction programs and then share the benefits of this enlarged pie that you are able to make better profits for the whole supply chain. That's supply chain management for you.