

Supply Chain Evolution through Additive Manufacturing

To survive and thrive in the future

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Abbreviations: AM – additive manufacturing
IR4 – Fourth Industrial Revolution

Executive Summary

There were 3 different industrial revolutions that were all instituted by a dramatic change in technology. The first industrial revolution by the steam engine, the second by electricity and the third by the personal computer. The fourth industrial revolution (IR4) is also earmarked by some disruptive technologies and the most disruptive technology is additive manufacturing (AM) or 3D printing.

Since the third industrial revolution, there was also a supply chain evolution where supply chain transitioned from supply to demand and from a linear chain concept to a demand concept. The purpose of this white paper is to discuss the impact of AM on the supply chain evolution and then to propose a new model for supply chain that take into account all the requirements to survive and thrive in the future.

Impact of industrial revolutions and technology on the supply chain

Before the first industrial revolution, manufacturing was based on craftsmanship. The craftsman produced an item, locally in the village and according to the customer's requirements see fig 1.



Figure 1 - Era of craft manufacturing

First Industrial Revolution

The discovery of the steam engine in the mid-1700s earmarked the start of the first industrial revolution. The invention of the steam engine also allowed the creation of a rail infrastructure and the steam boat, where manufacturers could expand their markets and could source material from suppliers on other continents. It also paved the way for the development of new production equipment and expansion of the supply chain.

Second Industrial revolution

The second industrial revolution started in the mid-1800s with the discovery of electricity. Some of the important developments of the second industrial revolution are the production line concept with mass manufacturing where customization became costly and economic order quantities had to be ordered due to the high cost of setup and tooling. This was also the time when work activities were divided into small fragments that could easily be measured and managed for productivity improvement. The 5day, 40 hour workweek as we know it today was also introduced during the 2nd industrial revolution.

Third Industrial Revolution

The third industrial revolution started after 1960 and that was when the personal computer became a tool of trade. People were now connected through basic networks and information could be captured and retrieved much quicker. Although the first discussion about concept of a supply chain started in 1960, the term was only phrased in 1983 by Booz & Allen. During this period supply chains became more complex with an emphasis on global expansion. The complexity in the supply chain manifested in the increase in inventory at each decoupling point to buffer the erratic nature of the demand. See fig 2.



Figure 2 - Complex supply chain

The fourth industrial revolution

IR4 Schwab, K. (2016) started around 2012. The catalyst for all the previous industrial revolutions was a new technological invention. There are a number of disruptive technologies that earmark the 4th Industrial revolution and that will have a profound impact on the supply chain model of the future.

The role technology played in shaping the supply chain model

Technology played a significant role to shape the model for supply chain management. From the inception of supply chain management, the focus was on the supply of products and services to the market based on a push philosophy. With the deployment of ERP and CRM systems, the emphasis moved from supply to demand where the business had to ensure that they can fulfil the requirements of the customer and this was based on a pull strategy. The concept of supply chain was then substituted by demand chain.

Although the word chain indicated a linear interaction Gattorna, J. (2010) of entities linked together the internet created a network of interlinked entities. The emphasis shifted then from demand chain to a demand network Freightwanger, H. (2018). The disruptive technologies of IR4 creates an ecosystem of linked entities working together for mutual benefit. See figure 3 for the role technology played in the evolution from supply chain to demand networks.

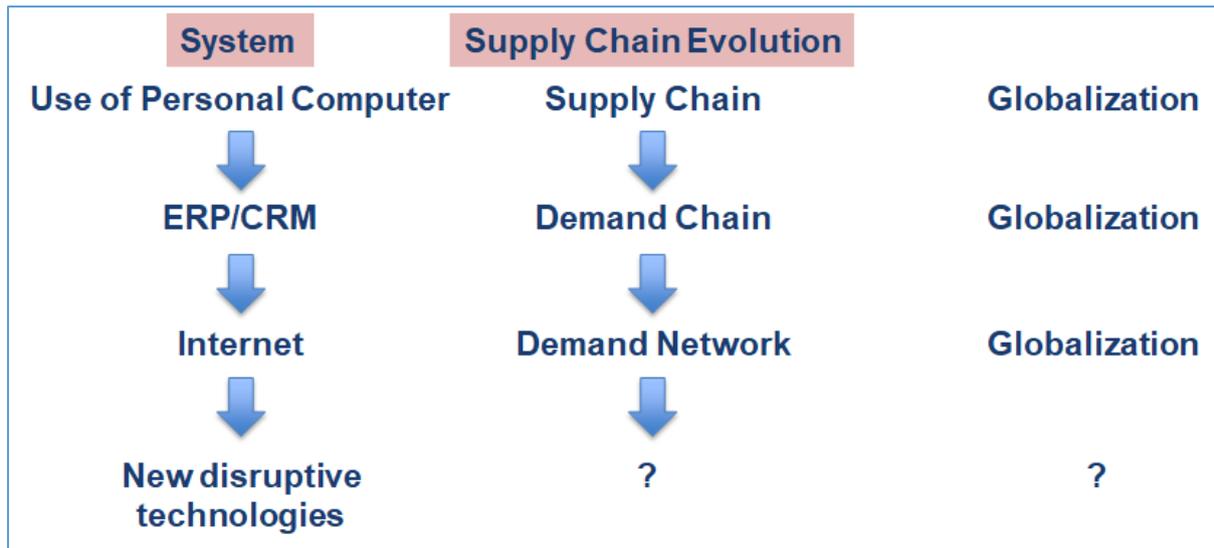


Figure 3 - Effect of systems on supply chain evolution

Disruptive technologies of the fourth industrial revolution

There are nine disruptive technologies that form part of IR4 see figure 4. Although each one of these technologies plays an important part in shaping IR4, AM is the most disruptive of all the new technologies.

Disruptive Technologies of IR4



Figure 4 Disruptive technologies of IR4

What is AM?

AM is the creation of an item by printing material layer by layer. Although it is described as a technology, it is in fact a technology that will be a strategic game changer Zelinski, P., (2019)



Figure 5 - Areas affected in business through AM

Figure 5 indicates all the areas that will be affected by the implementation of AM in the business. This white paper focuses only on the effect of AM on the supply chain and the establishment of a new model for supply chain that will be fit for IR4.

Impact of AM on the supply chain

The focus of AM is to produce items as close to the point of consumption as possible. These items will be customized since customization of items for AM virtually bears no cost. Since items can be produced anywhere, the concept of globalization changes to glocalization. Kraidy, M.M, (1999). This indicates that there is a local as well as a global focus.

There are many more role players whom are participating in this glocal environment. All these entities that form part of the global network interact as part of an eco-system. General Electric used the eco-system concept to obtain a new design for their aircraft engine bracket. They used the Grabcad platform to request submissions for a new design that would be 30% lighter than the current design. They received 700 designs from 56 countries from where they selected 10 designs that they printed and tested. The design that was selected was 84% lighter and the winner was a small engineering company from Saligna in India.

AM as a strategy is not only a new technology but a total disruptive strategy affecting all the components of the business. AM requires a flat, dynamic and agile environment to succeed. It will also create an innovative culture due to the way that AM unleashes creativity and new ways of designing products due to the design freedom that is inherent part of AM. The new simulation software that is available allows manufacturers to simulate a number of scenarios and then optimize the design before it is printed. AM will significantly shorten lead times and will reduce the complexity in the supply chain. See figure 6.



Figure 6 - Effect of additive manufacturing on lead time and complexity in the supply chain

Since the emphasis of supply chain remain on supply and the chain concept emphasises the linear nature of the supply chain, it is required to look at a new concept that will encapsulate the

requirements of the future. This new model should focus on the agility Bollard, A. et al (2017) required to operate in the eco-system, the demand requirement to satisfy the customers and the importance of the network where multiple entities are linked together for mutual benefits. The technology of IR4 transform the demand networks into agile demand networks suitable to be agile and nimble in the glocalized eco-system. See figure 7

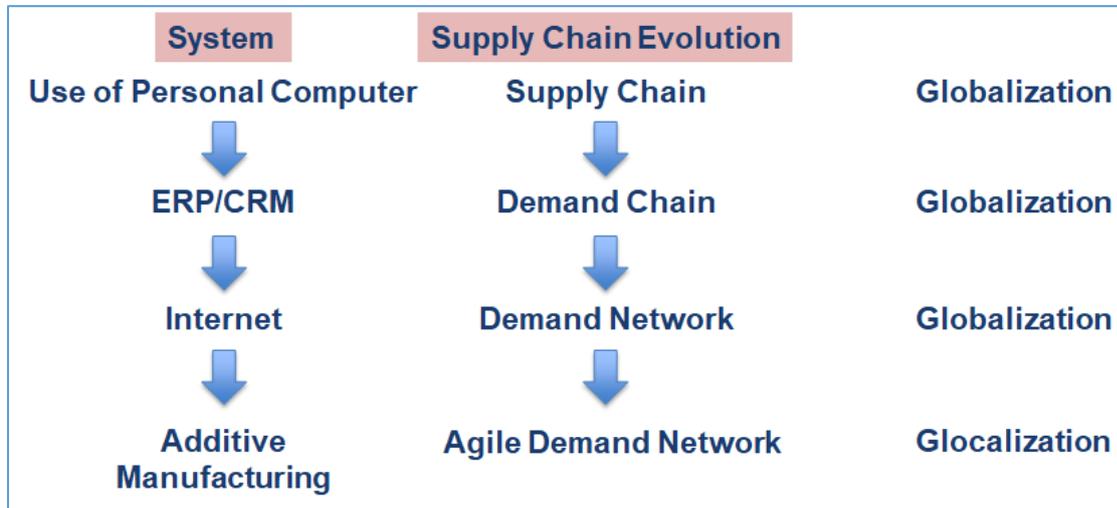


Figure 7 - Evolution from demand network to Agile demand network

Table 1 is a summary of the requirements to move from a linear supply chain to an Agile demand network.

Table 1 - From supply chain management to agile demand network

From Supply Chain	To Agile Demand Network
Globalization	Glocalization
Multiple warehouses	E-warehousing
Complex supply chain with many decoupling points	Agile Demand Network with very few decoupling points
Produce parts at lowest cost location	Produce parts close to point of consumption
Inventory obsolescence	No inventory obsolescence
EOQ	Single item - customization
Long lead times	On demand at point of consumption
Lowest cost	TCOO (Total cost of ownership)
Fragmented information	Real time visibility
Focus on linear processes	Focus on eco-system integration
Functional specialization and silo management along supply chain with emphasis on supply	Processes based on dynamic, agile eco-systems and cross functional interaction with emphasis on demand

Summary

There are so many changes that will take place when an organization starts to implement AM. The impact on the business will be profound and new business models will emerge. It is therefore suggested that a new model for supply chain is also adopted to emphasise the focus on the agility of the market demand through the integrated dynamic participation in the eco- system/networks. This new model is an agile demand network.

SPEAKER/S PROFILE/S + PHOTOGRAPH

Henk Harmse has obtained a honors degree in Industrial Engineering from the University of Pretoria and an MBA from the same university with the thesis on Agile Manufacturing. He has a successful track record for the design and implementation of Supply Chain strategies and systems in local as well as global companies. He is passionate about the impact of Additive Manufacturing to transform businesses and Supply Chains and to ensure that they thrive in the Fourth Industrial Revolution. Henk is currently busy with his PhD in Industrial Engineering at the North West University with the title : Develop a new business model for the implementation of Additive Manufacturing in Asset Management.



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