Logistics & Supply Chain Management

Professor Vikas Thakur

Department of Humanities & Social Sciences

Indian Institute of Technology, Kharagpur

Lecture 55 : Smart Supply Chains

Hello dear friends, welcome back to NPTEL online course on logistics and supply chain management. So in this session we will discuss about smart supply chains. So we'll discuss about the evolution of smart supply chain and we'll go through some structured definition of smart supply chain. We'll compare the traditional supply chain with the smart supply chain and we'll discuss about some key components of supply chain and how this smart supply chain will lead to resilience, efficiency, and sustainability. And then in the end, we'll discuss about the implementation of smart supply chain. So the evolution of smart supply chain so the concept of a smart supply chain has evolved in response to the increasing complexity and interconnectedness of the global supply network the thing here is that now, after globalization there are no limited boundaries right so businesses are going overseas in that way the supply chain has grown more complex and complex means there are n number of stakeholders in any supply chain can be stakeholder can be from any part of the world right so saying that that means there is the problem of so many stakeholders connecting those stakeholders at common platform because if those stakeholders are there obviously their role in making the decision will be in some or other way will be affected so we need to connect all those stakeholders widespread stakeholders right and obviously how coupled with advancements in technology and data analytics right so you can see just the history of this when we started talking about scientific management and assembly line by our some quality gurus or production pioneers right production manager frederick taylor and henry ford when we talked about scientific management and assembly line and then these principles were based on optimizing the production processes and improving your inventory right so how you can improve the inventory levels minimum inventory then give rise to this the term of zero inventory or just in time inventory right but still in many organization we are struggling to maintain just in time inventory or zero inventory because it is required because the future is very uncertain we never know what will happen through the supply chain and then we are maintaining some safety stock level then we talked about globalization led to the expansion of supply chains which is obvious now we are not limited if we are manufacturing here in India we should outsource the raw material or we should purchase the raw material only from India or if we are outsourcing some manufacturing also that should be outsourced in India only right so you believe me if you will outsource the manufacturing sub-assemblies to some other part of the world right

and then transportation cost and then again all those logistics cost will be there but believe me if you will do that instead of producing here you will be more cheaper because there the technology is so efficient may be you are exporting there processing there and again selling back in India right so that way the market is open right you can outsource from anywhere you can purchase the material from anywhere and then you can sell anywhere having said that you have obviously access to bigger market new market but then the cost of setting up the facility the supply chain is also huge right so and it's not only the cost then we are talking about in this era how we will manage the information how will it collect the data obviously then that much big data will be collected through all the stakeholders right anyone can be seller anyone can be buyer how we can integrate with our factory smart industry how we can create that user interface where all those customers can interact can place orders from anywhere right and how we can achieve the desired level of automation right.

The expansion also introduced new challenges which is obviously related to now you expanded to whole world but then coordination, visibility, risk management. If you have some vendors overseas and then during shutdown or any like if you are importing some raw material from Russia. So, right now the situation you can just imagine when the Russian Ukraine war is going on. so That is one point, and then maybe the geopolitical scenario is like that or maybe some disaster is there or maybe anything can go wrong at any point of time, right so these are the challenges of how you will manage so obviously the technology, the latest technology computers have helped us you know to ah just plan in advance in that way and we can analyze the risk right.

So, that plus point with us is that now we can go for you know we can predict the future up to some extent and then we can make the decision. So, you can see ERP enterprise resource planning system to integrate various functions such as inventory management, procurement you can integrate, production planning you can integrate and then it is up to you how many modules you can integrate in your ERP or SAP solution. even the employees working in your organization you can maintain the record of all the employees how many employees are working at different levels the skill set they are having the training program they need all those things you can have within your system your enterprise resource planning And then we are talking about the smart technology, how we can utilize that and we can have access to real time visibility to supply chain operations, enable predictive analytics for demand forecasting and we can optimize the inventory. So, that will also help you to enhance the collaboration among the various players. So, smart supply chains are characterized by their ability to leverage data driven insights, automation and connectivity to improve agility, efficiency and resilience right.

So your supply chain will be more agile quickly you can adapt to dynamic situations anything going wrong in the outside environment, you can adapt quickly, and you will be more efficient right, and disruptions will be just outside whatever is happening, your supply chain is disruption-free how you can ensure that will only be ensured once you have the alternatives If an alternative one is cut down, then how can an alternative second supply? How does alternative third work right so those all things are available with you another important aspect of supply chains is the integration of sustainability, like in digital supply chain also we talked about reducing the environmental footprint or carbon footprint first you need to track what carbon footprint you are leaving right so throughout all the production process whenever you are manufacturing whenever you are delivering the product all the stages you can record how much carbon footprint you are leaving right first record the carbon footprint then you can take the steps how we can reduce at different levels So, then you can go for green sourcing and then you can pick those suppliers who are taking care of maybe green packaging or in that way green manufacturing strategies, how they are minimizing the depletion of the environment. So, those strategies they are implementing. So, concepts like industry 4.0 which emphasizes the integration of cyber physical system, cloud computing and AI and these are shaping the future of the supply chain. instead of we are making the decision how industry 4.

0 embedded supply chains can make decisions for us right. So, when you are sitting at your home how efficiently, how easily that eco-friendly system is there that you can place the order, you can pick different brands, different sizes, different varieties and then you can quickly get the delivery at your doorstep and easy payment options are there you can track your movement of the material and this information because recorded digitally so then this will be shared by with everyone right so now if I'll quote one example here if you are going to restaurant and then taking food it is more costly for the restaurant Right so when you are placing online, it is you know, cheaper for the restaurant also, and that's why you are getting some rebates and some coupons also because if you are going to my restaurant, you will sit there for one hour you will enjoy the amenities and then AC is working staff is there to help you but if you are placing order online 24 hours people are working and in shifts and then they are preparing just packaging like anything and no you know those serving people are required we need not to maintain you know that much space and within the same maybe that capacity we can serve more number of customers. so we are efficient in that way so that margin will be efficiency will be shared with everyone as a customer also you will get benefit as delivery partner they will also get benefit out of that and as restaurant i will also get benefit out of that so smart supply chain definition you can see so yes our inconsistent literature have proposed so many definition but the concept is often referred to in terms of the different stages drivers of supply chains technology involved applications and characteristics so one by one we will

see smart drivers of supply chain when we talk about drivers of supply chain we talk about facilities we talk about information we talk about transportation, we talk about sourcing, we talk about pricing and we talk about inventory. right so smart supply chain so when you are talking about smart supply chain these six driver should be smart smart facilities warehouse should be smart automated warehouse should be there right you should not handle things manually and your record should be automated should be shared with the manufacturing unit immediately right this is smart warehouse system this is smart facility warehouse i am talking about if this facility is we are talking about the manufacturing facility how you can build up the smart factories so smart factories also you are taking decision based on information real time information and automated production lines are there where robots are taking decision anything going wrong they can take the corrective measure and if they need the machine requires predictive maintenance they can predict when the maintenance is required and then it can be done right. Information, obviously smart real time information so that we can make those decision.

Transportation. the very common thing we are using GPS right, how we can take the smart routes with minimum fuel cost, with minimum time and considering the weather condition, considering the traffic all those things. Sourcing, how we can convert sourcing into smart sourcing, we can purchase from the vendors who are kind of smart contracts we can set up right. so that is plus point pricing smart pricing system we are not only as a manufacturer you are getting benefit out of that your customer should also be delighted your stakeholder should also be delighted how you can go for smart pricing strategy and then inventory when you have that real time information how you can minimize the inventory so that inventory cost can also be minimized or may be somewhere at the central location you can manage the inventory from where you can channelize the inventory to all different locations because you know very well from where the demand is going to come. Let us maintain very big distribution hub here and from this we can channelize the inventory.

So, we need to convert all these drivers into smart right and then data streams and digital aspect because these drivers will generate so much data, right? Big data will be there and then using IoT big data, we will convert this into smart supply chain where the decisions will be made based on the whatever data is generated through all these six drivers. based on that only we will go for sourcing based on that only we will go for pricing what price you should keep today right based on that only we will maintain inventory daily inventory today tomorrow how much before noon after noon how much we need to maintain the inventory right so characteristics interconnected, intelligent, adaptability, instrumented, interconnected, intelligent, automated and integrated and innovative. How you can, these are some of the characteristics when you are talking

about smart supply chain. intelligent supply chain where supply chain all parameters will be set as per the requirement right automatically they are taking the decision which when they need to change the parameter when they need to go for the next stage information a decision right smart manufacturing We have advanced technologies and data-driven processes so that we can go for manufacturing in such a way which will be more efficient productive and flexible right so if we need to shift from one model to other models to the next model quickly we can shift that because we know that this is going to be the demand for that particular model from the market we can monitor that we can analyze that and we can optimize our manufacturing process how you can do that when you have that digital world internet of things connected you have data points touch points from where data is being generated and you are collecting that data right artificial intelligence you are using you are using big data analytics compute cloud computing and then you are doing the predictive analytics and your system is intelligent taking decision based on you now we need to shift from model a to model b So, then we need to shift these many units we will make of model B, then we will go to model C, this is how we will take the decision. So, smart supply chain management hierarchical model is there given by Zhang in 2023, this is level 3, all these technologies what we talked about right now will be the base of this at level 0 right, when we will talk about the smart supply chain management and this will lead to smart unit flow material either you are talking about the material is flowing through the supply chain it should be smart how how much level we need to maintain the flow of the material right information where we need to maintain finance how much finance is required how it is flowing through the channel and when customer is paying how many different options they have they can pay right how you are paying to your vendors if smart contract is there right if you have smart contract with your vendors that means whenever you have accepted the material no need to go for raising the payments to that particular vendor because it is smart contract the moment you will accept the lot automatically the contract will be executed and payment will be done to the vendor right smart drivers already i discussed about all these drivers which are the base of any supply chain right so how we can make that and smart decisions will be there because these are based on real time data touch points we have and from those touch points we are generating huge amount of data and then We have smart function, visibility, real time optimization.

This will lead to level 2 smart supply chain network which is defined as interconnected, intelligent and innovative and self organizing and self optimizing. Self organizing and optimizing again I am telling and stressing more on that because here we will not take the decisions on our behalf whatever are the parameters like if you are recording the weather condition right. So, may be you are recording temperature, pressure, humidity level and then you are saying that today 95 percent is the chance that rain will be there. How much

rain will be there? 50 mm rain will be there. So that means, if this is the time period, the rain will be there.

Now, how as a smart supply chain you will take decision, your system will take decision, will take the automatic route so that your supply should not be interrupted. So, in that way you will be responsive, more responsive to customer demand, to anything which is happening outside, you will be more efficient because in advance you know resilience, nothing will happen to your supply chain, agile supply chain will be there, quickly you are responding, flexible and you are hitting the sustainability also. So, then we will come up with the smart supply chain which will address all the issues of your sustainability. Economy, how? Because we will be more efficient, we will be consuming less resources, lesser cost. Environment, because we are consuming less resources.

you are depleting less environment and society as a society they will be benefited out of the smart supply chains because this value is being delivered to the customers right to the society just quickly if we will go through the traditional supply chain talking about transparency no we cannot talk about transparency in supply chain physical documents are flowing from one end to other end and now if you talk about the transparency everything is being shared through all the stakeholders still at that level it is not maintained because see if I am visiting your store let's say I am visiting Maruti Suzuki store may be for getting my vehicle service so I am visiting that store and something goes wrong so that they are recording the information there or may be feedback form we are filling offline form we are filling no online form is coming and even if it is online it is coming so whether the same information is because that is the official service partner right the same information is going as it is to Maruti Suzuki so that they can take decisions when they are you know outsourcing these service part to different agencies. Data collection obviously here bullwhip effect will there as I talked about at reason level you will compile the demand then you will compile demand district level then at the state level then at the country level that you can see the world level how you will be compiling the demand right so this data collection will be difficult but if you are talking about the smart supply chain quick data sharing will be there information sharing will be there the moment the touch point is generating data the same moment it is being shared throughout responsiveness here we are low responsive to the market condition because today something is happening in the market maybe after six months or so we will you know react to that traceability right now highest level of traceability is going on and if you are ordering something and then you know how you can track the order but during you know the traditional supply chain even if you are placing now order with the local vendors and then it is taking time let's say again the Maruti Suzuki or any other automobile industry you are placing order for a model where maybe 6 to 8 months waiting period is there in

between what is happening you never know Right, so let's say the system is like that right now, whether the the manufacturing facility has started making your unit or not, if they are making it today, what is the process, what are the components they are integrating, what is the stage what is the status when they are going to dispatch when you are going to receive in your nearby location and when you can go for final having that product right so that you can do adaptability so traditional supply chains are one level to unexpected changes which is obvious because once the things will happen then you are reacting to that right so that is a reactive process But now we are predicting in advance and we can plan for that. Feedback, just I quoted one example whether that feedback is really going to the concerned person who is responsible for providing those services or it is being you know stuck there only where we are filling that form. Key components of smart supply chain sustainable practices as I talked about optimizing energy consumption reducing waste and minimizing environmental impact because now we are utilizing fewer resources to deliver your product we are a smart manufacturing factory We are consuming less power, less resources, less raw material and those raw material which are more greener. So, that means we are taking care of the sustainability parameters.

So, you can give this information on your packaging as well. So, that customer will get this information that while producing this product this much carbon footprint was left out, right, agile and resilient supply chain because you know in advance the market condition you can analyze the real time data you have you have the predictive analytics so then you can go for the that kind of quick resilient supply chain because in advance you know after 5 days you require maintenance for may be your machine right so that you can plan. responsiveness again very important aspect of supply chain and how quickly you are responding to your customer requirement or changing market conditions and if any disruption is happening how you are responding to that right so that is that will define your responsiveness parameter as a smart supply chain right you should be smart enough to predict what is going to happen and if anything going to happen how you can ensure your agile manufacturing your agile supply chain so that if any even anything going wrong even then you can ensure the smooth supply of the material right efficiency So, efficiency initiatives in a supply chain help to streamline processes, reduce waste and optimize resource utilization. So, earlier this was the input, this was the output. Now, what is happening? Either you reduce the input, still the output is same, you are more efficient or may be at the same level of input, now you are producing more or may be you have increased little bit in input, but output is more.

so this is these are the ways you can be more productive and more efficient, right so because that quick information sharing is there so productivity is there flexibility so that is again critical to enable of success in a smart supply chain, allowing the organization to anticipate and respond to changes in demand market dynamics and operating conditions

right so whatever is happening in the dynamic environment business environment you can easily figure out that and then you can develop your resilient supply chain right so you because you know in advance so you have different options to deal with that risk so that way you have the flexibility right. So, real time visibility because we are operating with IOT sensors and devices which are continuously tracking the movement of the customer, movement of the goods and then within the factory also we can find out where the bottleneck is right now. where we are stuck in the manufacturing why it is not being processed further so there is one bottleneck may be breakdown is there may be something has gone wrong so throughout that supply chain you can track that Predictive analytics, big data analytics and AI algorithms are used to analyze large volumes of data collected from various sources including your IoT devices, production systems and external factors such as I told you the weather conditions, the market trends right. So, those all things you can predict in advance and you can plan for that. automated processes whatever are the routine processes you can just automate those processes because the robots will take care in a better way because these are repetitive process we need not to interfere and every time we need to touch that 100 percent so robots will take care of that dynamic optimization now that is not the time that you collected the data and then you are making the decision during this whole day you are making decision first thing and when I am saying whole day you are making decision that means that means you are configuring reconfiguring reconfiguring again your function if you are talking about the forecasting demand So, how quickly it is changing in the market same way you are implementing that function.

So, that is why we are saying that automation should be there. So, we should not interfere as human being. So, machines will take the decision based on the market conditions. and that will only happen if we have the collaborative network it is not that this we can leverage only for the manufacturing unit or only for the warehouses or only for the transportation or only for the raw material suppliers. So, all throughout this supply chain, should be interconnected, and that ecosystem platform should be developed where the information is being shared throughout the right.

so talking about supply smart supply chain first thing is resilience how it will add because supply chains are increasingly vulnerable to disruptions and challenges which is obvious and recently we have seen when the operations were shut down then you might have seen the panic buying people started buying product in bulk so that they can meet demand in future There is no such hike in the demand, but people are buying more because they are unsure about future supply. So, how you will your supply chain is resilient to handle this kind of disruption or any other disruption if any natural disaster happens right, how up to that point where the supply chain is ok, how up to that point you

can still you know supply the material and how quickly you can bounce back in the affected area. That will define your resilience right so by embracing emerging technologies such as Internet of Things artificial intelligence blockchains, companies can create a smart supply chain that enables a real-time tracking of proactive risk management and seamless coordination right so that means in advance you can respond to the disruptions or any any if you are talking about disasters or cyber attacks also because we are talking about too much about being smart right based on digital network so then this this becomes very very important how we will take care and obviously speed reliability and agility are the major major points which will you know the benefits the leverage will get out of implementing these technologies right So, efficiency in smart supply chain with same number of inputs how we can produce more or with lesser input how we can produce more that is how you can be more efficient. So, you need to minimize the expenses, the waste, the effort. effort in terms of human effort or machine effort the raw material you are using how you can minimize right how you can minimize the rejection in the manufacturing that also can add to if you are not producing any rejected material that means that is the material you can finally consume in the market right.

this is how usually we are calculating the efficiency what is the actual output what is the expected output and somewhere if we want to be in somewhere around 95 percent efficient all the time so efficiency in smart supply chain cost reduction if efficient using less resources wastage will be no wastage will be there so you will be cost efficient resource optimization because you are utilizing less resources so that's why you are reducing cost faster response time no delay in the supply chain no rejection in the supply chain quickly you will respond to the market condition improved customer services because customer are also satisfied they are getting on time lesser cost sustainable measures are being taken care Risk mitigation in advance you are predicting the risk and then you are mitigating and environmental sustainability because you are minimizing the resource consumption, you are minimizing the impact on the environment so that way you are more environmentally sustainable. Sustainability closed loop supply chain upstream or downstream. so how after the use of the product you are using you are again collecting the material and then ensuring the reuse or recycle right so these dimensions economic environmental and social dimension how your smart supply chain is addressing so we have one full session on this closed loop supply chain and recycling and green and sustainable supply chains right there we have discussed in detail So, sustainability key elements, economic value creation, this is one aspect, minimization of resource consumption will lead to productivity, will lead to economic measures, will lead to less degradation of the environment, collection, sorting and recycling of waste material, how that waste material can be reused in the same industry, can be recycled for some other industry inputs, those way. So, we can address profit people and planet by addressing

these issues of sustainability. So, implementation of smart supply chain, this is one example of IOT based sustainable smart supply chain, this is how customer is approaching one touch point right.

Sensor nodes are there, how it is generating the data that is being shared with by the manufacturer with transportation agency with packaging with supplier with warehouse everywhere information is going right so real time collection of data at this suppliers again touch point is there we have sensor nodes at warehouse during packaging we have sensor points in the plant in the transportation everywhere you have touch points from where you are generating data and adding to your cloud and cloud computing is being done and for these all functions you are taking the information based decisions this is one example of blockchain based sustainable supply chain and you can see smart contract which i was talking about you need not to interfere whenever you are receiving the material it is ok the contract will automatically execute next time whenever the inventory level will go Below the safety stock again, the contract will be purchase order will be raised right consensus cyber security immutable and decentralization of the records will be there these are the features and obviously will blockchain supply chain will ensure transparency, traceability trust, responsiveness and accountability and what else is required to maintain that healthy supply chain You want to ensure these parameters to all your stakeholders, and then all these are, you know, continuously dealing with all these activities, and the material is flowing from one end to another end, to another end, right, and again, you are reusing that raw material using a closed-loop supply chain. this is cloud and AI based sustainable smart supply chain and during those stages of supply chain here also you are generating data here also from everywhere information is going on from every point information is going in the clouds and in the cloud you are doing the analytics you are doing the prescriptive analytics descriptive analytics predictive analytics you are defining what happened why this happened in what way this can happen in future And how we can control it and the way we want it to happen and we can control in that way, right. So, these all decisions in predictive analytics we will take and decision will be issued for raw material suppliers, for manufacturer, for customers, for the closed loop supply chain, for the disposal also. How we will go for recycling, right.

This is as simple as that. Here we are processing the whole information and decision making is being done for all the stakeholders. another example smart grid power distribution system we know we have these many resources from where the power is being generated these are the consumption points we have smart factories we have homes and cities and we are using to charge the vehicle right so from where how much energy is coming if 20 percent is coming from this point may be thermal is adding more may be 35 percent right and then only may be 2 percent or 3 percent is coming from here. So, then

we can see how much energy we are utilizing, how much is coming from different sources and then we know that this is very sustainable source leaving minimum impact on the environment, how we can go for the strategies where we can get energy more energy from the wind generator. So, smart power distribution system we can design in that way.

So, that is all for this. These are some of the references. You can go for further reading. Thank you very much.