Industry 4.0 in Supply Chain

Identifying & Overcoming the Challenges of Industry 4.0 in Supply Chain Management – An Empirical Research Study

by
Praveen Vadivel
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Table of Contents

List of figures

List of tables

List of abbreviations

CPS	Cyber - Physical System
IoT	Internet of Things
SME	Small and Medium Sized Enterprises
SCM	Supply Chain Management

All abbreviations that you use in your text must be introduced the first time they are used. Abbreviations that you can find in a standard dictionary are excluded from this rule.

Abstract

This Research paper focuses on identifying & countering the Challenges of Industry 4.0. Although Industry 4.0 has been a boom of the century, the underlying challenges still need to evaluated and counter measure must be taken in order to have long-term goals satisfied. Therefore, first part of the research focuses on identifying the key challenges and then second part of the research has been dedicated to counter measure. The research contains serious of interview ranging from Industry 4.0 experts to end user of these technologies to validate the identified challenges and counter measure. Thus, the research has a practically backed evidence and real time problem scenarios have been well documented through the course of research. Therefore, this research points out six quantified and qualified Industry 4.0 challenge cluster. They are 1. Economic Challenges, 2. Technical Challenges, 3. Competency Challenges, 4. Cultural Challenges, 5. Managerial Challenges 6. Collaborative challenges. Thus, the identified counter measure falls into four areas of system of Innovation. They are 1. Role of Central Government 2. Co-operation of State Universities and Industries 3. Role of State Government in Promoting Technology Fairs 4. Role of Company Management and Unions. This research also a Supply Chain Limitation which must be considered. Therefore, the research serves as a base guideline for companies in knowing the challenges and provides a direction for the mitigating these challenges through System of Innovation.

1. Introduction

In the recent years, the word ‘Digital Revolution’ has taken the world into its swirl. The application of this new technology has had significant impact on the lives of every individual, ever since its existence. This new beginning of Internet era, which means the convergence of physical object to real world using cloud technology, has proven to offer immense wealth to its right users (Kagermann, 2015). Often referred to as the ‘Fourth Industrial Revolution’ has shown significant impact in all the fields such as Medicine, Energy, Mobility Household, Manufacturing and health (Ströhle & Flath, 2016). This new technological advancement has not only offered us man-machine interaction but also machine-machine interaction (Stock & Seliger, 2016). The manufacturing industry often involves several integrations of different global Organisations. The use of intelligent product and system to integrate these Organisations together into single value creating network, referred to as the ‘Industry 4.0’.

Since its existence, the ‘Industry 4.0’ is a major topic in all-manufacturing sector. As this can provide a significant advantage to any Organisation, the technology has been at the centre of market for the past few decades (Working Group Industrie 4.0, 2013). There have been numerous amounts of research dedicated to this new technology in discovering its hidden true potential. Industry experts and Industrialist have taken step to push their step ahead towards their Industrial future. The ‘Industry 4.0’ was the most spoken topic in the recent year, despite other global issue, thereby showing its global importance (Schwab, 2015).

While studying about the Industry 4.0, it is important to understand the facts behind this huge market buzz. Although, there are numerous surveys on Industry 4.0 and its implication, some of the key surveys are mentioned here. As accessed, there would be cost of 28 billion Euro in the year 2016 to 2020, due to successful adoption of Industry 4.0 in the automotive sector. In addition, there would also be 2.6% reduction in annual

inventory level ("Winning with the Industrial Internet of Things", 2015). The Surveyed 35% of companies adopting Industry 4.0 expects their growth by at least 20% in the next five years. Not surprisingly, 33% of the business adopting the Industry 4.0 said to increase their revenue to 72% almost doubling in the year 2020 (Columbus, 2016).

Although the Industry 4.0 sets to spin around the manufacturing industry, it also has other important impacts across the everyday lives. It is necessary for us to understand the real hidden potential of Industry 4.0 and its importance in our everyday lives. However, Industry 4.0 has its strong roots in Supply Chain & Manufacturing, it also encompasses the business operation, strategy, workforce and as well the society (Cotteleer & Sniderman, 2017). It makes us rethink the way we are doing our normal everyday lives. Means, it can change the way in which the product is made (Automation robots, Production plant automation), how we communicate and analyse things (Big data & advanced analytics), and how we store things (Warehouse automation, Cranes, RFIDs) how we move things (AGVs & Logistics Automations). Therefore, the Industry 4.0 will foster higher flexibility, transparency and more connected platform for the companies to interact. In turn, this will alter the existing business model, transform economy, and revise company strategy. Additionally, paving a way for new working style and innovative society (Rüßmann et al., 2015).

For the past few decades, the Companies are more involved in researching the positive impact of ‘Industry 4.0’. Due to this, there have been numerous researches focusing on the advantages of these next generation technologies. Thus, these vibrant contributions have already offered the scientist / Industry specialist / Companies a deep knowledge on the technical aspect of these devices (Oesterreich & Teuteberg, 2016). Although, the major technical research is necessary, there are also other aspect of these devices, which remain sparsely researched. Organisations willing to be a part of this digital future faces multiple challenges in successfully implementing across the entire value chain (Schneider, 2018). The challenges faced when adopting these technologies are vast and highly unexplored. Therefore, a significant amount time needed to explore

the hidden challenges that often serve as a barrier for successfully adoption these technologies (Orzes et al., 2017).

Scholar and Industry experts should know the challenges that they might face while implementing these technologies rather focusing on the advantages alone (Cotteleer & Sniderman, 2017). Therefore, this research aims to identify the challenges that companies might face when implementing Industry 4.0. This research also aims to identify the ways to overcome those challenges as a part of recommendation. The research is Empirical backed by high profile research journals. Some additional information is also drawn from Industry 4.0 articles written by experts and scholars. In addition, this research study also backed by some fruitful interviews from Experts. The participants of this research include the Industry 4.0 Experts, End user of these technologies, Industry 4.0 consultant, Authors along with the manufacturers of these technologies itself. The participant of this Interview comes from distinct and international background like United States of America, Germany and India. Thereby, this research can serve as a solid information base for companies from both developed and emerging economies that are un-aware of the challenges that might come up along with the Industry 4.0 boom.

Analysed Research Paper / Articles / Books / Interview clearly point out the fact that challenges could be viable from different areas of supply chain. Therefore, the research classifies each identified challenge into six clusters. They are 1. Economic Challenges, **2.** Technical Challenges, 3. Competency Challenges, 4. Cultural Challenges, 5. Managerial Challenges 6. Collaborative challenges. Then, each of these identified challenges are studied in a detailed Interview with Industry Experts. Therefore, the Interview serves as the quantifying / qualifying medium for the identified challenges.

Finally, using literature reviews, a logical solution drawn for overcoming each of these identified challenges.

The research is structured as follows. Firstly, the Literature review of Industry 4.0 and its impacts in Supply chain is proposed along with other surrounding factors. Secondly, the methodology of this research is cleared mentioned. Thirdly, the identified and qualified challenges from the literature and Interview are systematically explained. Fourthly, a part of the research also dedicated to identifying the ways to overcome these challenges. Finally, conclusion drawn from the research is pointed out which can serve a guideline for the companies / Industry expert / future journal article. Finally,

Keywords: Supply Chain Management **-** Industry 4.0 - IoT **-** Challenges - Barriers - Technologies - Strategy - Impact - Connected Industry.

2. Literature Review

In this section of the research, the topic of Industry 4.0 is briefly introduced along with the other supporting factors, which related Industry 4.0 and Supply chain.

2.1. Industry 4.0 & Impacts

Industry 4.0 is one of the most common terminology used in the recent decades. The term ‘Industry 4.0’ first originated from the initiative of German government trying to automate their Production and Logistics process (Schröder, 2017). Due to its immense potential ‘Industry 4.0’ has almost gained the entire attention of world of scholar and Industry experts (Liao et al., 2017). In order to understand the concept of ‘Industry 4.0’, it is first good to look at all the four revolution. First Industry revolution is coming into market, immediately after the introduction of steam powered machine. During this time, a lot of production happened with help

these newly build engines, which can produce at faster rate than traditional man production. Second industrial witnessed the use of science and electricity into manufacturing environment. Third industrial revolution brought a sense of automation into production and distribution environment. Currently we are the Fourth Industrial revolution. As the most advanced system of all the time, this revolution depends heavily on the use of Cloud, Cyber physical system (CPS) & Big data (Duarte & Cruz-Machado, 2003). Experts also refer, Industry 4.0 as the platform connecting digital world along with the physical world and the process accompanied with it (Cotteleer & Sniderman, 2017).

Industry 4.0 has proven to affect all areas of the Supply Chain. The four main areas of its major impacts are identified as follows,

Productivity: Industry 4.0 has said to increase the Productivity of all manufacturing sectors from 90 billion to 150 billion in Germany alone (Rüßmann et al., 2015). It also has it impacts on effective asset utilisation and reduction of downtime of the machines. Efficient use of Industry 4.0 could bring stability in Supply Chain network and therefore, reducing cost and other key attributes. It has its major influence in term of providing transparency and thus in turn affect the collaboration between companies in Supply Chain (Cotteleer & Sniderman, 2017). Additionally, it also drives direct and indirect labour efficiency (Oesterreich & Teuteberg, 2016). Thereby, increasing the overall productivity of the Supply Chain.

Revenue Growth: Industry 4.0 is also set to increase Customization in the production market. It can boost the revenue income and satisfying more demands of the customer. In turn, this deepens the integration between customers and companies (Rüßmann, et al., 2015). Additionally, Industry 4.0 is also said to

increase the growth revenue of aftermarket revenue streams (Cotteleer & Sniderman, 2017).

Risk reduction: Risk is always a major defining factor in all everyday business. Industry 4.0 could also help in mitigating risk. Due to advanced analytics and Big data, it ensures the raw material availability and price stability (Cotteleer & Sniderman, 2017). Sensors can be activity used to monitor the performance of the good even after sales. Thereby, providing efficient market knowledge and recall of defects, especially in Automotive industries (Rüßmann et al., 2015).

Increases Employment: Although, Industry 4.0 is said to replace low-skilled labour task, it promises to increase the growth of Employment in other areas. Due to the growth of Automation, Connectivity & Analytics, the Mechanical Engineers coupled with software ability is said to play a major role in employment boom (Rüßmann et al., 2015). It is estimated that in Germany alone the job growth rate would rise up an additional 6% in the next 10 years.

'Industry 4.0' more often referred to as the 'Integrated Industry' or as 'Smart Factory'. It has ability to change the current business operation, both at Operational level as well as Strategic level. That is, it can alter the way in which the goods are Purchased, Manufactured and Distributed (Liao et al., 2017). This shared and transparent technology could provide more control over the traditional manufacturing system (Luthra & Mangla, 2018). Although, Industry 4.0 seems looks like a successful topic, there are also some addition challenges that accompanies it. To exactly point out the challenges underneath this huge technology buzz, we must first look into fundamental and its impacts on supply

chain. Means, Understanding the concrete advantages of these technologies in different areas of Supply chain.

2.2. Fundamental of Industry 4.0

Industry 4.0 means shift in normal operation of shop floor into an automated one. Accompanied by the hefty involvement of Internet and digitalisation, there is huge potential revolutionary change and it set to alter the way of business, process, manufacturing and services (Tjahjono et al., 2017). Across, the continents and countries, the term ‘Industry 4.0’ is labelled differently although it has the same meaning. They are ‘Smart Factories’ or ‘Internet of things’, ‘Advanced manufacturing’ or ‘Smart Industry’ (Schröder, 2017).

The Industry 4.0 is the collective name given to all technologies of this current revolution and it is especially hard to distinguish them. However, the Fundamental concept of and Industry 4.0 can be clustered into the following group,

Smart Factories: Often referred as the Industry of the future, Smart Factories use High tech sensors, advanced analytics, Automation robots and cloud computing system to monitor the Production and other surrounding activities (Lucke et al. 2008). Other words, smart factories are said to radically shift how the current shop floor operates I.e. Manual to automated Shop floor (Tjahjono et al., 2017). Therefore, the smart factories said to provide Visibility, connectivity and autonomy. Main objective of this is to make the Production a lot smoother and efficient without human intervention (Schröder, 2017). Smart factories also pave a way for digital supply chain network, where there is a shift from linear, sequential operation to an interconnected open supply chain operation. The intelligent products listed above plays an important role in modifying the current operations. Due to the availability of intelligent product within the system, these factories can learn and adapt, thus, providing the more Flexibility than the tradition factories

(Turbide, 2018). Thus, Smart factories are not just autonomous robots, as it goes well beyond it involving self-optimization system that can itself learn, adapt & change according to real time processes (Lucke et al., 2008).

Cyber-Physical System: It is defined as the merging of physical component to a digital cloud (Brettel et al., 2014). Usually, there are some deviation between physical and digital entities. Cyber-Physical systems are said to avoid the variation between the physical world and the digital world. Therefore, the physical and digital value could not be differentiated from each other anymore (Brettel et al., 2014). Suitable example of application of Cyber-Physical System would be in area of Preventive maintenance process where the process parameter (Productiviy & Stress) from the machine is reflected directly as the digital value using intelligent components (Tjahjono et al., 2017). It as well increases the efficiency of the machines and allowing the operators to know the real potential of the machine and avoiding bottleneck situations. These new technologies could also help industry to face repeated fast changing shopping patterns (Brettel et al., 2014).

Big-Data and Artificial Intelligence: Industry 4.0 is also said to use the Big-data and AI technologies as its key drivers. The strong Algorithms, which stands as the backbone of these technologies, can identify production issue before even it happens with less human intervention (Lucke et al. 2008). These technologies not only affect the production floor, but also the way in which the whole business operates. These are said to perform task with normally requires high human intelligence such as visual, speech perception and decision-making. The AI enabled sensors can ‘think’ for themselves, thus for instance are able to measure

machine vibration, capacity therefore also for alert management. Thus, it identifies the mal function well before it affects the actual production (Ratliff, 2019).

Although, Industry 4.0 is collectively defined in the previous sections, to give out the clear outline, these are the two main features of Industry 4.0 in supply chain.

Vertical Integration of Smart production systems: Industry 4.0 creates a strong network of connected operating system within the vertical layer of the company. This is made possible by the use CPS that creates smart factories flexible for the changing customer demands. It not only supports autonomous production management but also maintenance management. The resource and products can be easily tracked across the entire vertical chain. Additionally, all process is tracked, and deviation are reported in real time (Schröder, 2017).

Horizontal Integration of Global Value Chain: Industry 4.0 is also used to bring the alignment across the entire horizontal value chain. Horizontal integration is considered as one of the key important aspect when determining company's success. The entire business partners must be globally in order to provide great value to the end customer. Industry 4.0 plays a key role in Horizontal integration thereby providing optimum level of Transparency and efficiency (Hahn, 2014). In

addition, it also said to increase the relationship within all players of the Global value chain.

Thus, having understood the fundamentals and implications of Industry 4.0, it is certain to investigate its challenges & counter preventive measure, as it is the primary focus of this research paper.

2.3. Previous research contributions:

There are some previously identified research contributing to the challenges of Industry 4.0, that are more theory driven.

Luthra and Mangala (2018) work on identifying the key Industry 4.0 challenges in emerging economies provides a good starting point to this research. Their work mainly focused on identifying the key challenges in Emerging economies, such as India. The research pointed out 18 challenges identified from 96 survey responses from Indian manufacturers. Additionally, they also rate the challenges depending on the probability of occurrence or highest importance.

Orzes and others (2017) also had provided a significant contribution to identifying the challenges of Industry 4.0 in Small and Medium enterprises through Literature review. They Empirically and Conceptually identified the challenges in four countries USA, Italy, Austria and Thailand. They have identified six cluster of challenges from the Literature review and through focus group methodology.

Helu and others (2015) has identified and evaluated the performance assurance challenges for smart manufacturing. They have used Implementation Risk Assessment Framework (IRAF) for identifying the weakness of technology in

manufacturing environment. Finally, they have provided the base line for best smart manufacturing process.

Schneider (2018) has identified the challenges of Industry 4.0 from a managerial perspective. This paper doesn't focus on any other challenge but focus mainly on the challenges faced by management when implementing Industry 4.0 in their current supply chain. The challenges identified were revolving around the areas of Planning, Human resource, Business model, Leadership, Cooperation and Strategy.

Nylander and others (2017) discussed the challenges faced by the SMEs entering the new era of IoT. The research points out a Case study of an anonyms SME trying to implement IoT into their current supply chain. The company was studied in detail and the challenges that comes up are reported and documented. Also, this research is only concerning SMEs, and not the bigger titans, which can have more leverage in overcoming these identified challenges.

3. Methodology

This research focuses on identifying and overcoming the challenges of Industry 4.0. In order to identify the challenges a systematic literature review is conducted. Additionally, these identified challenges are then qualified and quantified with Industry 4.0 experts in the form of Interview. Then, final identified list of challenges is clustered and presented.

The second part of the research focuses on overcoming these identified challenges. A review of literate and article conducted to find out the ways to overcome the

identified challenges. Finally, the logical results then presented as a part of conclusion and recommendation.

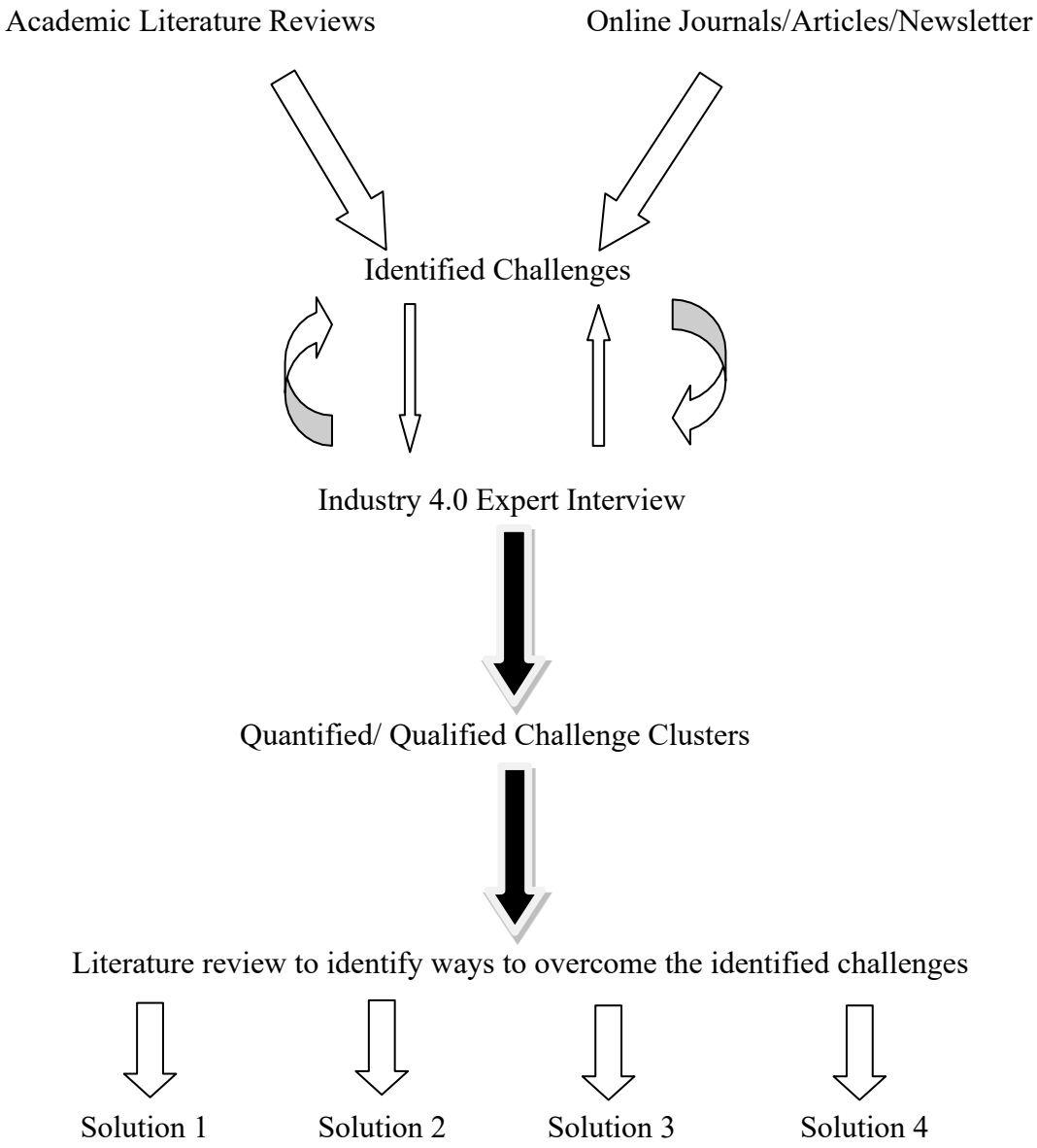

Figure 1: Research Approach Methodology

The above Fig 1 shows the pictorial representation of the method in which the research is carried out.

3.1. Review Approach:

Literature reviews are often the best way to learn about a specific topic. They are the analysed, synthesised and qualified list of articles that can serve as baseline of understanding for any new topic of interest (Mulrow, 1994). There are lot of literature reviews available in every topic that can be in-turn used by scholar to get fruitful insights and directions into their future research (Jones & Gatrell, 2014). As this research is based on review of literature, it is important to understand the importance of Literature review in any new research.

The literature review part of this research can be divided into three sections. They are

1. Identification.

2. Relevance.

3. Analysing and Segregation.

3.1.1. Identification: In order to find out answer to the research question, it is very much necessary to identify the right journals. Keywords are considered as one of the key important elements in identifying the relevant research literatures (Mulrow, 1994). Articles taken into consideration for this research were key word specific. The articles are first identified according to the keywords used in the research question. These articles are all from Google scholar, which serve as the good starting point for this research. Some of the keywords used to identify article in this research are ‘Industry 4.0 and Challenges’,’ Smart Manufacturing’, ‘Automation in Supply Chain Management’, ‘Barriers in Industry 4.0’, ‘Connected

Industry', 'Overcoming Hurdles in Automation', 'Problems - Internet of things.

As Industry 4.0 is quiet a new and budding topic, it is yet to be uncovered in large scale. Through our extensive research, we have found around 70 articles relating closely to the keywords. These articles serve as a base for identifying the challenges and overcoming solution for Industry 4.0.

3.1.2. Relevance: It is also one of the key important steps used in this research to identify the relevant article from the identified chunk of articles. For that, a deep study into the above-identified 60 articles is done. After the study of 70 individual articles, 40 of those chosen and are identified to be more relevant. The focus of this part is to omit the excess amount of article and to give clear focus on the research question. The article chosen were mostly of English, but also few German written research papers.

The Quality factors of the articles (Eg. High standard Journals) weren't taken into consideration, as Industry 4.0 is still an emerging topic and is yet to be explored on a full scale. Additionally, most of the article focuses on indirect challenges and majority of the papers identified and sorted does not directly contribute the research question. Thus, few papers identified directly contributes to research question and other were used as reference to support the claims.

3.1.3. Analysis and segregation: Thus, identified relevant list of articles are studied in detail. After a detailed study, the challenges were identified and are group into specific set of clusters. In total, there were six clusters of challenges identified. The articles chosen are also segregated based on their degree of contributions to each challenge cluster. As the challenges were classified into six different types (1. Economic Challenges, 2. Technical

Challenges, 3. Competency Challenges, 4. Cultural Challenges, 5. Managerial Challenges 6. Collaborative challenges), the articles were chosen, in order to contribute all six different areas. Similarly, the articles contributing to the remedies of the pertaining challenges also sorted according to the relevance in the same way.

The challenges identified from the literature review are then verified with other online website / company newsletter / articles. During this stage of the research process, the clusters were grouped more appropriately, according to their relevance to the specific group. Therefore, a clear sense of distinction between the groups can be made.

3.1.4. Understanding of Industry 4.0 & surrounding Technologies:

The understanding of Industry 4.0 is vital, to understand the course of this research. Although, this research focuses on challenges of Industry 4.0 and not into individual technologies or Industry 4.0 devices, there is always an underlying Industry 4.0 devices behind every identified challenge. Therefore, Industry 4.0 means the use of advanced technology devices and this research focuses on identifying the challenges when companies try to adopt/use these technology devices.

These technologies include AGVs, Automatic Cranes in Warehousing, Advanced sensors, High end robots for Production, Advanced Industry 4.0 software for Connected Industries, Advanced analytical software for Procurement 4.0. The companies which manufacture these technologies, as well the end user of these technologies was interviewed and to get a clear

view on challenges of these technologies both on implementation level and management level.

3.2. Interview Approach:

Finally, the gathered the information from previous steps were then put into a Interview – Interview in order to quantify and qualify the obtained results. Conducting an interview with Industry 4.0 expert gives more practice relevance to the research result. The reason why Interviews are chosen over normal survey is that to get mode deep insight into actually problems faced by the interviewee itself and thus providing more real case problems.

The people who are interviewed are contacted through social media platforms like LinkedIn. Since, Industry 4.0 is a wide topic, the experts were identified based on their job roles. An equal number of participants contributing to each challenges cluster were identified through specific use of Keywords in LinkedIn. Once they are identified, they are then contacted, and interviews were scheduled to discuss about the research question. Another medium used in identifying the potential interview candidates was "Hannover-Messe festival 2019". It is one of the biggest Industry 4.0 and future automation festival in the entire Europe. There were numerous of companies participated in this festival. Some of these companies include Siemens, Bosch, Ifm, Accenture & Akeo. The 6000 plus companies participated in this event includes the mixture of small, medium and big sized firms from all over the world. This research study also includes the interview - inputs from Industry 4.0 expert from this event.

The people who are interviewed comes from different educational background and job sector. Expert from companies such as Siemens, Hellermanntyton, ifm, Akeo, DSV, Wagner Informatik, IBM. Etc.

Additionally, some of the participants are also Industry 4.0 Authors and former graduates of top Business schools such as MIT, HEC Paris. They do have distinct job roles such as Managers, Warehouse Operators, Industry 4.0 software specialist and Industry 4.0 implementation Consultants.

In-order to get the most out interviews a specific set of predefined question were prepared for each different job roles and are presented to the participants. The interviewees were then asked to put forth their thoughts on every identified challenge cluster. After having their opinion written down, each of their point were then added to cluster. Accordingly, the contradicting ideas were removed from cluster. Thus, hereby the research produces quantified and filtered practical identified challenges. Additionally, the solutions to these problems were also discussed during the interview process, which are then listed as counter measures.

3.2.1 Questionnaires:

As the interviewee comes from distinct background, there are distinct set of questionnaires prepared for each of their job roles to contribute to different set of challenge cluster and pertaining challenge. For instance, Technical questions were prepared to be answered by Technical consultant, thereby contributing to Technical cluster. So, the managerial questionnaires were designed for Manager of a company and managerial challenges that they face during Industry 4.0 implementation, thus contributing to Managerial Challenge cluster.

The questions were chosen based on the reviewed literatures on challenges of Industry 4.0. There were paper discussing about the challenges of industry 4.0 but doesn’t have any practical evidence. In order to contribute to those researches, these questions were designed in order to get more clear practical

evidence and correctness of the previously identified challenges in the literatures. Thus, the new cluster of challenge are formed which are qualified / quantified and has practical real time evidences.

The List of questionnaires for each job roles are listed below,

Technical Software – Industry 4.0 consultants:

- What is the main Technical challenge that you face, while implementing Industry 4.0? Explain it with real time scenario.
- What is the technical maintenance cost associated with these new technologies?
- Should these devices be continuously monitored?
- How often does it go wrong? What is the risk accompanied?
- Are the systems mature enough? Technical Integration drawbacks.
- Any though on Universal standards and Data security?
- What could be a good solution to overcome this technical drawback. What the industry can look up to?

Manager of Companies implementing Industry 4.0:

- Does your company has already implemented Industry 4.0 in the Supply Chain? If no, then why?

- Does your company funded by the government for adopting to Industry 4.0 technology?

- Does your company have a good knowledge on Industry 4.0? What it can do?

- Is finding a suitable implementation partner a challenge?

- Does the company management support this initiative?

- How complex it is to implement Industry 4.0 across your supply chain network.

- Having identified the challenges, what are your though on improving the current condition?

Management Consultant – Industry 4.0:

- How hard it is to precisely evaluate the long-term cost benefits of Industry 4.0?

- Do the companies face a problem of lack of skilled labours?

- How does the implement, going to the change the Business model of the company?

- Comments on Change management process.

- How far are your clients willing to take Industry 4.0? Is it a partial automation or are they willing to change to complete remodelling of their supply chain?

- What are the other critical factors to be considered while implementing the process change?

- Does your client truly understand and welcome the idea of Industry 4.0? Or they still resilient?

- Any other possible recommendations to overcome the challenges?

End users of Industry 4.0 – Warehouse, Production professionals

- What is your current job role and what are your though on Industry 4.0 pertaining to your job?

- Does your company had already tried/attempted to implement Industry 4.0 on their Supply Chain?

- After Industry 4.0 implementation, how far does your new role differ from your previous role?

- Are you and your fellow colleagues, are satisfied with the new change?

- Were you officially trained on using these new devices? Was it satisfactory?

- What are some other challenges that you faced post implementation?

- Any possible recommendation on overcoming those challenges?

After discussing these questions in detail, the cluster we remodified and re-clustered with the obtained information. Therefore, the quantified and qualified list of challenges are presented in a logical format as follows.

4. Findings

Industry 4.0, also known as the modern industrial revolution is one of the most recent topics spoken at current 21st century. While the current industry studies about its advantages, this research focus on some of the challenges the companies might look out for when adopting these technologies. Over the course of time, after having studied, researched, analysed, synthesised and interviewed the result, a six cluster of Industry 4.0 challenges becomes clearly visible. These are the key areas in which the companies or Industry 4.0 expert must focus on or when are trying to implement these future technologies. Hurdles faced by small and medium sized companies (SMEs) and Larger companies in Industry 4.0varies a lot (Helu et al., 2015). Due, to the economic and social pressure, even the smallest of companies are trying to adopt these technologies, doesn't knowing the real hurdle that might possibly come up (Schröder, 2017). The size of the company plays a

significant role in implementation of Industry 4.0. As the size of the company gets bigger, the potential for implementing these technologies are is higher. And as we know, the larger companies have more potential in integrating its entire value chain and its asset together with the strong IT system (Schröder, 2017).

The challenges that are put forth in the research, are common for both SMEs and larger companies. But the identified challenges might vary depending on the contribution or the level of intensity to each company. As derived from the logical conclusion, when the company has good financial wealth to carry out Industry 4.0, it might lack the technical know-how or a good knowledge base. And if a company has a good technical know-how but lacks financial stability and vice-versa. Another example would be, if a company has good technical know-how and financial wealth, but it lacks the culture to adopt to these changes. Therefore, the degree of intensity of these challenges might differ from Organisation to Organisation, but each identified challenge prevails and common for all Organisations.

Also, the research is about all high-level challenges that company management might need to know for efficient management of Industry 4.0. As there are a lot of research focusing on technical challenges (Which aren't needed for top management nor the scope of this research), this research tries to bring out the general challenges of Industry 4.0 implications. Additionally, since the interviewed people comes from different education and job sectors, the research is also not Industry specific but serve as a common for any Organisation willing to implement Industry 4.0.

The identified, quantified and qualified list of six challenge clusters are listed. These are the prime challenging factors of Industry 4.0 implication. Each cluster as

then a different number of individual challenges which are then listed below in the course of research.

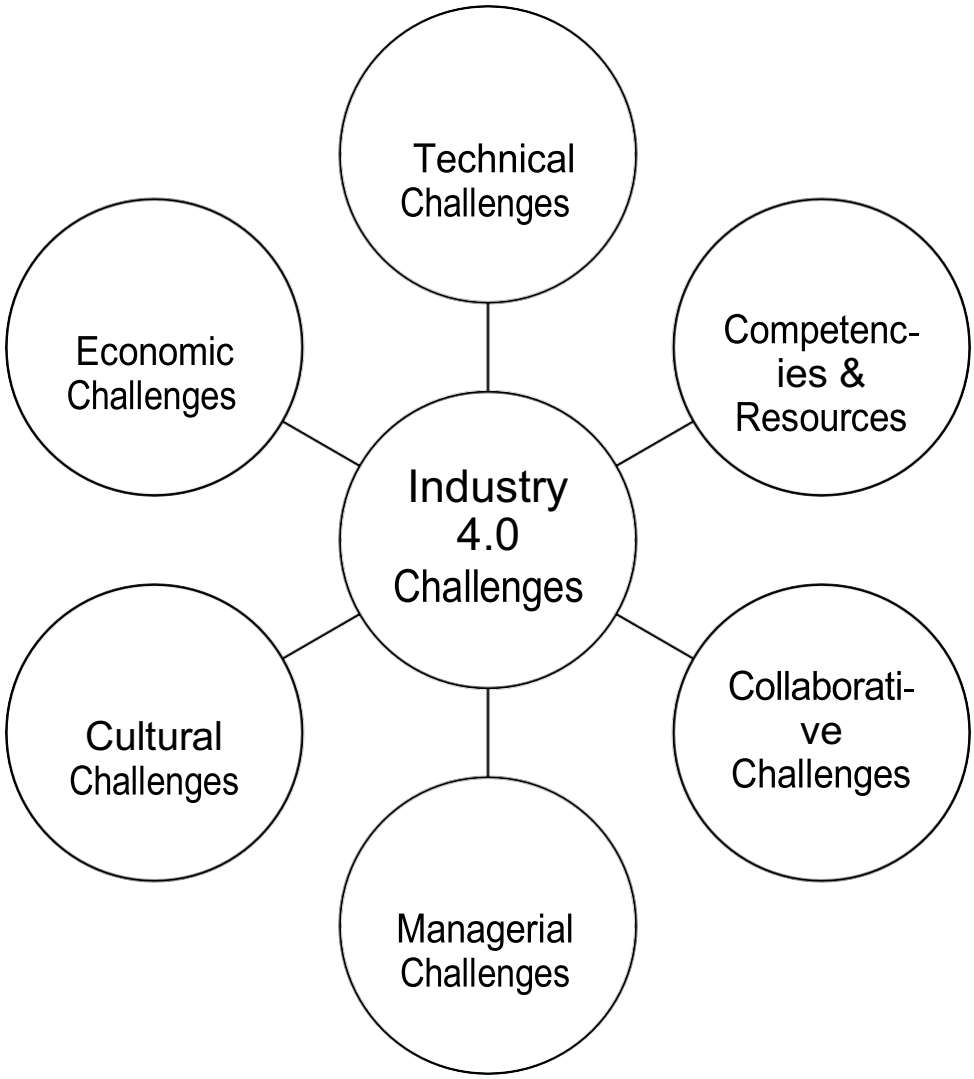

Figure 2: Identified Challenges in Industry 4.0

Fig 2 show the identified cluster of challenges of Industry 4.0. Each of these cluster are then explained in detail, as follow. Additionally, the result or outcome of the reviews are also presented sequentially.

4.1. Economic Challenges:

It is one of the primary and most common challenges faced by many Organisation that are willing to adopt Industry 4.0. Financial constrain are crucial for companies that are willing to enhance their machine and process innovation (Theorin et al., 2017). The companies must take a careful look into what it is planning to invest and what are the outcomes or benefits. The economic challenge cluster is predominantly for the SMEs and medium sized firms, as the larger firms have more financial power to overcome these challenge cluster (Jäger et al., 2016). Although, some of the bigger players cam evade these challenges, they face the problem of identifying the long-term benefits of these financial investment. That is, failure to understand the return on investment from these technologies (Marques et al., 2017). Some of the key important factors surrounding the Economic challenges are listed below,

4.1.1. High Investment:

Although Industry 4.0 is a revolutionary factor for the modern-day companies, it also involves a lot of investment (Jäger et al., 2016). The research literature reviews and articles clearly point out the fact that Industry 4.0 include wide variety of technologies and only possible with different set of Integration tools and method. All these tools come with high Investment cost, which make them harder for the SMEs to get a hold to it (Geissbauer et al., 2014). Thus eventually, stopping the companies from adopting to these technologies.

For Instance, one of the basic Industry 4.0 technologies are AGV and picking robots. When SMEs are looking out for these technologies, they

also need to bear IT investment cost, as these devices rely highly on to strong IT systems (Dawson, 2014).

4.1.2. Lack of Enough Monetary Funds by the Government:

It is necessary for the government to play a role in promoting Industry 4.0. The Government policies and guidance is also one of the most crucial factors to promote Industry 4.0. The studies show that there is clear lack of government support or policies to directly support Industry 4.0 adoption (BRICS Business School, 2017). SMEs are most affected by this, as large number of companies expect at least little amount of Financial support by the government. If the government is expecting it companies to change over to smarter production or smart processes, then it is very much necessary to support SMEs by Financial means (Mueller et al., 2017). Even though, government support some amount of Industry 4.0 support articles, its is largely on the Production environment rather on other auxiliary activity such as maintenance, logistics (Schröder, 2017).

4.1.3. Unknown Long-term cost – Benefit:

Even though, companies are ready to invest in these future technologies, there lacks clear sense of Long-term financial benefits (Mueller et al., 2017). As these devices are of high investment, the it often challenging for companies to clearly point out the Cost-Benefit predictions. These also comes with high maintenance cost, which can be even unpredictable and thus making it harder for companies. Since, IT infrastructure are also needed to be maintained on the regular basis, there is also additional possible cost of increase of IT service. Thus, the companies are still unclear

of the long-term Financial benefits of Industry 4.0. Therefore, possessing a direct threat to Company's long-term financial stability (Dawson, 2014).

The result of the survey & Interviews also revealed the same. Industry experts strongly believe that the Financial constrain are one of the major factors for companies to adopt Industry 4.0. The high investment needed, Lack of monetary support from the government & Long-term cost-benefit together form a strong wall of barrier that hard sometime even hard for Larger companies to overcome. The spokesperson of WAGNER Informatik GmbH also said that there is huge software maintenance cost after the implementation of Industry 4.0. Another spokesperson from DSV Logistics also noted the fact that, the company had already tried & using AGVs for specific set of warehouse activities, but it is sometime cheaper to use Labour than these machines. One of the warehouses of the company, has done Business case to find out the cost difference between using a manual labour and AGV. The results were that the manual Labour cost were way cheaper than using AGVs. Additionally, the manual labours in turn provide more flexibility to the change in process. Further interviews, from bigger Industry 4.0 service providers like IBM, revels the fact that these technologies are sometimes costly and hard to implement and maintain for SMEs as the cost is incurred with the whole process is high.

4.2. Technical Challenges:

After the companies have tackled the monetary challenges, the second biggest hurdles are the Technical challenges. As these devices and technologies are still being research and developed there is lot technological drawback even for the technological company itself (Otuka et al., 2014). Technical Integration always play a key role in Industry 4.0. As Industry 4.0 relies strongly on the cloud and digital platform, it is very much necessary to build up a stable and strong IT platform for its working itself and productivity (Zhou et al., 2015). The companies face severe challenges in handling these technological problems arising with these

technologies. Some of the contributing factor to these challenges, are listed below along with result of the interview and surveys.

4.2.1. Complex Software Integration:

Since, Industry 4.0 depends heavily on the software part, there is also serious challenges, when it comes to software integration part. Various components capable of transmitting data needs to be integrated in order to perform together as system. The companies are still facing considerable amount of challenges in interfacing these distinct components together (Zhou et al., 2015). In the manufacturing environment, the Cyber Physical network of different devices in machines needs to be integrated strongly to promote effective data exchanges. Lacking common platform among these devices acts as a bigger problem for companies trying to connect its systems and devices together to act a as a complete sustainable supply chain.

4.2.2. Lack of Data security:

Internet is often exposed to threat such as hacking and credential theft. As the Industry 4.0 means to connect different platform through common clouds system, mean it is also automatically exposed to illegal activities in the internet. These Supply Chain systems are often subjected to vulnerabilities by the hackers. Some case or the other the people share their personal credential and the system become exposed to phishing attack and thereby mass data being exposed (Sommer, 2015). For instance, if a company at top of the supply chain is hacked or if there is possible credential theft, there is a risk being mass data exposure of the whole supply chain. Therefore, Data security is one the prime challenge when converting a normal factory into a smart digital factor through cloud

platform. Additionally, as identified from the literatures, companies are also worried about the company data being sent out to third party Industry 4.0 service providers as a part of Integration process (Wang et al., 2016).

4.2.3. Technically Immature devices:

Since, Industry 4.0 is developing technology, the devices used in this is Technically immature by itself (Geissbauer et al., 2014). All these devices need to be periodically marinated in order to keep it running. Although, these technologies are base line of the future, most of these devices still lack a tendency to run by itself and often subject to failure due to improper and lack of maintenance. Since, it also run by software and algorithms, these devices lack technical maturity if it is subjected to different kind of task. And are therefore, not flexible as the labour. This is also one of the strong points that serves as the barrier for companies to adopt Industry 4.0 (Koch et al., 2014).

The results of the interviews and survey also revealed the fact that Technical challenges are one of the common challenges in Industry 4.0. An author and former MIT graduate also pointed out the fact that The Pentagon (Headquarter of Department of defence) is moving completely into cloud Technology and one of its prime challenging factors is the data security. Another spokesperson from the IFM GmbH pointed out the fact that data from these different devices sometime doesn't integrate and there is lot of challenging work associated with brining these data together to provide a meaningful result. Sometimes, the clients often expect large amount of data from small device (For Instance, Pressure sensor can only sense pressure), that aren't technically well advanced to efficiently support the Industry needs. Additionally, one thing that contradict from the literature, is that the

companies doesn't care about its data being leaked to the third-party service providers as they work together.

4.3. Competencies & Resource:

The third set of identified challenge cluster arise due to lack of proper competencies and resources. As Industry 4.0 involves the use of smart machines and technologies, there is a strong need for skilled work force and technical and functional know-how of the whole system (Otuka et al., 2014). Companies find it challenging to identify proper source of Industry 4.0 experts. Training of employees is very much essential when it comes to adopting these complex systems. A company which needs to adopt Industry 4.0 into its supply chain, must train it workers in various areas such Production, Logistics & Procurement, as these system needs a strong technical know-how of software system which form the base of Industry 4.0. Additionally, most of the company's lack the proper knowledge of what Industry 4.0 is and its surrounding applications (Jäger et al., 2016). It means, the lack of knowledge on where these advanced systems can be used. Some of the contributing factors to this challenge cluster are listed below,

4.3.1. Lack of Skilled Labour:

Labour are key driving factor in any factories, whether in normal factor or in smart factories. Skilled labours are often an asset to a company. They amount of skilled labour is directly proportional to the productivity and innovation of any company. Although smart factors require a smaller number of employees when it compared to its predecessor, it requires high degree of intelligence in the workforce (Otuka et al., 2014). A proper trained workforce is necessary to have smooth transition on the supply chain. Companies often find it challenging to training existing workers on their newly job. Often time, it also comes up as time consuming process (Jäger et al., 2016). The Business also lack some of the competencies, when it comes to

data analysis & effective Industry 4.0 adoption (Ras et al., 2017). Therefore, workforce must also be trained to adopt the new digital supply chain structure and to know the essential process (Erol et al., 2016)

4.3.2. Lack of know-how:

Not surprisingly, companies lack the technical know-how of Industry 4.0. Most of the companies are still unaware and unclear about the potential benefits of Industry 4.0, and thus, still reluctant towards adopting to these technologies (Perales et al., 2018). It means, Organisation have no-idea about what these devices can do and how much productivity it can bring to the supply chain (Otuka et al., 2014). The big challenge for the companies is to clearly manipulate the usage of these technologies. Most of the companies willing adopt Industry 4.0 in their supply chain lack the accurate strategic adaptation roadmaps of these technology (Jäger et al., 2016). This can due to lack focused research on various aspect of adaptation of these technologies (Wang et al., 2016). Sometime, the answer to some of know-how question can be only answered by the manufacturer of the product itself, due to complexity of the Industry 4.0 systems.

4.3.3. Finding a suitable partner:

After overcoming the challenge of know-how, the next is the finding a suitable partner who can successfully transition the current business into a digital one. Finding a suitable partner is also a challenge when it comes to Industry 4.0 adoption (Erol et al., 2016). As the system are new and complex, the adopting company must find out a suitable partner who can successfully provide a well-tailored solution (Jäger et al., 2016). Since, there is lack of standard and certification, there is sometimes no clear distinction between companies that are

providing those solutions. Company must know what it wants, and then must look out for effective and reliable Industry 4.0 service provider.

The result of interviews and surveys also points out the strong lack of competencies and resources across all sectors for Industry 4.0. A spokesperson from DSV Logistics, confirmed the fact that company had just set up Industry 4.0 division and it is still in development scale. Therefore, even the big player lack know-how of Industry 4.0. The CEO of the company Dillygence, also pointed out that it is very much necessary for companies to find a right suitable partner when it come to Industry 4.0 adoption. Also, one must have keen eye on the change management of the whole supply chain process, as adaptation process will have its impact on the whole supply chain.

4.4. Cultural Challenges:

Having studied literature and article about the challenges in Industry 4.0, there also exist some degree of cultural challenges within the Organisations (Erol et al., 2017). Companies willing to adopt to Industry 4.0 must have open culture and promoting new ideas. Since, the implementation of Industry 4.0 is going to alter the everyday job role of all individual in its environment, there is strong sense cultural influence behind it (Mueller et al, 2017). Often the people are the ones, who are affected the most from Industry 4.0, as it has major influence on their routine (Perales et al., 2018). Therefore, cultural challenges play a crucial when it comes to adopting new technology and process. Some of the contributing factors to cultural challenge is listed below,

4.4.1. Lack of support by the Top management:

According to the literatures there is some degree of hesitant shows toward adaptation of Industry 4.0 from the top management of the company

(Savtschenko et al., 2017). This claim is still debatable as it depends from company to company and from country to country. According to a survey, in some companies in Thailand, the top management aren't aware of the potential benefits of Industry 4.0 (Shamim et al., 2017). Therefore, in order to develop efficient concept of Industry 4.0 into organisation culture there is strong sense of support needed from the top management of the company. Top management must try to improve and shift the focus towards the process improvement, employee training and knowledge management platforms through digital revolution (Goekalp et al., 2017).

4.4.2. Lack of interest from Employees:

No matter, what process are changed through Industry 4.0, there is going be an effect on Employee. The professionals have shown considerable amount of hesitance to changing process of the company (Savtschenko et al., 2017). Young work force normally tends to be more flexible when it comes to changing process. The tendency or acceptance to change is directly proportional to the age of the Employees. For instance, when a process in production is changed and all employee need to learn new methodology or the process (Goekalp et al., 2017). Therefore, the job role of the employees is also affected along with this change. There lies significant amount of dis-interest within the Organisation itself, when it comes to adoption of new technology (Shamim et al., 2017). This often comes as big challenge to whole Organisation in adopting to new technology.

The outcomes from the interviews and survey from Industry 4.0 shows a varied amount response. An Industry 4.0 consultant from WAGNER Informatik GmbH said that there is significant amount hesitance or dis-interest shown from the Shop floor employees after a process change has

been made. This is due to fact that the process after the Industry 4.0 implementation, changed the working culture within the shop floor that leads to sort of dis-interest. Employees were said to work on the job that are normally not intended for them. Another spokesperson from DSV Logistics reported the contradicting fact that company is willing to change over to new methods and process through Industry 4.0, with well guided assistance form the top management of the company. The CEO of Dillygence also commented that company will to adopt Industry must have an open culture within the Organisation that promote Innovativeness and Long-term growth. As it is new change to the whole Industry, the companies must be willing to try and implement the new process and digital models for promoting innovativeness and effectiveness within one's supply chain.

4.5. Managerial Challenges:

It is one of the common challenges arising within any company when it comes to adopting Industry 4.0. The companies must first discuss within itself on how it visualises itself in the future, focusing towards adopting to Industry 4.0. It means, to discuss where these technologies can be put in use. For Instance, it can be Production, Logistics or Procurement. As the implementation process is going to completely alter the working of the whole company, there needs to be clear idea on tackling the challenges arising then and there (Bischoff et al., 2015). Conceptual model that show the readiness and maturity model of company should be assessed and can serve as a good starting point of the company (Kagermann, 2015). The

transformation phase is crucial when it comes it comes adopting to a new process. Some of the factors contributing to this managerial cluster are as follows,

4.5.1. New Business model:

Industry 4.0 implementation or the process change always require a change in the new business model. The contribution often assumes that the change in technological side of Industry 4.0 are the driving factors of innovation and productivity, but it is usually the change in Business model of company that determines its actual effectiveness and pace of change in the future (Dais, 2014). Therefore, there is strong connection between the Industry 4.0 and Business model of the company. Most of the firm are trying to use Industry 4.0 just to create the value proportion but not adapting their extant business model. Thus therefore, the company must carefully evaluate the competence, available resource and therefore the firm culture in coherence with Industry 4.0 (Laudien and Daxbröck, 2016).

4.5.2. Alignment of the Strategy:

Companies must also carefully analyse the strategy and its impacts market environment (Otuka et al., 2014). It must carefully assess its current market condition and positioning in term of Industry 4.0. It means, what are its key essential driver of change. After the market analyses, the company should come up with the right strategy approach towards the change (Iansiti and Lakhani, 2014). This can be done by evaluating the maturity model of the company, thereby focusing on its strength and weakness. Therefore, understanding how the change is going to affect their current market

condition. Once clearly understanding the approach, the company should come with the right roadmap for achieving it (Agarwal and Brem, 2015).

4.5.3. Quick adoption to a new Business structure:

Motivation and taking calculated risk are the prime factor when it comes to adapting to any new change (Dais, 2014). Every individual of the company must be part of change. The level of participation is directly proportional to the speed and the effectiveness of the change (Fleisch et al., 2014). People should motivate to explore and take risk. Even though, the new processes can lack precisions it shouldn't be a stopping factor. The company wiliness to take it forward plays a key role in future development. This also means to eradicate any negative motive towards adopting and trying a new culture. The top management, employee should all together participate and promote the new transformation (Agarwal and Brem, 2015).

The results from the interview and survey of the Industry 4.0 consultant also point out fact. The CEO of Dillygence pointed out the fact that, speed of the change is crucial in every process. The company must make sure, its current process isn't affected when implementing the new change as it is crucial and can directly affect the reputation and sometime financially too. Sometimes, you also need have a right amount of knowledge and potential development chart to prove the change is going to be worth it. Management must also be strong in making the clear road maps of the change as it crucial in every step of the change. The company must also try

to bring out and promote the right cultural mindset among its Employee in order to promote the effective and efficient change.

4.6. Collaborative Challenges:

The another and final set of identified challenges are the Collaborative challenges. In-order for the supply chain to perform well, Collaboration is the key. Collaboration is the most important factor when it comes to supply chain sustainability. Every member of the partnering organisation must understand the Organisation policies in adopting Industry 4.0 to improve supply chain sustainability (Lee et al., 2014). The efficient collaboration between the manufacturers and suppliers directly proportional to productivity of the Supply Chain (Mueller et al., 2018). The transparency in data is very much likely to affect the outcome of the products (Pfohl et al., 2017). Having Interviewed the organisation and Industry 4.0 experts, there is clear sign of existence of some degree of Collaborative Challenges. Here are some of them listed below,

4.6.1. Lack of transparency in data:

The cause of this problem is due to sharing of inconsistent or false data across the supply chain. This is often crucial when in comes to manufacturing of component that requires high of synchronisation and interfacing. The data from supplier and manufacturers must be always synchronised, as the Industry 4.0 needs and lives with data for each of its process and steps. For instance, if a company manufacturing Die casting product through Industry 4.0 technologies, it needs to know the exact measurement of Flexibility and thickness from the supplier Organisation. The technology at the supplier end must be capable of transferring the exact data as required. Since, the Industry 4.0 is not fully expanded, there is lack of its existence itself across industries. Therefore, even when the

company tries to implement Industry 4.0 into it supply chain, there is whole lot of data missing from its suppliers and peers. There it serves as one the challenges faced by companies after implementing Industry 4.0.

After having interviewed the Industry 4.0 experts, the challenges faced by the companies are to a certain extent unavoidable. Consultants said that Industry 4.0 runs and depends heavily on the software and the corresponding data. As the system are not that flexible enough yet, there need to be exact data for it to function. The transparency in the data across the supply chain is the key. A Logistics Engineer from DSV Logistics pointed out the fact that the company doesn't had any clear data about the items stored in their warehouse. Due to lack of proper data and differentiated sizes of the boxes, makes it harder for the company to put forth the use of Industry 4.0. For Instance, if the robot needs to pick up a specific sized product from a group of products stored together in the same box. Each product has varied sized and shape and often doesn't have any specific dimensional data. This is also one the big challenge faced due to lack of data sharing. And the company cannot find the proper Industry 4.0 solution.

5. Counter Measure:

Thus, having identified, qualified and quantified all these challenges, the scope of this research also extends to finding and countering these challenges through logical

approach. Some of these are also identified counter measure are also put under interview as question to interviewee.

5.1. Concept of Systems of Innovation:

The best way to counter Industry 4.0 challenges are by using the system of innovation concept. The system of innovation is defined as the network of organisations whose activities are interrelated and contribute to diffuse a specific set of problems arising due to technologies or due other causes (Edquist, 2013). The Organisation taking part of this varies from sizes to industry field and can be private or public organisations.

5.2. Industry 4.0 & Systems of Innovation:

In order to counter these challenges, we have identified four major factor which together can counter or can have a direct impact on these identified challenges. They are,

1. Role of Central Government.

2. Cooperation of State Universities & Industries.

3. Role of State Government in promoting Technology fairs.

4. Role of Company Management and Unions.

All these factors together can contribute to vast range of advantages which can lead to higher economic growth of a country. These changes must be put into immediately practice by the government in order to foster the fourth industrial

revolution further (Edquist, 2013). The four major contributing factors are explained below,

5.2.1. Role of Central Government.

The central government is the main coordinating and commanding body for any national and state technological advancement. The funding from the government is very much necessary to counter the Financial or Economic challenges which is identified previously in this research. The funding by government is directly proportional to growth of any technological activities within the country.

As the Economic Challenge cluster consist of variety of factors such as need for high investment, Lack of monetary resource and Unknown long-term economic benefits, the role the government could play here is crucial. Most of the companies are still hesitant towards Industry 4.0 is due to lack of enough monetary funds both from within the Organisation and the Government. Although the government funds exist in some big economies like Germany, there are some countries where the monetary funds are scarce. Additionally, some of the major contributions by the government goes mainly to technological improvement in Production process but not to other auxiliary activities such as Logistics, Procurement and Distribution. Therefore, a steady government monetary fund system would help in overcoming the Economic Challenges of Industry 4.0. This can be achieved by forming a team of experts regularly monitoring the growth of Industry 4.0 for a state. This team can assess the financial stability of a company and provide feedback to government, concerning the necessary

monetary funds needed for Industry 4.0. Therefore, acting as a connecting bridge between the government and the company.

As Identified from the interview, many of the interviewee feel that Lack of government support often stands as hindrance for Industry 4.0 adoption. Especially, in the case of Small and Medium sized firm. Therefore, a strong sense of support from the Government is very much necessary to improve the current condition and thereby countering the effects of Economic challenges.

5.2.2. Co-operation of State universities and Industries:

The collaboration between the academia and university is vital for any mode of systems of innovation. Since the influence of Technical challenge cluster is huge, in slowing down the Industry 4.0, it is very much necessary that the University and Industry must work-way through to solve this issue.

As identified from the interviews, there is clear lack of enough research to cope up with technical challenges. The immature system and complex software integration still possess major threat to growth of Industry 4.0. The Industry – University linkage can provide an edge to this challenge. The Companies can gain access to highly trained student, professors and current research up to date Industry 4.0 research trend within the University (Bower, 1993). In turn, the Universities can also gain insight and expertise from employee to solve real world problem through practical approach. Therefore, it is win-win situation. But, most of times, the new advanced Industry 4.0 technologies has not been a motivation for Industries to partner with Universities, because the companies often seek other companies for this purpose and not the universities (NSB, 1996). The tradition university often focuses on uncovering new technological

innovation and then tries to integrate useful for long-term insight and goals. But the tradition role of Companies is to use the result of the research to stabilise or increase its customer base and to improve wealth of the company (Reams, 1986).

Leading spokesperson of WAGNER GmbH said that in order to foster Industry 4.0 the Universities must strong partner Industries in trying to find out the new capabilities and implementing them into practical situation rather than waiting for years to obtain stabilised results. Since, the Industry 4.0 is changing quick and needs immediate attention, it's not time for Industries to depend only on University result but rather take part in collaborative action to bring the technology to market as soon as possible. This action can have a major impact and can neutralise the identified challenges.

5.2.3. Role of State Government in promoting Technology fairs:

Technology fair often play an important role in introducing the technologies and current trends to the market. They serve as a platform for any companies trying to promote their new products to the market. Role of government play an important part in promoting these events. Often, the size or type of the fair is decided by the state or central government.

Industry 4.0 technology fair are one of the technology fairs happening across the world at present. There are many varieties of Industry 4.0 technology companies participating and showcasing their product capability in such event. One of such events is Industry 4.0 Hannover

Messe fair, Germany. These events are a great way to learn about new product and current research in Industry 4.0.

As identified in this research, one of the biggest factors challenging factor for Industry 4.0 is lack of know-how by the companies willing to adopt these future technologies. The companies couldn't find the suitable partnering companies that can provide customized solution. These fairs can could serve as a good way to tackle these challenges. The government must put extra effort in making these fair more accessible to wide variety of audience. One of the interviewees also pointed out the fact that some of these fair even has entry fee that often serve as hindrance to people who wishing to know these technologies. Therefore, the government must realise the true value of these fair i.e. to making technology available to wide audience and not making money out of these fairs. Some of the Small and Family run business doesn't get invitation to these fair due to high number of big corporations dominating these events. Therefore, increasing the number of fairs happening across the country could boost the growth Industry 4.0. Sincere, effort by the government can boost the reach of Industry 4.0 across the country. Thus, the companies willing to adopt these technologies can no longer have problem in reaching out to the right technology partner.

Therefore, the identified Lack of competencies / resource challenges cluster can be countered by the sincere effort of government in increasing the number of yearly fairs happening across the country, increasing the

marketing for these events and making itself free so that people are more open to such events.

5.2.4. Role of Company Management & Unions:

A company's top management and union together shapes its culture. They are the actual runners of the company, who are responsible for everyday activities and current trends in the company. Therefore, they also play an important role in deciding the future moves of any company. Some Employee unions are also engaged in cross company activities and program that brings in mutual benefits to both companies. Company Management and Union must collaborate with each other in determining the right strategic path for the company.

Number of challenging factors that serve as hindrance to Industry 4.0 can be eliminated by proper efficient functioning of these bodies. Mainly the identified Cultural, Managerial and Collaborative challenge can have serious impact, as these challenges arises from within the company. Developing the right culture is one of the identified challenges from this research. Organisation often struggle to find the right momentum for adopting these new technologies. The company management and the union can together influence this challenge. Management can provide frequent training to its employee pushing employees to learn about Industry 4.0 and its capabilities. Another important factor of Collaborative challenge is the lack of date. The company unions can play a part in reducing this effect by efficiently coordination with its dependent company. By making the strategies and decision together, correct data can be shared, and common platform can be laid, creating a win-win situation for both the companies. This can be further led to sharing of knowledge and employing body of employee from both companies for discussing about further Industry 4.0

technological developments. Therefore, the top management and union must play their part in order to overcome these challenges. They must be more open to new ideas and outcome of the Industry 4.0 and thereby passing them onto the Organisation and Employees.

6. Conclusion:

6.1. Results and Primary Reflections:

The Industry 4.0 challenges identified in this research, serves as a starting point for companies trying to adopt these new systems. Before even trying to adopt these technologies, the companies must investigate each criterion categorized in this research to avoid any potential loss. The Industry 4.0 interviewee participated in this research are experts in their respective fields. And therefore, the results mentioned in

this research is already quantified and qualified. Table 1 shows the identified challenges in tabular form,

Table 1: Overview of Identified challenges for Industry 4.0

Challenge Cluster	1	2	3
Economic Challenges	High Investment	Lack of Government Monetary Resources	Unknown Long-term Cost Benefits
Technical Challenges	Complex Software Integration	Lack of Data Security	Technically Immature devices
Lack of Competencies/Resources	Lack of Skilled Labour	Lack of Know-how	Finding a suitable technology partner
Cultural Challenges	Lack of Support by Top Management	Employee disinterest	-
Managerial Challenges	Need for new Business model	Alignment of cross organisational Strategy	Quick adoption to new Business structure
Collaborative Challenges	Lack of data transparencies across organisations	-	-

Although, there are many numbers of challenges identified, this research also aims to tackle these challenges through systems of innovation approach. These approaches were also discussed during the interview with Industry experts, to get a better practical

approach to solution provided in this research. The four identified system of innovation bodies that can influence Industry 4.0 challenges are shown in Table 2.

Table 2: Proposed system of Innovations Approach

Systems of Innovation	Affected Challenge Clusters
Role of Central Government	Economic Challenges
Cooperation of State Universities & Industries	Technical Challenges, Resource/Competence Challenges
Role of State Government in promoting Technology fairs	Resource/Competence Challenges
Role of Company Management and Unions	Cultural, Managerial and Collaborative Challenges

6.2. Limitations & Scope of the research:

Although, there are major finding explored and explained in this research, there are certain limitation factor associated. They are,

6.2.1 Supply Chain Limitations:

The research is mainly focused on identifying and countering the challenges of Industry 4.0 within the specific area of the supply chain. The people who were

interviewed were mainly focusing on within a specific range of their supply chain. The following figure 3 shows the focused supply chain range,

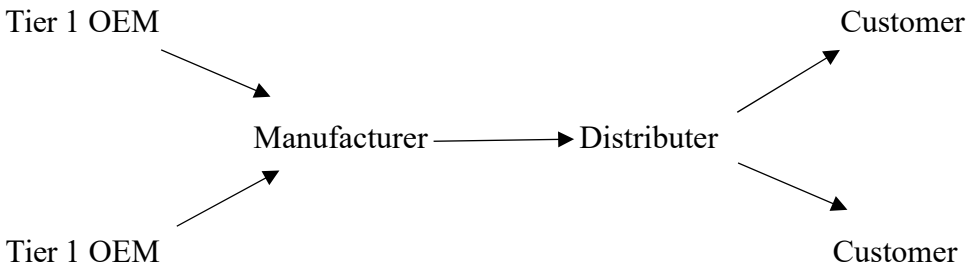

Figure 3: Supply Chain Range

As seen from the Fig 3, the range supply chain starts from Tier 1 OEM to Customer. The rest of the Tiers i.e. Tier 2, Tier 3, Tier 4, Tier 5 aren't taken into consideration. Additionally, the provided solutions through system of Innovation approach, is valid within this specific range of supply chain for each considered Organisation.

6.3 Distinct research methodology:

There are already some research contributions pointing out to challenges of Industry 4.0 and its adoption. All these researches are theory based and there is no practical evidence or contain very less practical evidence of the problem that usually occur within Industry 4.0. Additionally, there is no research paper that explains about countering the problems due to Industry 4.0.

But this research contain interview from Industry 4.0 experts and from spokesperson from the company itself who are directly responsible for implementing these technologies. There questionnaires were tailor made for each set of Expert groups to get clear practical evidence to the problem they faced. This research contains lot of real

time problem scenarios and which are explained in detail. Thus, the identified problems are not only theory based but practically qualified and quantified by experts. Additionally, this research also tries to counter the challenges from Industry 4.0, making it a one of a kind.

6.4 Future Research direction:

As the challenge are identified and way to mitigate those has been documented in this research, the future of this research can be directed towards the feasibility of making this work out. Since, this research had strong point to overcome the challenges, through interviews from experts of Industry 4.0, but the extent to which it can be feasible is still under question. The future research can focus on identifying the feasibility of the provided solution through interview from the respective system of Innovation bodies itself. By this way, these researches can serve as strong baseline for the digital future.

For further reading of the Logistics Engineering and Technologies Group please refer to Auerbach & Uygun, 2007; Keßler et al., 2007; Keßler & Uygun, 2007; Kortmann & Uygun, 2007; Droste et al., 2008; Uygun, 2008; Kuhn et al., 2009; Uygun & Wötzel, 2009, Jungmann & Uygun, 2010; Keßler & Uygun, 2010; Uygun & Kuhn, 2010; Uygun & Luft 2010; Uygun & Schmidt, 2011; Uygun & Wagner, 2011; Liesebach et al., 2012; Uygun et al., 2012; Uygun, 2012a; Uygun, 2012b; Uygun, 2012c; Uygun & Straub, 2012, Besenfelder et al, 2013a; Besenfelder et al 2013b; Güller et al., 2013; Scholz et al., 2013; Uygun, 2013; Uygun & Straub, 2013; Güller et al., 2015; Mevenkamp et al., 2015; Uygun et al., 2015; Karakaya et al., 2016; Uygun & Reynolds, 2016; Güller et al., 2017; Reynolds, & Uygun, 2018; Uygun & Ilie, 2018; Lyutov et al., 2019.

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