The Future of Manufacturing Business: Role of Additive Manufacturing

Prof. R. K. Amit
Department of Management Studies
Indian Institute of Technology-Madras

Lecture – 17
Digital Supply Network - I

Hello. You would have attended the sessions by Mr. Jimo on how you integrate additive manufacturing and supply chains and by Mr. Murali on the industrial IoT. That would have given you some glimpse of how the things are changing in the context of manufacturing. So, before I start today's discussion, let me just revisit some of the points we already have talked about. If you recall, we started with the what is manufacturing?

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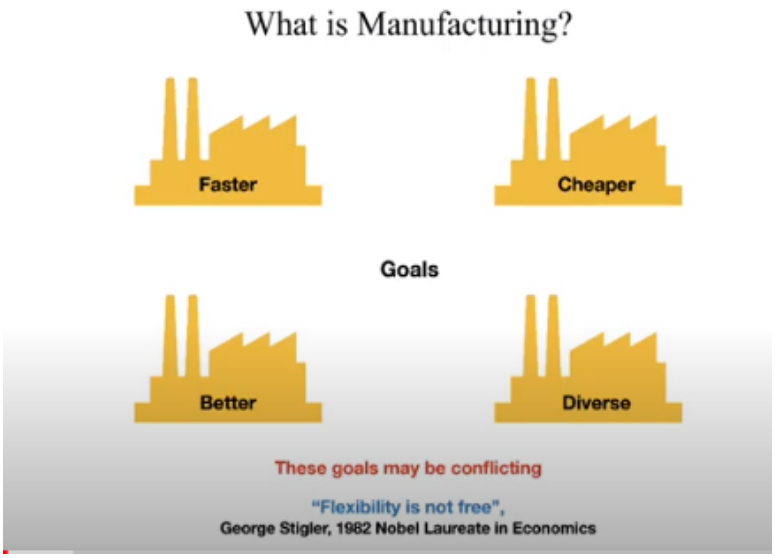

We mentioned about the four important goals. So, you want to make the things faster, cheaper, better and diverse. We also mentioned that these goals may be conflicting and so the flexibility is not free. It means that if you want to have higher flexibility you have to forego. So the tradeoffs will be there among these goals.

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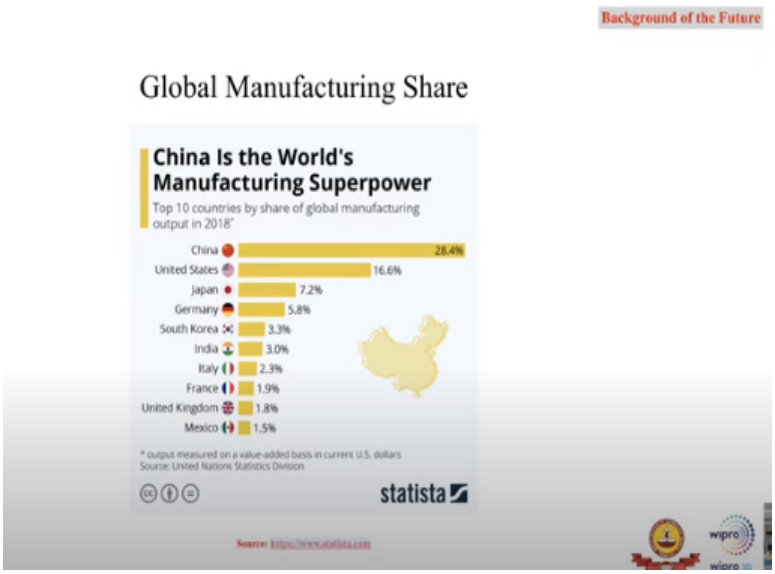

We looked at some macro data. We talked about the increasing importance of China as a manufacturing superpower.

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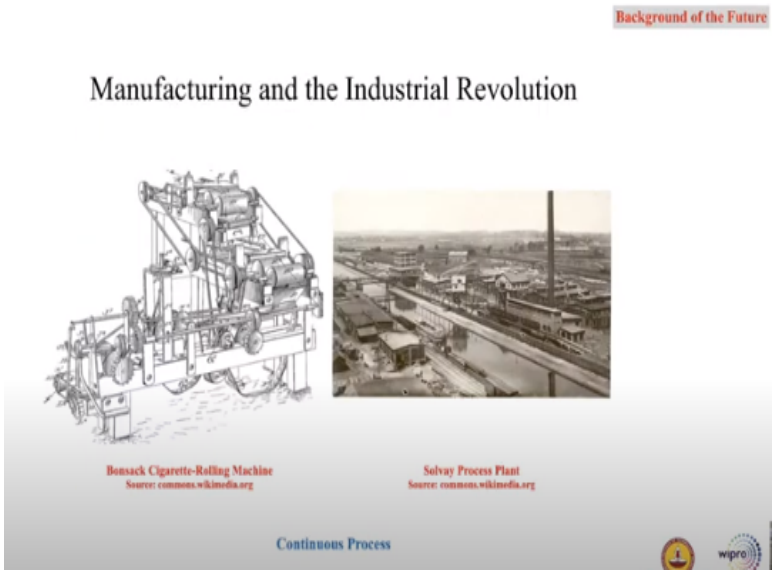

We talked about different manufacturing processes right from the job shop to batch to assembling and continuous.

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We got some wisdom about what is the tradeoff between the volume and the variety, which comes as part of the Hayes and Wheelwright product process metrics and we also mentioned that whether it is possible for technology like additive manufacturing, to actually move that diagonal tradeoff towards something which is technical invisible as of now.

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So, this wisdom and then we talked about different eras of manufacturing right from the mass production to mass customization.

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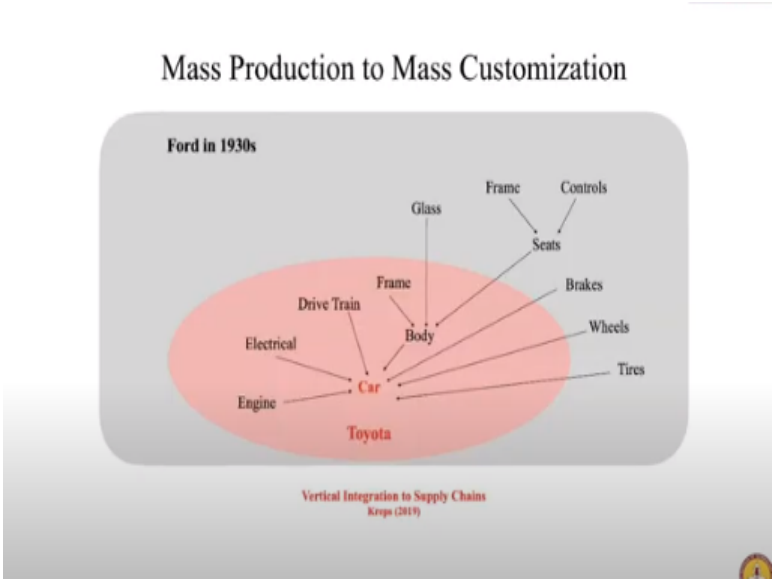

I think this is important, because transaction cost defines the boundary.

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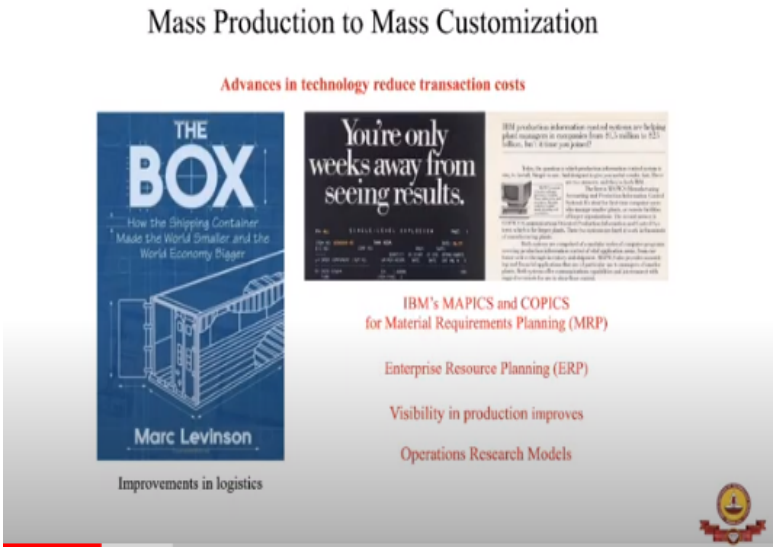

So, whether the newer technology like blockchains can actually redefine the boundaries of the organization. In fact, today's discussion, I will try to talk about the digital supply networks. So, that may be the next level of organization structure in the context of manufacturing. Then, we talked about weather technology of machine intelligence, IoT platforms.

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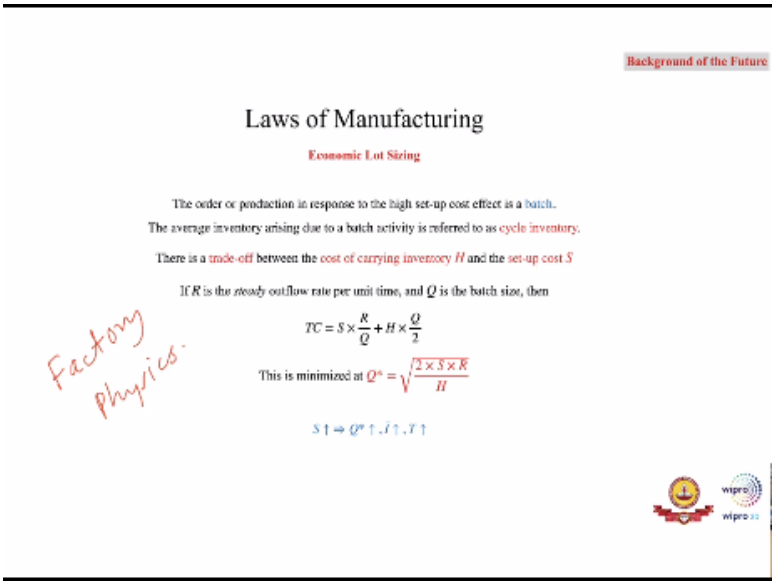

We also had a very brief discussion on the laws of manufacturing, right from the Little's laws to the Kingman's law and if you recall, these laws give you the wisdom, why the status quo is like this. So why you want lower inventory, because that would actually reduce your cost. That will reduce the batch size.

We also talked about how you reduce the setup cost, because setup cost will have direct implication on the batch size and then the Little's law comes into the picture, because if it is the setup cost, your Q* will come down. Your Q* will come down, your average inventory will come down and if your average inventory comes down your cycle time actually improves.

All these things are related, you can actually call it the physics of manufacturing. In fact, if you are keen you can look a book titled Factory Physics. Then we talked about what are economies of scale, economies of scope, the economies of complementarities.

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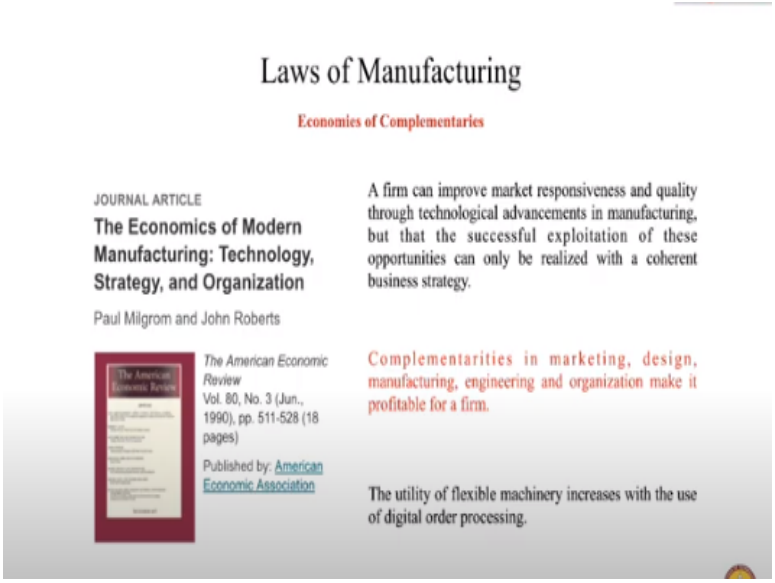

In fact, this point will come again today.

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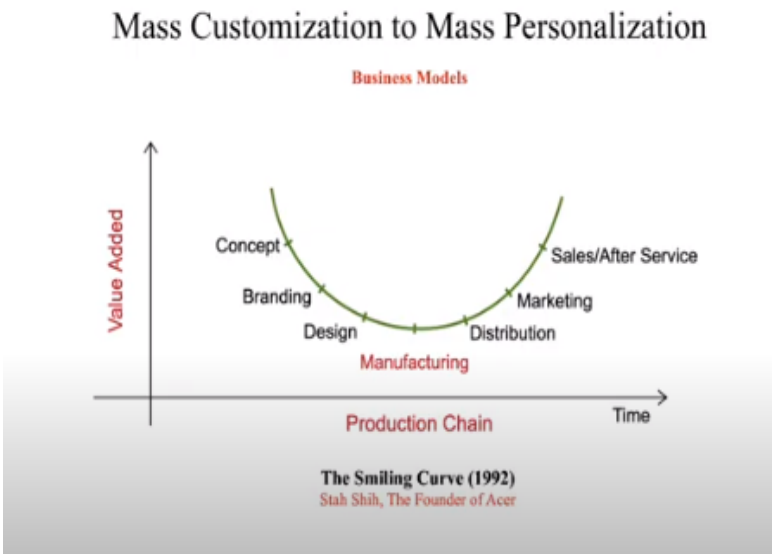

Then we talked about the business models. We also talked about why the servitization as a business model could lead to successful organizations because you can actually see that the value-added part. So, that is part of the smiling curve.

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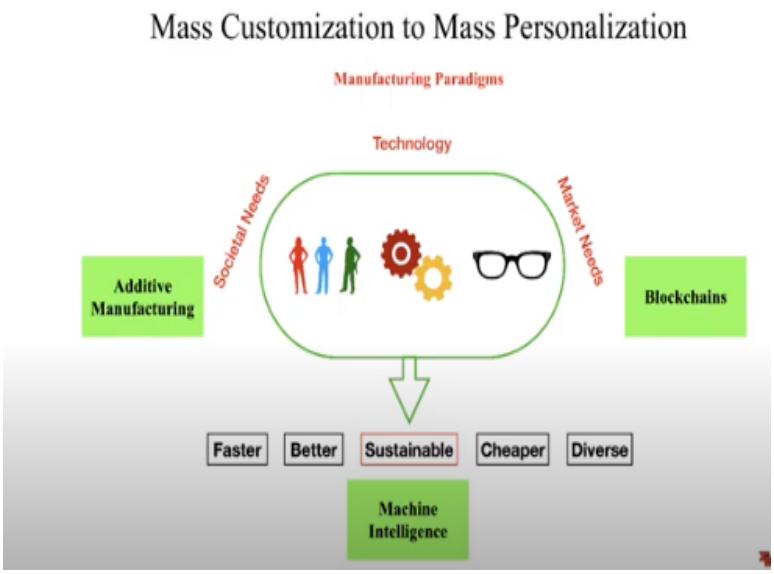

These five goals will still be there and the point here is whether the technology, the societal needs, the market needs, when they converge, how they integrate with the technology to achieve these manufacturing goals.

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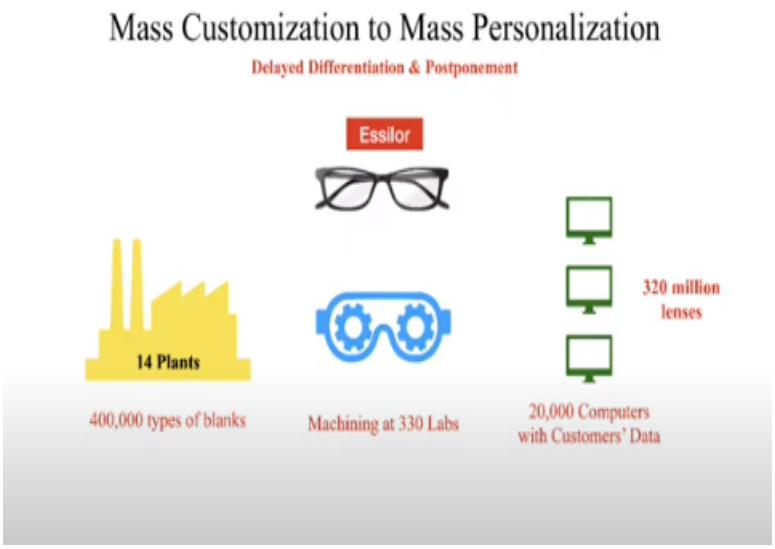

We talked about the mass, when we would go from mass customization to mass personalization, I gave you example of how the technology is actually matching the demand with supply. One example was the delayed differentiation and postponement.

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That is true not just for the eyeglasses, it may be true even for products like a computer. Dell is doing something similar. They call as the vanilla boxes. The configuration of the final product happens closer to the customer. LG is doing something in terms of modularity. Asian Paints, in fact paint is just Asian Paints could be just one example. Other paint companies may be doing something similar.

The main wisdom here is aggregation reduces variability, and minimizing internal variety without compromising the external variety.

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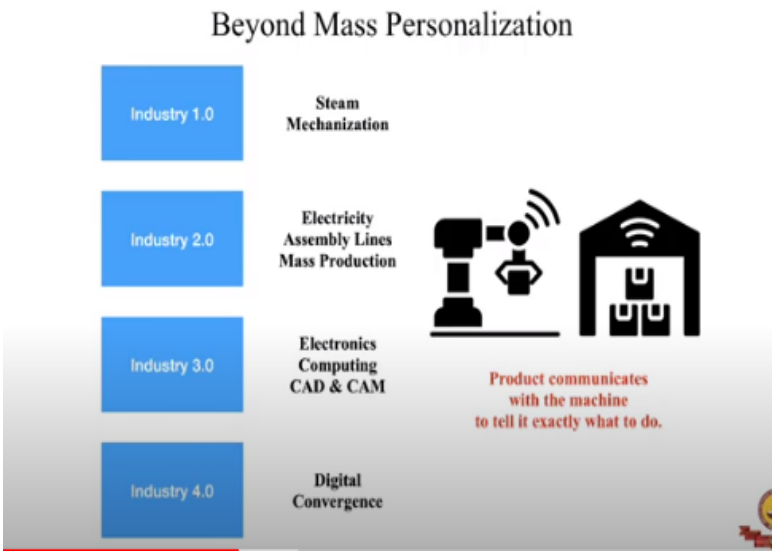

Then we talked about how you actually go beyond this mass personalization and that is where the industry 4.0 part comes in.

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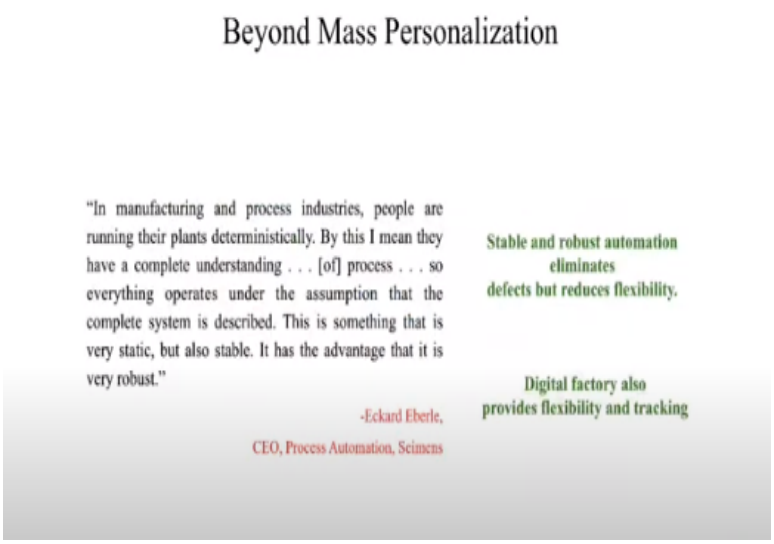

So then, I gave you example of Siemens. We talked about how they are actually, it is not just automation, it is actually going beyond that, and when we talk about digital factory, it actually provides the flexibility and tracking. Remember that this tracking part is still relevant to that how you actually make the process as transparent as possible. So, can blockchain allows us to do that

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This is something which I discussed in the previous sessions. We talked about technology and manufacturing. We talked about digitization and the future of many operations.

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I gave one example of a company like John Deere, which is a major what you call agriculture equipment manufacturer. But now they are actually becoming more like a data analytics company.

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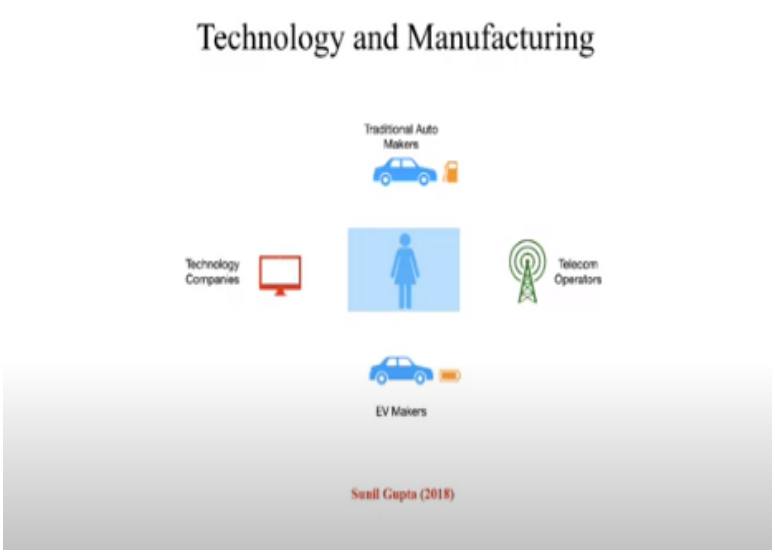

In fact, the whole business paradigm may be changing that. Customer comes at the center, and you can actually see that the traditional OEMs, the electric, EV makers, the technology companies, telecom operators, they are actually making the whole ecosystem. They are becoming part of that ecosystem and so this whole paradigm is actually changing. The customer is at the center now.

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Then I give examples of servitization. You can actually see the lighting as a service as well as compressed air as a service.

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We talked about, briefly talked about Predix as a platform. That is mainly for the predictive analytics and I gave you the insights about how it can be relevant in the context of manufacturing.

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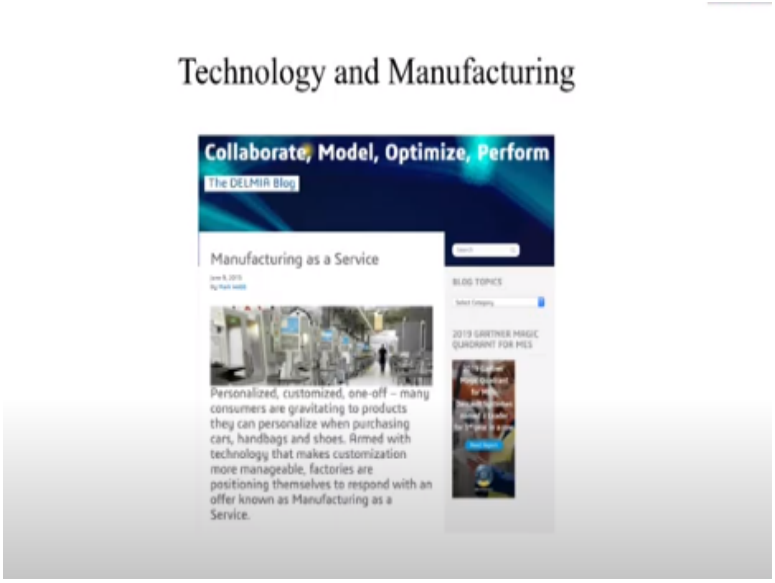

In fact, this should be the most you can say revolutionary idea that you actually say manufacturing as a service. I gave example of where I think one example which I give was of this Voodoo manufacturing, who are looking for servitization of manufacturing, and then we just briefly talked about additive manufacturing.

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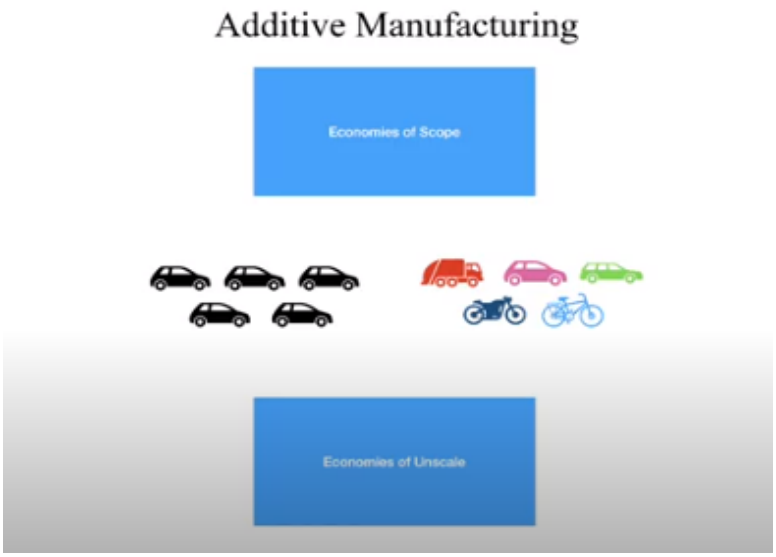

I think Dr. Chandrasheker will cover it significantly, what are the advantages which comes along with it. It brings the economies of scope. It also brings the economies of unscale, which means that the scaled down organization, so that is the new wisdom. The traditional wisdom was always to look for economies of scale and now we are actually talking about the economies of unscale. In fact, today's discussion will cover some part of that also.

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If you recall, we talked about some of the advantages which comes along with it. So, ability to produce complex products, customization, on demand production, reduced cost of inventory, so both the transportation and the inventory. Because in this case, you may be actually producing closer to the customer. And along with it, we could have the design platforms. So today's discussion, I will try to bring some of these issues, maybe in more detail.

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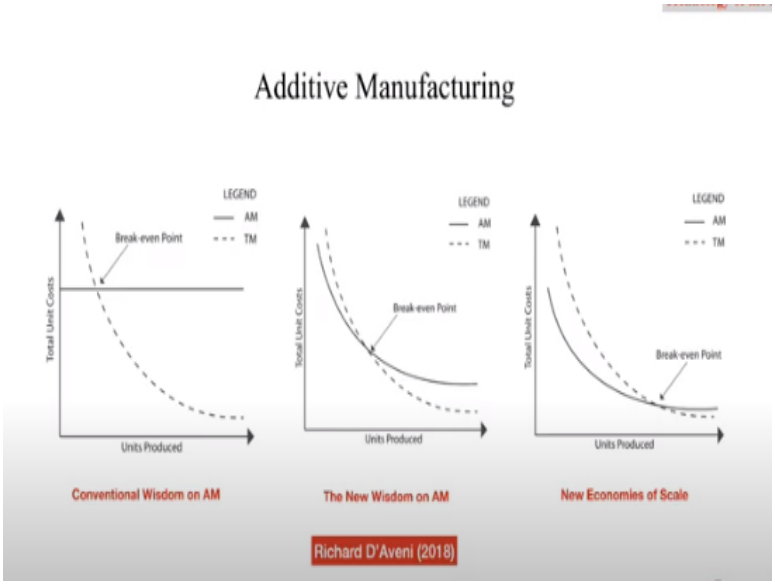

Then we just looked at how economies of scale is related to additive manufacturing. So, remember that this scale part is very important. The traditional wisdom or the conventional wisdom in AM is that for small scale, AM may be better. But for large scale you have to go for the traditional manufacturing. But that wisdom is changing that you would actually see the scale effects in additive manufacturing also.

Some of the reasons so could come because of this. Richard D'Aveni in fact, argued that even this actually can go further. You may actually observe the new economies of scale. The new economies of scale actually mean that even the breakeven point will further go on the right side. If you recall, this is the curve which we discussed as part of the economies of scale that as you keep on scaling the average cost keeps on diminishing.

In this case, in fact the total unit cost you can easily assume like we are talking about average cost. It is not the total cost. So, the breakeven point will actually go further on the right side. This still has to be actually observed. For time being I think, we are still not even at the second part.

But the way the technologies are converging it may happen that we may eventually see the extreme right figure which talks about the new economies of scale.

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So, I gave some examples of NextGenAM.

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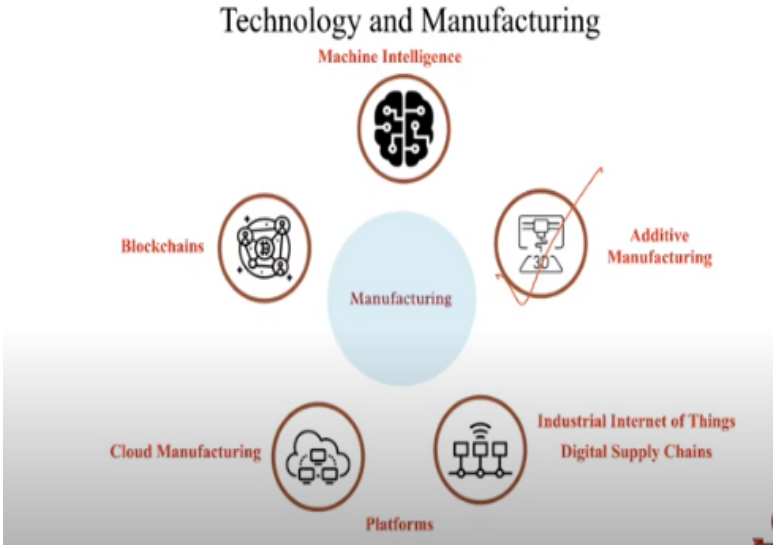

Let me just continue the discussion on technology and manufacturing. Today, I will try to go more into the digital supply networks. I am going to discuss briefly about AI blockchains and with some used cases. So, that actually gives you the complete wisdom for the things are actually changing in the context of manufacturing.

Once my part is over, you would actually see discussion from Dr. Chandrasheker and that discussion would only be confined to the additive manufacturing part. Other things may still come, but the main focus would be on the additive manufacturing and then that will give you the complete clarity on how these technologies actually integrate.

I think because of paucity of time, our emphasis would confine only to additive manufacturing, but down the line it may happen that we may actually come up with the more courses where you would actually see the say, you can actually see future of manufacturing business, the role of machine intelligence where the emphasis would be how you integrate machine intelligence with manufacturing.

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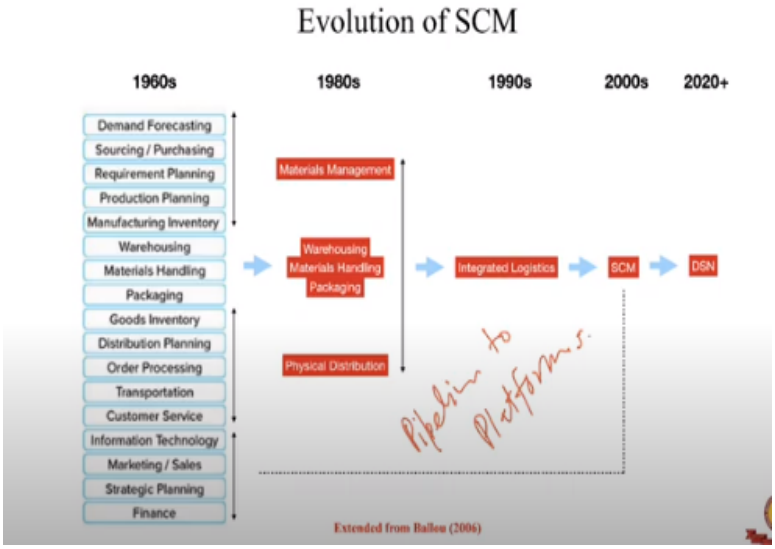

Now I think it is important to understand the context of manufacturing, because in the modern times, you cannot decouple supply chains with the manufacturing, how the things are manufactured. You might have seen the Ford relation and the Toyota relation in that context. I will just give you a brief overview of how the things actually have evolved over a period of time.

Now if you see the 1960s part what is given here, so it actually talks about maybe different functions in a organization right from demand forecasting, sourcing. 1960s if you see the figure, all these things were decoupled. You can actually say the production planning may be different from how you actually put the manufacturing inventory.

Even the requirement planning could be decoupled from the production planning. You can actually see means we still talk about organizations, which are vertically integrated. But these functions are seen in silos. Most of the time, the common term used for some of these things, was part of logistics and the procurement style was because some of these over related concepts developed during World War II.

The thinking was still more like a military kind of a procurement. So, you would still talk about the military kind of procurement in terms of maintenance, transportation. The organizations were not fully realizing the tradeoffs and benefits which actually comes of providing the right good at the right time at the right place. Things evolved in 1980s.

The demand forecasting, sourcing, requirement, planning, production planning, manufacturing and inventory. It converged to materials management and some of the things like goods inventory distribution, they become the physical distribution. In 1990s in fact, you see more integration of the functions and it actually became integrated logistics. So, till 1990s the concept of supply chain was still not there.

Then you actually see the evolution of IT, marketing, strategic planning, finance, and that actually converge to supply chain management. In fact, the modern era would go from even supply chain management to digital supply networks. There is an HBR article, if you get a copy of it, that would be interesting. It is called Pipelines to Platforms.

It means that, so even supply chains are still linear. You have right from the move to make to store and then move. The things would still be linear. That is why it is called a pipeline model or a business model. Now we are actually going to a digital supply network, which maybe you can sit closer to a platform.

That is where this title Pipelines to Platforms. You can actually see that you start integrating ERP systems along with the logistics and that is where the supply chain becomes what we know as Supply Chain Management today. I have taken it from a paper by Ballou, published in 2006. But I think the paper stopped at supply chain management.

DSN part is the new part there. This gives you the context how these things have start getting integrated. It means that you actually see vertical disintegration of the organization. But you actually see integration of the functions maybe the operation functions.

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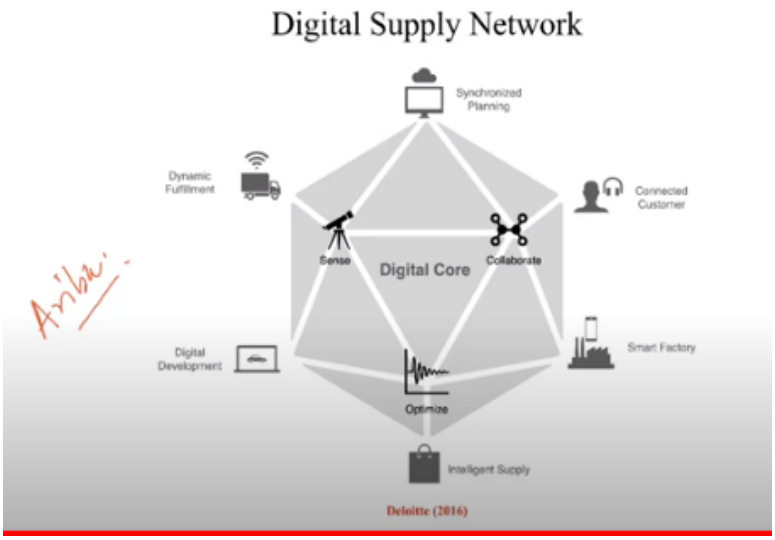

This brings us to what we want to see as part of the digital supply network. The concept of digital supply network actually came from Deloitte. This was a report published in 2006. I have adapted the concept from that report of digital supply network, but you can actually see the six dimensions of this network and the core is called as the digital core.

There are three functions, which comes as part of digital core, which is the sensing, which is the calibration and which is the optimization. It means that you are looking at the sensing of what actually is happening across this network. You are looking, how you can actually calibrate across the network and you can actually do the optimization at the network level.

So, these three things will form the functions of the digital core. But along with that there are six more dimensions, which is synchronized planning. I think let us start with the first one, maybe the synchronized planning. Then we have connected customer. We have smart factory. We have digital development. We have dynamic fulfillment. These six dimensions form the part of the digital code.

Now in traditional supply chains, normally the planning is actually done based on the historical data and the execution and optimization is predefined. What does that mean? It means that, even if any changes happen, the flexibility is not there. This you might have seen in the Siemens example also. Now if any unforeseen changes or some new opportunities occur, the organization is not agile enough.

So, and moreover the customers do not have much involvement in the creation and delivery of the products and the services. I think that is where the concept of the digital core or the digital supply network comes in to mitigate all the issues which comes along with the traditional supply chains. So, you want to reimagine the organization.

If you recall I talked about when we talked about Toyota that from Ford the organization as a start getting vertically disintegrated. Whether it is possible for us to actually have an organization which is even more disintegrated? That is where the digital supply network comes into the picture and what they actually bring is end to end transparency, high levels of agility.

We are talking about connected organization, connected environment. We look at resource optimization and holistic decision making. Now when we talk about the digital development, the capability leverages technology to conceptualize design, and launch products into production, ensuring cross functional calibration through product lifecycle and improving design efficiency to develop high quality products.

It means that we are looking for the development more in the digital form. I gave you an example, a context to this. There is some kind of a law of nature, when we will talk about the new product designs at least in the automotive that only one-third of the products actually become successful. So, two-third of the products actually are not successful.

So, whether this whole digital development where you actually can think even of a connected customer, whether it would actually improve the development part of the product. This is important. When we talk about dynamic fulfilment, in fact, digital deployment should succeed by the synchronized planning. It means that you actually do the whole thing at the network level.

It should not be done at a customer level or at a supplier level. You try to integrate all the suppliers. You want to see how the customer demand is changing. You do the plan based on that thing. Same thing is true, when we talk about the smart factory. You

actually thus the same logic of sensing, call, update, optimize is also to be written at the smart factory levels.

So when we talk about smart factory, we are not just talking about the hardware part of it, we are actually talking more on the software part of it. Data analytics which comes along with it. You actually do a lot of prognosis. You do the tracking of the defects. I will give you the examples of it, where these things have been implemented.

We also should consider as part of digital supply network, the intelligent supply, which means that even I think we talked about that. We shall look at platforms like Ariba where you actually can bring lot of suppliers at your platform. Then you optimize at the platform level. You can actually adopt advanced electronic platforms. So, could be an example for it, for acquisitions and invoices.

I think some examples if it is not well connected, I think when we talk about the used cases, you can easily correlate to what I am saying now. Then one thing which comes as part of dynamic fulfillment so that is at the customer end where you actually enable companies to deliver the right product to the right customer at the right time and then you also have the connected customer.

We talk about customer engagement throughout the customer lifecycle. So, to anticipate better customer needs, enrich the customer use experience. If you recall when we talked about the smiling curve, we talked we mentioned that the most value actually comes after sales. In this case, you actually can remain connected to the customer for announcing the customer experience.

One more thing which becomes critical here is I gave you an example like if you talk about the circular economy, you should know that the vendor the customer is going to discard the product and moreover the customer also knows how the product is going to be taken back. So that will actually come. It is not like you sell something and your relationship stops.

The connected customer suddenly will form a very important part of this whole digital supply network. So, this gives you the context of it.

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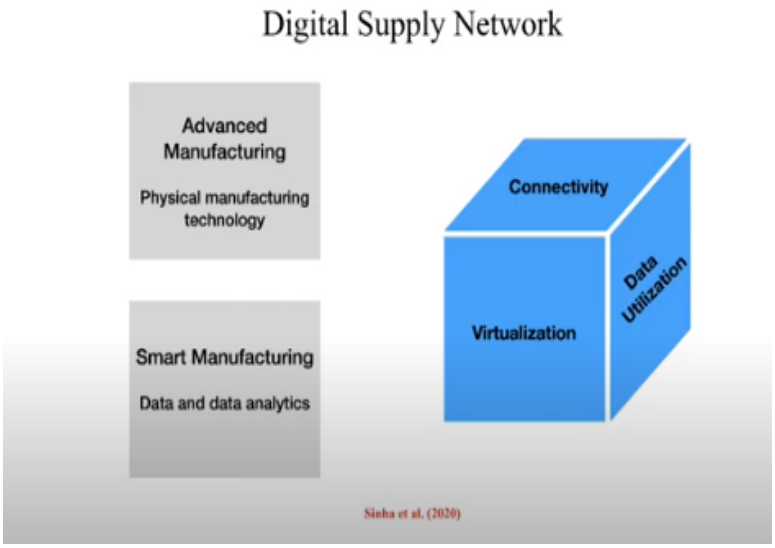

I still have to discuss some more things, which I will do in the next session, which we try to relate to digital twins. We will do it in the next session. Thank you.