An Overview of Industry 4.0 Means To Supply Chain

Kamble P. R.[1], Potdar D.G.[2], Kavatkar T.V.[3], Mangaonkar K.R.[4]
[1, 2, 3] Dept of Mechanical Department
[4]Assistant Professor, Dept of Mechanical Department
[1, 2, 3, 4] FAMT,Ratnagiri

Abstract- *The vision of Industry 4.0 accentuate the global networks of machines in a smart factory setting capable of autonomously exchanging information and controlling each other. The term 'Industry 4.0' was coined to mark the fourth industrial revolution, a new pattern enabled by the introduction of the Internet of Things (IoT) into the manufacturing environment. By employing Cyber-Physical-Systems and real-time interconnection in industrial value creation, the term Industry 4.0 expresses direction towards a fourth industrial revolution. Current research theme of Industry 4.0 mainly focuses on manufacturing itself or on production-related logistics and supply chain processes. However, interconnection across the entire supply chain is required to successfully obtain the potentials estimation for Industry 4.0 Still, supply chain management been barely investigated by current research in contrast to results based on Industry 4.0 in production.*

Keywords- Supply Chain Management, Industry 4.0,Internet of Things, IoT.

I. INTRODUCTION

The term Industry 4.0 is coined by political institutions and industry associations in Germany, expressing the opinion that industrial value addition is heading directed towards the fourth Industrial Revolution. The previous three Industrial Revolutions were driven by three main technologies: electricity, mechanization and IT (Vezaet.al.,2015). These technologies, also described as general-purpose technologies, and hence resulted in strong technical improvements and increased productivity after its introduction (Bresnahan,1995).For Industry 4.0, the general-purpose technologies arecyber-physical systems, which impart on the Internet of Things (Lasi et al., 2014). Lee et al. (2015) explained two outcomes of CPS: connectivity between data collection and analysis and the physical and virtual worlds. Cyber-physical systems gives mechanisms for object-to-object and human-to-object interaction (Wan, 2011), whereas their combination in industrial manufacturing related field can be termed as cyber-physical manufacturing systems (Schlechtendahl et al., 2015).

The utilization of cyber-physical systems in industrial logistics, production and accompanying processes offers different potentials, such as remote diagnosis, real-time condition monitoring, prognostics and remote control (Lee et al., 2013). Further potentials include continuous optimization, self-organization, error predictability and exceeding the boundaries of industry to its customers and suppliers, as well as across functions. This interconnection in real-time is also deliberate along the entire product life cycle, value creation, interconnecting, value consumption and recycling (Monostori, 2014; Lennartson et al., 2010). Both experts from practitioners and academics expect a high potential for different industry branches as well as complete supply chain system through Industry 4.0 (Kagermann et al., 2013).

For supply chain and logistics management, multiple potentials come along with the need for new processes and logics of value addition, for which the need for organizational transformation is analyzed (Tan et al, 2015; Zhou et al., 2015). By using new technologies in the content of Industry 4.0, foremost CPS and time, real-time interconnection and effort can be reduced within complete supply chains (Ivanov et al., 2016). However, these approaches require interconnection solutions and intelligent automation at minimum costs (Kolberg & Zühlke, 2015) as well as standardization along complete supply chains (Weyer et al., 2015).

II. FUNDAMENTALS OF 4.0

Industry 4.0 specifically involves a revolutionary shift in how production shop floors currently operate. Defined by many as a global transformation of the manufacturing industry by the introduction of the internet and digitization, these transformations consider radical improvements in the system, design and manufacturing processes, operations and services of manufacturing systems and products. Though coined in Germany, the opinion of Industry 4.0, to a huge extent, shares correspondence with developments in other European countries where it has been classify differently, for instance Smart Industry, Smart Factories, World Class Manufacturing or Industrial Internet of Things.

A smart factory is referred to as the use of new innovative methods in digital technology including "advanced robotics and artificial intelligence, cloud computing, hi-tech sensors, data capture and analytics, digital fabrication (including additive manufacturing), software-as-a-service and other new advertising models, mobile devices, platforms that use algorithms to direct automobiles (including ride-sharing app , navigation tools, delivery and ride services), and the embedding of all these contents in an interoceptive global value chain, shared by many industries from many countries”. Within the context of Industry 4.0, the factory of the future will enable the inter-connection between human-beings machines in Cyber-Physical-Systems. These new systems emphasize their resources on the introduction of industrial processes and intelligent products that will allow the industry to face rapid changes in shopping patterns and many other things.

Because the term Industry 4.0 is introduced, still, has not yet been purely defined, neither are its features and aspects; nonetheless, mostly, among others there are four main features.

- Vertical networking of smart production systems: This type of networking is based on CPSs to build adaptable factories that react rapidly and flexible to changes in the customer demand. Production processes in a smart factory accredit the true mass customization. It enables “not only autonomous organization of manufacturing management but also maintenance or repair management. Products and resources are networked, and materials and parts can be relocating anywhere and at any time. All processing stages in the manufacturing process are logged, with variations registered automatically”.
- Horizontal integration through a new generation of global value chain networks [5]: The implementation of the CPS within the smart factory requires business models, strategies, networks to accomplish a horizontal integration, which subsequently provides expected levels of flexibility, enabling the company to react faster. The transparency within the value added things allows the producer to identify changes in customer demand and to reflect them in all of the production steps, from development to supply.
- Through-life engineering support across the complete value chain: Technical improvements and innovation in engineering are present in the design, development and production processes. These enable the development of new product and manufacturing systems utilizing a large amount of data and information (big-data).
- Acceleration through exponential technologies: The implementation of innovative technologies enables companies to increase productivity, reduce costs, flexibility and customize the product. Industry 4.0 involves automated systems including Artificial Intelligence (AI), robots, drones, and variety of inputs that enable customization, rapid manufacturing and flexibility

III. RESEARCH METHOD

The research described in this paper has largely been carried out via a desk-based study using various types of literature as primary data sources, including scientific papers, journals, articles. The initial step to be taken was to better understand the features of SCM by identifying its components and KPIs for each of the elements. A review of SCM was then performed to understand the scope in which the supply chain has already been tied with Industry 4.0. The purpose was to concentrate on the analysis in these areas. Once the areas have been formed, the KPIs, also known as effect of variables, used to evaluate the indications of different new technologies for these areas were analyzed. The next analysis was to examine the impacts of the transition in technology on each KPI. The opportunities and risk exhibited in each of the technologies for each of the KPIs were then discussed by linking them with each and every area of the SCM under study. Finally, in order to support all the propositions made in the other stages, a hypothetical example of a supply chain with different KPIs which have an influence on the current state of the system was developed.

IV. ANALYSIS

Regardless the industry sectors, cooperation between the different functions involved in the supply chain is necessary. However, depending on the contents of business and final products or services supplied to the consumers, these functions can be diverse. The coordination and integration of all the processes in the supply chain is crucial to fit the supply and demand. Figure 1 shows the four supply chain levers considered for this research. These levers are these areas, KPIs are defined in order to obtain quantifiable measures to differentiate if there are changes over time. The highlight these KPIs is, however, rather complex because there are no clear outlines between the levers. For instance, by ordering larger quantity of raw materials, the customer demand cycle could be reduced, similarly reducing procurement and delivery costs. However, warehouse storage costs could increase due to the growing inventory and materials level.

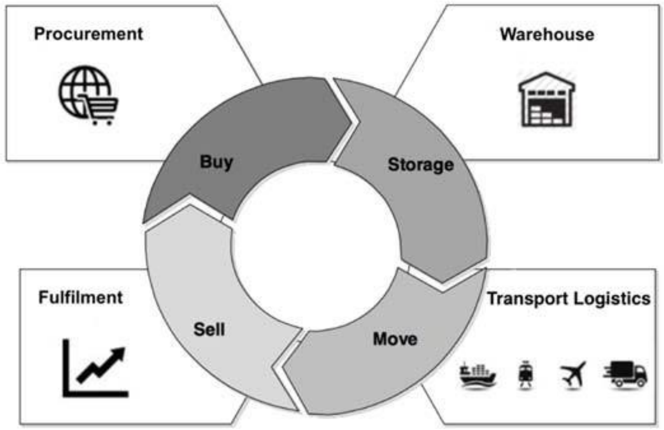

Fig.1- Supply chain levers.

The "buy" lever mainly involves purchase. It is the business lever in charge of all the processes and tasks necessary to procure services or goods from suppliers. The performance elements are, for instance: standardize quality of the raw materials, rejection rate, level of service, order accuracy etc. The term "make" means the manufacturing of goods or creation of services. It defines the operations required to convert inputs into outputs or final products. The inputs are the raw materials, other resources, technologies and data needed, and outputs are what the customers receive from the industry. Nonetheless, within the scope of this paper, the production function has been excluded. The term "move" refers to the transport logistics that are responsible for delivering supply and transporting inventories from one place to another at the perfect time. The KPIs to be analyzed are for: truckload capacity, turnaround time, shipment, on-time picking, on-time delivery, etc. The "sell" or fulfillment process ensures the orders are supplied within the committed schedule. This function of the supply chain generally makes a appropriate difference between industries, as its depend on their reliability and the on- time deliverable. Correct order fulfillment management enhance both gaining market share and maintaining current customers.

V. RESULT

Industry 4.0 signify changes in the way companies work and organize themselves. Currently, there are many theories about the general reverberation of Industry 4.0; however, there are only some stipulated examples of the impacts on SCM. For this reason, with the entire objective of evaluating the opportunities (and possibly threats) as a result of the introduction of Industry 4.0 at every function of the SCM selected, this theoretical analysis has been mentioned.

Table 1. A template to list the technologies potentially impacting the KPIs.

Technologies	Impact?	If Yes, Why?
Virtual and augmented reality		
Additive manufacturing – 3D Printing		
Simulation		
Big Data analytics		
Cloud technology		
Cybersecurity		
The Internet of Things		
Miniaturization of electronics		
Automatic Identification and data collection (AIDC)		
Radio-frequency Identification (RFID)		
Robotics, drones and nanotechnology		
Machine-to-Machine Communication (M2M)		
Business Intelligence (BI)		

analysis of how each KPI was affected by many technologies was first carried out. The next step was the creation of propositions. Based on the results obtained, the research analyzed the opportunities for each function in SCM. In order to link each technology with each KPI, an starting template was built (Table 1).

Table 2. KPI affected by the technology – Warehouse. KPI: Reduction in truck time at the dock

Technologies	Impact?	If Yes, Why?
Virtual and augmented reality	YES	It standardises how to perform the different processes involved when the truck arrives at the dock. It enables the reduction of the time.
Additive manufacturing – 3D Printing	NO	-
Simulation	NO	-
Big Data analytics	NO	-
Cloud technology	NO	-
Cybersecurity	NO	-
The Internet of Things	YES	All the devices and sensors enable the obtaining of data that can be used to increase the efficiency of the load and unload of the truck. It would result in reducing the time the truck is at the dock.
Miniaturization of electronics	YES	By using these elements, there is no need of checking the quality of the products received or the ones which are going to be delivered. This occurs because it is known in advanced the conditions of the products transported. It avoids "last time surprises" like inadequate quality or non-compliance of requirements.
Automatic Identification and data collection (AIDC)	YES	The exact position where items are located/need to be located at the truck are known in advanced. Moreover, the location and position of items inside the truck is also pre-established. It enables to save time.
Radio-frequency Identification (RFID)	YES	The exact position where items are located/need to be located at the truck are known in advanced. Moreover, the location and position of items inside the truck is also pre-established. It enables to save time.
Robotics, drones and nanotechnology	YES	Loading or unloading is done more efficiently and safely, for instance being able to transport different products of different sizes with one single pallet truck.
Machine-to-Machine Communication (M2M)	YES	It helps for instance to know the type of truck arriving with the number of carriers, the amount of items and the type of product among others. By using this information plan the materials required to unload or load in advanced is possible.
Business Intelligence (BI)	YES	By using all the information collected from different sources of the organization, it can be reduced the time the truck is at the dock by having all materials required in advanced. Helps to plan automatically and change plans if unexpected situations occur.

With the main objective of assessing whether there were "changes" or not, nouns were added to most of the KPIs to make them more effective. The nouns were added based on what every company expected to improve for cost reduction and increase benefits. For instance, the KPI "Truck time at the dock" now converts to "Reduction in truck time at the dock". In this way, 'YES' was added in case the introduction of the new contents of technology would affect (positively or negatively) the KPI. Similarly, 'NO' was added when the KPI not affected. Finally, the third column is filled only if there is an effect to the KPI. In such cases, the arguments or examples of why the technology having effect of the KPI will be described. Table 2 shows an example of how to use the template for detail analysis.

Once this process was done for each of the KPIs, general tables† (like in Tables 3) created for each area (e.g. warehouse and transport logistics), giving details of which technologies affected that specific area of the SCM; √

represents the YES mentioned as above .So far, the tables already explained for which technologies affected in which areas; however, there was no indication if this “change” was an opportunity or a risk.

Table 3. Technologies vs KPIs – Warehouse.

	Reduction truck time at the dock	Accurate receipts received	Reduction time from receiving to pick location	Increase putaway per man hour	Inventory storage per square foot	Consumable usage	Reduction labour hours consumed per order	Reduction time from picked order to departure	Reduction times running out of stock
Virtual and augmented reality	√		√	√	√		√	√	
Additive manufacturing – 3D Printing							√	√	
Simulation								√	
Big Data Analytics						√	√	√	√
Cloud technology		√							
Cybersecurity									
The Internet of Things	√	√	√		√	√		√	√
Miniaturization of electronics	√	√			√	√		√	√
Automatic identification and data collection (AIDC)	√	√	√		√	√		√	√
Radio-frequency identification (RFID)	√	√	√		√	√		√	√
Robotics, drones and nanotechnology	√		√	√	√		√	√	
Machine-to-machine communication (M2M)	√		√	√			√	√	√
Business Intelligence (BI)	√	√	√	√	√	√	√	√	√

VI. CONCLUSION

From the analysis performed, it can be seen that the implementation of relevant technologies, such 3D-Printing, augmented realities and simulation, results will all result in opportunities. On the other hand, , cloud technology, big data analytics, cyber security, the IoT, miniaturization of electronics, AIDC, RFID, robotics, drones, M2M and BI could be opportunities or threats for the industry. The fact that some technologies can result in both of opportunities and threats is because all the variety of areas are interconnected, with no clear boundaries between, depending on where it was analyzed mostly, it could have a positive or negative side. Some clear benefits can be significantly identified from the implementation of Industry 4.0. The most relevant benefits are increased flexibility, quality standards, productivity and efficiency. This will enable mass customization, allowing companies to meet consumer demands, creating value addition through constantly introducing new product development and services to the market. Moreover, the collaboration between humans and machines could socially impact the life of the operators of the future, especially with respect to perfect decision making.

Despite the fact that the impacts of Industry 4.0 have been discussed in this paper content, due to its theoretical and descriptive nature, there remain some questions to be answered which sets limit the generalize ability of this paper, not only in its implementation, but also for its proper management. We therefore call for empirical research in this area. Due to the fact that the implementation of these technologies will be associated with new environment where people work with machines, we believe that legal aspects, insurance, liabilities and ethics should be considered. This paper has been our initial attempt to support organization in better understanding the implications of Industry 4.0 and its relevant technologies regarding the achievement of the Digital Supply Chain or Supply Chain 4.0. Our work continues with some speculative work and assessment of how companies can digitally integrate their supply chain.

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