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Research Article

Analyzing The Readiness Factors Of The Industries For Implementation Of Industry 4.0 In Production Planning And Control

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ABSTRACT

Purpose: The purpose of this paper is to find out all the readiness factors involved for integration of Industry 4.0 in Production planning and Control using Delphi study and to analyse them as per their importance and relativeness using Fuzzy COPRAS methodology. Thus, integration of Industry 4.0 in production planning and control will give the overall new dimension of scope to fight against changing customer demands, against requirement of agility, against inventory management, against right decision making in right time and controlling the industrial value chain.

Design/methodology/approach: Industry 4.0 is a revolution which demands digital transformation of all mechanized and manual activities so that the interconnection between the technologies through web makes the human interface more live and updated. Production planning is the main branch of any industry in operational environment and controlling them is yet another level of difficulty which requires a level beyond human intervention. In this paper Delphi study is conducted after rigorous literature review among top auto makers to finalize the most relevant readiness factors and Fuzzy COPRAS method to analyse their importance.

Findings: This paper focuses on readiness factors which are directly or indirectly related to the implementation of Industry 4.0 in production planning and control and to analysis is done as per their importance and relativeness.

Practical implications: This study has been done with all the top auto makers in India with the key contacts responsible for Production Planning and Control in their organization so this paper gives the results which is having practical relevance

Originality/value: This article results are generated from original work of the authors and will help industries to kick start their Industry 4.0 journey towards implementation of Industry 4.0 in production planning and control.

Key words: - Industry 4.0, Production planning and Control, Readiness Factors

1. Introduction

Planning and control behavior provide the systems, decisions and procedures which bring all aspects of supply and demand put together. The purpose is always to make perfect connection between demand and supply that will ensure the operation's processes run much more effectively and efficiently to produce products and services as desired by customers. Production planning is the planning of production and manufacturing activities in any company or industry that utilizes the available resources and allocate activities to employees, evaluate materials and production capacity, to serve different customers based on their niche requirements. Production planning is an activity that is performed before the actual production commences. It involves juggling with the schedule of production, pattern and sequence of operations, economic and profitable batch quantities, and also dealing with the dispatching priorities for sequencing of jobs based on patterns.

Herrmann (2021) expressed that the main motive of production planning and control (PPC) is to schedule the production in a planned way and ensure its adherence by dealing with different obstacles occurring during the execution. Kuprat (2015) distributed PPC concept into four different objectives that are capacity utilization, short lead times, high schedule reliability, and lastly low inventory level.

Schmidt (2021) imposed that increasing demand for individualized and customized products creates the need for high variability in production and may be manufacturing through mass customization. Mass customization requires much more flexibility and adaptive in production systems. For implementation of Industry 4.0 for Production planning and Control, the industries need to be ready with all latest technologies, management and human resource like in SCM and Mfg but research related to factors affecting the implementation of Industry 4.0 in PPC are not found in academic literature.

Catalysts and Impediments have been identified for Industry 4.0 and various other areas like SCM, Logistics, plant operational etc. but the Catalysts and Impediments required for Industry 4.0 in Production Planning and Control is missing in the academic literature.

Prioritizing the top enablers and barriers are very essential for any industry to look for its implementation drive. Research related to identify the key enablers and barriers followed by prioritizing them is missing in the literature.

Knowledge of top driving and obstruction factors are very essential for any industry to look for its implementation drive. Research related to identifying the key enablers and barriers related to Industry 4.0 in Production Planning and Control followed by prioritizing them is missing in the literature. Since there are many parameters which supports, and which hinders the implementation of Industry 4.0 in Production Planning and Control. A Causal framework is required for setting up a context for any industry for any technological advancement. The research work for setting up causal framework for Industry 4.0 implementation in Industry is missing in academic literature.

2. Literature Review

Fourth generation of industrial revolution is digitally transforming entire industrial and consumer markets. The theoretical concept of Industry 4.0 was discovered in 2011 by Henning Kagermann (Paprocki, 2016). With the advent of smart technologies, Industry 4.0 is increasingly becoming a lot more popular, and it has received high attention across the globe (Liao et al., 2017; Rennung et al., 2016). As explained by Lopes de Sousa Jabbour et al., (2018), "the core of Industry 4.0 is digital connectivity between machines, employees, orders, customers and suppliers due to the Internet of Things (IoT), and electronic devices known as IIoT (Industrial Internet of Things); as an advantage, all firms are able to produce their products using decentralized decision-making process and autonomous systems." The major function of Industry 4.0 is to equip with a smart manufacturing industries with network based on automation and digitalization where all types of machines and products to be produced which can interact with each other with absolute no human involvement (Gilchrist, 2016; Vladimirovich Sokolov et al., 2017). The sole outcome of Industry 4.0 is to develop Smart factory systems that includes smart machines, smart manufacturing processes, smart engineering, smart devices, smart logistics, smart products and smart suppliers etc. (Kamble et al., 2018). Implementation of Industry 4.0 in any industries promote the use of cyber-physical systems, Internet of Services (IoS), Internet of Things, robotics, big data and cloud manufacturing, thus including devices, production modules, products and machines and applying them to various fields such as manufacturing, supply chain and management, especially to react in real time (Moeuf et al., 2018; Haddud et al., 2017). Machine learning algorithms, business analysis, artificial intelligence, and dynamic optimization, are applicable tools and techniques for implementation of Industry 4.0 in any industry, to maximize automation.

The rapid speed of technological improvements in this area is magnifying the need for accelerated adaptation, and in fact the larger portion of the companies quipped with innovative culture have always been among those that were able to conceptualize this theory and recognize early on how new digital tools and techniques affect their business models and for what value they can extract and collect the information generated by their activities (Castelo, Isabel & Cruz, Frederico & Oliveira, Tiago, 2019). Transformation of industries digitally has been affecting production processes, integrated business models and Indusrty corporate governance. Innovations in information and rapid communication technologies infrastructure, and in data analytical capabilities in the last decade have accelerated a stream of innovations at every levels of corporate business models, corporate organizations and the technical abilities of companies to successfully master them (Castelo, Isabel & Cruz, Frederico & Oliveira, Tiago, 2019).

In order to perform outstanding, all industries have been taking continuous efforts to develop self-assessment models that can conceptually analyze and evaluate the Industry 4.0 readiness of the organizations. Spotting and identifying these Industry 4.0 readiness factors are also needed as these will enable companies to analyze antecedents and precedents in the era of digital transformation process which can lead to organizational transformation (Hanafiah, Hizam & Soomro, Mansoor & Abdullah, 2020). It will then enable policy-makers to reiterate their digital policies and decision-takers to choose among when and how to intervene for its implementation in their industries, and then will determine how to measure the success of digitalization. If not addressed now, the coming era will create a digital wave on the company level, where the companies with low focus on digitalization will be taken off from the market (Hanafiah, Hizam & Soomro, Mansoor & Abdullah, 2020).

This area of implementation of industry 4.0 in industrial planning gives a wonderful opportunity for us to deep dive into and develop our research experience about this topic and know how we can implement Industry 4.0

in production planning in the companies with more options and more branches. However, exact meaning of Industry 4.0 is yet to be determined.

The assessment model referred from the literature for readiness of innovation and smart manufacturing consists of two categories: strategy and culture and smart factory facilities. These two categories were commonly included to assess the status of manufacturing companies in these three references. The first one is related to the smart factory systems based on technological perspective; if a company is equipped with proper hardware & software and network condtion, and if it possesses enough operating abilities. And the second one is related to the organization and culture in a manufacturing area; if the company belongs to an innovation friendly organization supporting their employees' rights and responsibilities with a horizontal enterprise culture (Sheen, Dong & Yang, Yunna, 2018). To know more about the development of the readiness model "IMPULS – Industrie 4.0 Readiness" based on a comprehensive dataset and minute details about various dimensions, items and different approach to assessment are offered. This model is scientifically perfectly grounded and its structures and outcomes are explained in transparent manners (Schumacher, Andreas & Erol, Selim & Sihn, Wilfried, 2016). Therefore this study would be redefining our Readiness model for Production planning and control based on most of the inputs from IMPULS model.

Today we are in that era and in that state where we need the information of everything happening outside sitting in one place. Our agility depends of customer behavior. Consumers are demanding more on Industry 4.0 (Mirela at al, 2019). A firm's capability to implement a new introduction can be influenced by the perceived catalyst and impediments. The drivers or catalyst can promote while barriers or impediments can obstruct a new initiative (Ali & Aboelmaged, 2021). An industry 4.0 equipped industries requires qualified staffs, and today there are lack of agility for the technical colleges, institutions and industries that have to put their efforts to prepare new operators and members for the "factory of the future" Lack of required expertise and exact knowledge is yet another barrier or impediment to Industry 4.0. Barriers or Impediments to Industry 4.0 inducement are due to the scarce of regulations and working structures in developing countries, the missing of legislation in place for the involvement and development of Cloud Computing, Augmented Reality, Cyber-Security, Artificial Intelligence in all developing countries (Mirela at al, 2019). Upgradation and changes in economic and social life due to this Covid-19 era have also led to policies that have been transformed and support industry digitization. People are not having enough time; everything needs to be done quickly and in simplified manner, and this modern digital technologies offer exactly the same. Thus, updated Hi-tech Strategy is a key element working in which Industry 4.0 is built and lots of latest desired innovations underlie its development (Mirela at al, 2019). The study done by Chauhan posits that the performance implications based on Industry 4.0 are sensitive to several Impediments or barriers and that managing them is critical to the firms. Based on the investigation of Indian manufacturing firms, the research findings mostly support the founding arguments (Chauhan, Singh & Luthra 2021).

2.1 Objectives of the research

1. To explore quantitatively the possible readiness factors for implementation of Industry 4.0 in Production Planning and Control of automobile industry.
2. To rank those readiness factors using a fuzzy based MCDM techniques.
3. To suggest multiple pathways to implement Industry 4.0 in Production Planning and Control of automobile industry.

3. Research Methodology

This study is exploratory in nature which is to be conducted among the Indian Automobile Manufacturing industries in order to assess the prospect of I4.0. This will help in better understanding of the existing problem in I4.0 implementation. A mixed method approach is chosen to complete the objectives derived for the research. The Delphi method will help to arrive at a conclusion based on group opinion or decision by bran storming and surveying a panel of experts. Incorporation of fuzzy tool will help in minimizing the vague, uncertain, subjective human perception. Moreover, MCDM tools will help in finding importance degree of each criterion as the measurable indices.

3.1 Research Tools

Table 01: Tools and methodology adopted

Research Objectives	Tool Used/ Methodology adopted
To identify and analyze the readiness factor of the automobile industries for implementation of Industry 4.0 in Production Planning and Control	Systematic Literature review/ Fuzzy Delphi study & Fuzzy COPRAS

Above Table 01 states the objective driven out by the extensive literature survey done in the field of Production Planning and Control for implementation of Industry 4.0. The objective mentioned above will be analyzed by systematic literature review for finding out the related readiness factors and analyzed with the help of Fuzzy Delphi and Fuzzy CoPrAs method.

3.2 Fuzzy Delphi Method

Fuzzy Delphi method is derived from fuzzy set theory with traditional Delphi technique which is proposed by Ishikawa (1993). Noorderhaben (1995) explained that by applying FDM to a group decision, the solution to the fuzziness of common understanding can be performed, based on the expert's opinions. The FDM forms a different set of weights for a variety of criteria by its application. Delphi is a method of having an expert opinion survey with three features: Anonymous response, controlled feedback and Iteration and finally the statistical group response. Delphi method although usually provides easy understanding for the group opinions through the two times provision of the similar questionnaire. Since FDM merges the fuzzy theory with the FDM, it provides the researchers with add on advantage of Delphi method with reduction of the questionnaire time and cost (Hsu 2010; Yu-Feng 2008). The triangular membership functions with the fuzzy theory are integrated and applied in this paper to analyze the group decisions and present the attributive factors of the stages by using FDM. Application of the fuzzy theory can evaluate the fuzziness of common understanding by solving with involvement of experts on a variety of scales. Aliev (2004) explained that when a relevant or appropriate measurable data base is not available, as in the case of measuring the feeling for a new product for market introduction, the conventional statistics and forecasting methods & models cannot be used. The research forecaster must then rely on other intangible evidence, such as subjective or judgmental information, for a market forecast. Qualitative Forecasting models are that models which do not rely on a historical data base. Saffie (2016) concluded that Fuzzy Delphi Method (FDM) is the enhanced and modified version of the classical Delphi technique. FDM employs the probability theory unlike Delphi technique which uses mathematical concepts which make it different when dealing with fuzziness in decision-making. Thus, FDM has been generated by combining fuzzy theory and traditional Delphi Method to consider linguistic preferences of human in decision-making. The Delphi method is a step by step process used to conclude at a group opinion or decision by brain storing with a panel of experts. Experts involve themselves and respond to several rounds of questionnaires, and the responses are evaluated and shared with the same group after each round. These experts are given freedom to adjust their answers after each round, based on their maturity with the "group response" provided to them. The ultimate result after multiple rounds is referred to be a true consensus of what the panelist group thinks. A new fuzzy Delphi method with Triangular fuzzy sets employs the fuzzy statistics tools and technique to fit membership functions.

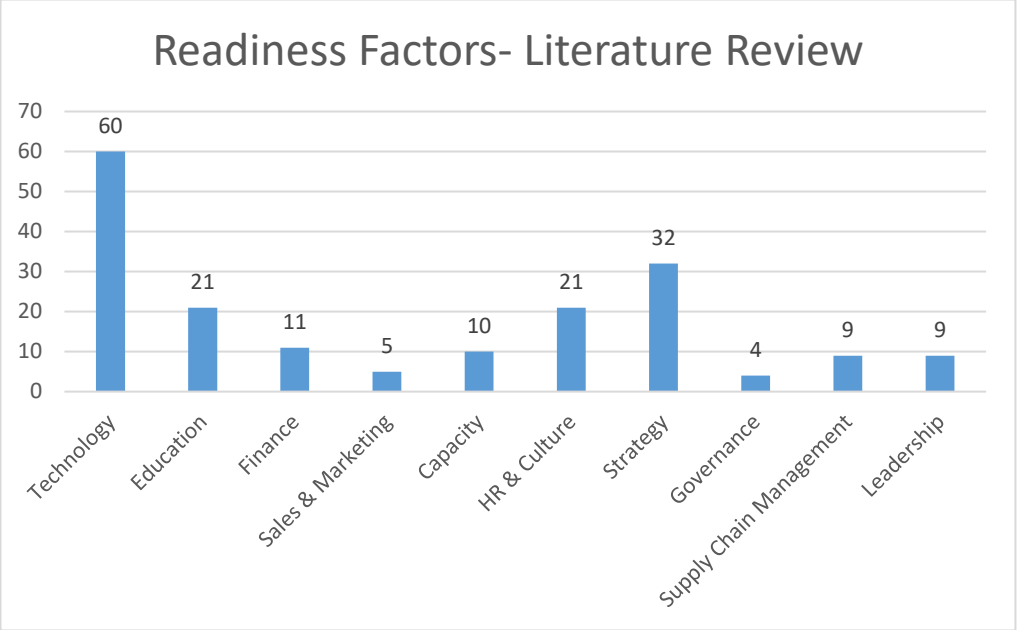
3.3 Delphi discussion from Past Literature

Since we have enormous amount of data regarding the readiness factors for implementation of Industry 4.0 in any industry. To begin with the Delphi approach, this study has collected many readiness factors from depth literature review. These factors are then sorted based on their parent group and then flashed to the different experts in the form of Questionnaires to get the most appropriate readiness factors. There were around 10 parent groups formed namely

1. **Technology** – Technology required for driving and execution
2. **Education** – Skills required for driving and execution
3. **Finance** – Budget required for driving and execution
4. **Sales and Marketing** – Benefits, feedback and feed forward from driving and execution
5. **Capacity** – Capacity planning for driving and execution
6. **Strategy** – Strategic decision for planning and execution
7. **Leadership** – Involvement of leadership decisions for planning and execution
8. **HR & Culture** – recruiting and developing right talent for driving and execution
9. **Governance** – Government rules and regulation for driving and execution
10. **SCM** – Supply chain Management involvement for driving and execution

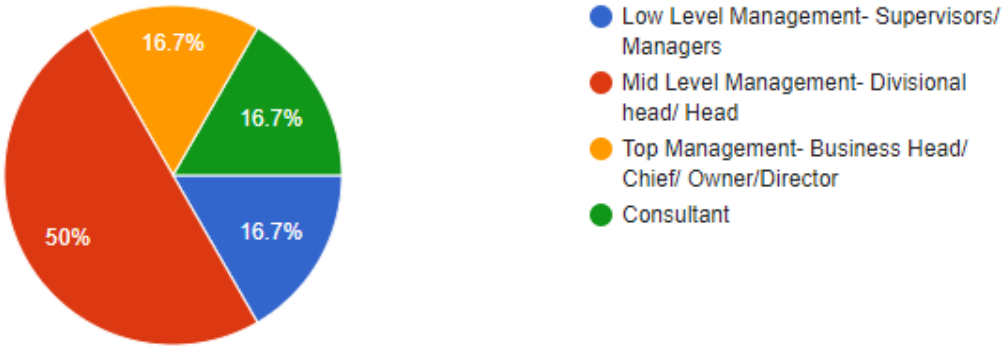
There we around 182 different readiness factors which were derived for the Fuzzy Delphi Study which are as follows.

Figure 01:- Readiness Factors from Literature Review



After in depth literature review there were around 182 readiness factors in ten different broad areas termed as parent group as shown in Figure 01. Each and every factors are required in some or the other stage for implementation of Industry 4.0 in any industry.

Figure 02:- Levels of management involved



The questionnaire was such designed to take inputs from different management levels as mentioned in the Figure 02. The round one of this study constituted 50% of the total experts from mid management level and other three of low management level, top management level and consultant constituting 16.7 % each.

3.4 Fuzzy Delphi Calculation

Table 02:- Fuzzy Set for Delphi Study

Variable	Rating scale	Fuzzy Scale
Strongly disagree	1	(0.0, 0.1, 0.2)
Disagree	2	(0.1, 0.2, 0.4)
Not Sure	3	(0.2, 0.4, 0.6)
Agree	4	(0.4, 0.6, 0.8)
Strongly Agree	5	(0.6, 0.8, 1.0)

The above Fuzzy set in Table 02 is derived from the Fuzzy Triangular Number Matrix in which rating scale from 1 to 5 describes from Strongly disagree to Strongly Agree with three vertices as Strongly disagree with 0.0, 0.1 & 0.2 Disagree with 0.1, 0.2 & 0.4 people with neutral reaction or not sure about the decision will have 0.2, 0.4 & 0.6, Agree stands for 0.4, 0.6 & 0.8 and Strongly Agree means 0.6, 0.8 & 1.0. These Fuzzy sets will replace the rating scale for further Fuzzy calculation.

Data analysis is done with the help of Fuzzy Delphi and Fuzzy triangular Matrix. To view the degree of agreement among experts, a threshold value (d) for two fuzzy numbers m = (m1, m2, m3) and n = (m1, m2, m3) are calculated using the formula:

$$d = \tilde{m},\tilde{n}\sqrt{\frac{1}{3}[(m1-n1)^2+(m2-n2)^2+(m3-n3)^2} \quad (1)$$

Step 1- Building of Likert scale table with the responses collected by 18 different Experts in 1-5 scale for individual 182 probable readiness factors

Table 03:- Likert scale

	LIKERT SCALE																
EXPERT	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**...**	**....**	**177**	**178**	**179**	**180**	**181**	**182**
1	5	2	5	3	1	4	3	3	4	--	--	2	2	2	4	5	4
2	2	5	2	5	5	5	5	5	5	--	--	5	3	4	5	4	4
3	3	1	1	1	2	2	2	3	3	--	--	2	3	3	3	3	2
4	1	2	1	1	2	3	2	3	2	--	--	5	3	2	3	2	2
5	5	3	2	3	5	2	4	3	2	--	--	5	2	2	2	2	3
6	4	1	5	2	5	5	1	3	5	--	--	5	2	5	2	1	2
7	2	2	3	1	5	2	2	3	4	--	--	2	2	2	4	1	3
8	3	2	1	2	5	3	5	5	5	--	--	3	5	5	2	2	2
9	5	4	2	1	5	2	4	4	5	--	--	3	3	3	4	2	4
10	4	3	3	2	5	5	1	1	5	--	--	2	5	2	2	3	2
11	1	2	2	2	1	2	2	2	5	--	--	4	2	2	4	5	4
12	3	1	4	2	5	3	5	3	5	--	--	2	5	2	2	2	2
13	5	2	5	2	5	2	4	5	5	--	--	5	2	4	5	4	2
14	2	5	3	2	4	5	1	4	3	--	--	1	5	5	2	5	2
15	4	4	2	2	5	3	2	2	5	--	--	2	4	2	4	2	2
16	4	2	4	3	2	2	4	3	3	--	--	3	2	3	2	3	4
17	4	2	4	4	1	1	4	4	2	--	--	4	1	4	5	4	5
18	4	3	5	5	4	5	5	5	3	--	--	5	2	5	1	5	5

The above Table 03 represents the Likert scale in which 18 Decision makers were considered for fuzzy Delphi and their input against each readiness factors (all put together 182 readiness factors) were noted down in a tabulated column and given their rating scale as stated in Table-2, where Strongly disagree stands as 1, Disagree stands as 2, Not sure stands as 3, Agree stands as 4 and Strongly agree stands as 5

Step 2- Building of Triangular Fuzzy scale matrix based on expert input

Table 04:- Triangular Fuzzy scale matrix

	FUZZY SCALE														
EXPERT	**1**			**2**			**----**			**181**			**182**		
1	0.6	0.8	1	0	0.8	0.4				0.2	0.4	0.6	0	0	0.2
2	0	0.2	0.4	0.6	0.8	1				0.6	0.8	1	0.6	0.8	1
3	0.2	0.4	0.6	0	0	0.2				0	0	0.2	0	0.2	0.4
4	0	0	0.2	0	0.2	0.4				0	0	0.2	0	0.2	0.4
5	0.6	0.8	1	0.2	0.4	0.6				0.2	0.4	0.6	0.6	0.8	1
6	0.4	0.6	0.8	0	0	0.2				0	0.2	0.4	0.6	0.8	1
7	0	0.2	0.4	0	0.2	0.4				0	0	0.2	0.6	0.8	1
8	0.2	0.4	0.6	0	0.2	0.4				0	0.2	0.4	0.6	0.8	1
9	0.6	0.8	1	0.4	0.6	0.8				0	0	0.2	0.6	0.8	1
10	0.4	0.6	0.8	0.2	0.4	0.6				0	0.2	0.4	0.6	0.8	1
11	0	0	0.2	0	0.2	0.4				0	0.2	0.4	0	0	0.2
12	0.2	0.4	0.6	0	0	0.2				0	0.2	0.4	0.6	0.8	1
13	0.6	0.8	1	0	0.2	0.4				0	0.2	0.4	0.6	0.8	1
14	0	0.2	0.4	0.6	0.8	1				0	0.2	0.4	0.4	0.6	0.8
15	0.4	0.6	0.8	0.4	0.6	0.8				0	0.2	0.4	0.6	0.8	1
16	0.4	0.6	0.8	0	0.2	0.4				0.2	0.4	0.6	0	0.2	0.4
17	0.4	0.6	0.8	0	0.2	0.4				0.4	0.6	0.8	0	0	0.2
18	0.4	0.6	0.8	0.2	0.4	0.6				0.6	0.8	1	0.4	0.6	0.8
AVERAGE	**0.300**	**0.478**	**0.678**	**0.144**	**0.344**	**0.511**				**0.122**	**0.278**	**0.478**	**0.378**	**0.544**	**0.744**
	m1	**m2**	**m3**	**m1**	**m2**	**m3**	**m1**	**m2**	**m3**	**m1**	**m2**	**m3**	**m1**	**m2**	**m3**

The above Table 04 is the driven out Triangular Fuzzy scale in which the outputs received by the various decision makers against each 182 readiness factors are formulated based on the Fuzzy sets tabulated in the Table 02. The table stands as Strongly disagree with 0.0, 0.1 & 0.2 Disagree with 0.1, 0.2 & 0.4 people with neutral reaction or not sure about the decision will have 0.2, 0.4 & 0.6, Agree stands for 0.4, 0.6 & 0.8 and Strongly Agree means 0.6, 0.8 & 1.0. These Fuzzy sets will replace the rating scale for further Fuzzy calculation.

In this average of each column is calculated and denoted as m1, m2, m3 respectively for each Readiness factor decisions given by 18 decision makers.

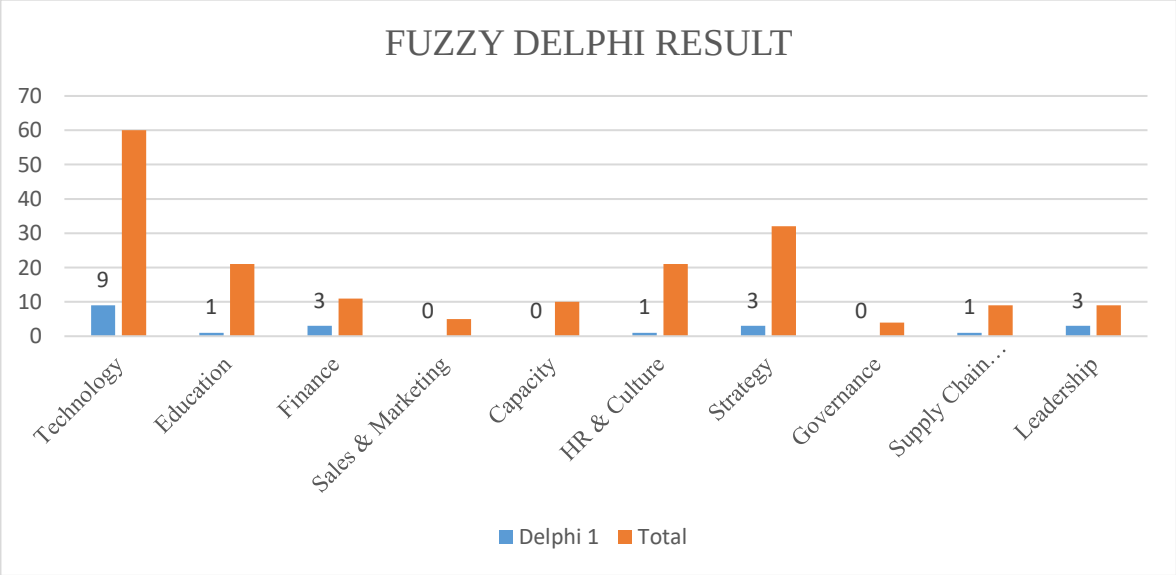
Step 3- Finding out the threshold "d" value

Table 05:- Threshold matrix

EXPERT	ITEM								
	1	2	3	-----	-----	179	180	181	182
1	0.5	0.5	0.4			0.3	0.0	0.1	0.0
2	0.4	0.7	0.5			0.6	0.6	0.5	0.3
3	0.1	0.5	0.4			0.3	0.3	0.1	0.3
4	0.7	0.2	0.5			0.0	0.3	0.1	0.6
5	0.5	0.1	0.5			0.3	0.3	0.1	0.6
6	0.2	0.5	0.5			0.6	0.6	0.1	0.3
7	0.4	0.2	0.4			0.3	0.3	0.1	0.0
8	0.1	0.2	0.1			0.0	0.6	0.5	0.3
9	0.5	0.4	0.1			0.3	0.3	0.2	0.3
10	0.2	0.1	0.4			0.6	0.6	0.7	0.3
11	0.7	0.2	0.2			0.3	0.3	0.4	0.3
12	0.1	0.5	0.4			0.0	0.6	0.1	0.3
13	0.5	0.2	0.5			0.3	0.3	0.5	0.3
14	0.4	0.7	0.7			0.6	0.6	0.2	0.3
15	0.2	0.4	0.4			0.0	0.3	0.4	0.3
16	0.2	0.2	0.1			0.3	0.3	0.1	0.3
17	0.2	0.2	0.2			0.6	0.3	0.2	0.6
18	0.2	0.1	0.5			0.6	0.6	0.5	0.3
Value of d each item	0.339	0.327	0.383			0.350	0.402	0.280	0.326
Value of d construct	**0.313**								

The above calculation in Table 05 has given the individual threshold value "d" for all 182 readiness factors as 0.313 which was identified by in depth literature survey. With the criteria of d≤0.2 and expert group consensus above 75% we came up with 21 nos of readiness factors which was declared as most probable readiness factors for implementation of Industry 4.0 in Production Planning and Control. The value of construct is formulated by defuzzification of the fuzzy matrix by the formula of threshold value and then taking out the average of each column to identify the threshold of that particular readiness factor and rate them with group consensus.

Figure 03:- Fuzzy Delphi result



After calculating with Fuzzy Delphi study we got to know that 18 different experts have suggested that the readiness factors related to sales and marketing, capacity and governance has least or no significance towards implementation of Industry 4.0 in Production planning and control. With the completion of Fuzzy Delphi

Study, 182 readiness factors got reduced to 21 readiness factors which was declared as most significant factors and is mentioned in the Figure 03.

These are the most preferable readiness factors which got identified after Fuzzy Delphi study

Table 06:- Readiness factors after Fuzzy Delphi study

1	Requirement of Industrial Internet of Things (IIoT) in Industry for implementation of I4.0 in PPC
2	Level of digitization of the organization for implementation of I4.0 in PPC
3	Digital Capabilities of the industry for implementation of I4.0 in PPC
4	Capacity of Data Storage of the industry for implementation of I4.0 in PPC
5	Machine communication- Hardware component for implementation of I4.0 in PPC
6	Requirement of Data Driven services in industry for implementation of I4.0 in PPC
7	Requirement of IOT platforms for implementation of I4.0 in PPC
8	Availability of Internet and Communication Technology in industry for implementation of I4.0 in PPC
9	Availability of IT Integration software for implementation of I4.0 in PPC
10	Requirement of Knowledge about technology in industry for implementation of I4.0 in PPC
11	Requirement of Calculating the Cost of technology for implementation of Industry 4.0 in PPC
12	Requirement of calculating the Implementation cost for implementation of Industry 4.0 in PPC
13	Requirement of Financial aid given for implementation of Industry 4.0 in PPC
14	Requirement of technology Proficiency in industry for implementation of Industry 4.0 in PPC
15	Availability of Leadership in industry for implementation of Industry 4.0 in PPC
16	Presence of long term strategy in industry for implementation of Industry 4.0 in PPC
17	Requirement of Road map Strategy in industry for implementation of Industry 4.0 in PPC
18	Evaluation of digitization of supply chain in industry for implementation of Industry 4.0 in PPC
19	Requirement of Top management involvement and commitment in industry for implementation of Industry 4.0 in PPC
20	Requirement of Collaboration Network in industry for implementation of Industry 4.0 in PPC
21	Presence of change management in industry for implementation of Industry 4.0 in PPC

The above Table 06 represents the list of Twenty One Most probable readiness factors out of 182 readiness factors derived out by Extensive Literature Review and calculation of Fuzzy Delphi method. These 21 readiness factors are the most probable and much needed readiness factors for implementation of Industry 4.0 in Production Planning and Control. These readiness factors can be the building blocks of upcoming production planning where digitization will play a most vital role in future.

3.5 Fuzzy CoPrAs Method

Zavadskas et al. (1994) invented the complex proportional assessment (COPRAS) method which makes a stepwise ranking calculation and evaluation procedure of the alternatives with respect to significance and utility degree. COPRAS Method is a multiple-criteria decision making process which is based on combination of fuzzy set theory and Complex proportional assessment (COPRAS).
When comparing with other alternatives, it can decide which one is better or worse.
As required above there is a need of fuzzy-based MCDM techniques which help a research decision-maker to remove the present redundancies due to ambiguous data, so this study will be accepting the COPRAS model with fuzzy data sets.

3.6 Fuzzy set for Calculation of CoPrAs method

For this study we have to consider Triangular Fuzzy Number. A fuzzy number ã on R is termed as a TFNs if its $\mu_{\tilde{a}}(x)$: R–› [0,1] membership function equal to

$$\mu_{\tilde{a}}(x) = \begin{cases} 0, & x < l \\ \frac{x-l}{m-l}, & l \le x \le m \\ \frac{u-x}{u-m}, & m \le x \le u \\ 0, & x > u \end{cases} \qquad \ldots\ldots (1)$$

Where *l, m* and *u* are unfolds the lower, modal and upper values respectively of the support of ã, All are crisp numbers ($-\infty < l \le m \le u < +\infty$)A Triangular Fuzzy Numbers can be shown as a triplet *(l,m,u)* triangular
Step-1: Linguistic variables below and their corresponding TFNs below in table for assessing the readiness factors based on parameter

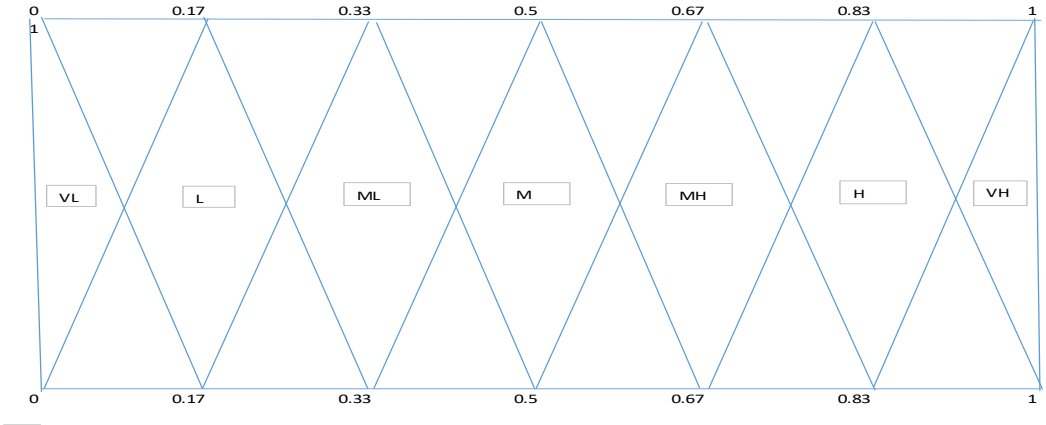
Table 07:- Linguistic variables-1

ABB	MEANING	MAGNITUDE	MAGNITUDE	MAGNITUDE
VH	VERY HIGH	0.83	1	1
H	HIGH	0.67	0.83	1

MH	MEDIUM HIGH	0.5	0.67	0.83
M	MEDIUM	0.33	0.5	0.67
ML	MEDIUM LOW	0.17	0.33	0.5
L	LOW	0	0.17	0.33
VL	VERY LOW	0	0	0.17

The above Fuzzy set in Table 07 is the linguistic variables derived from the Fuzzy Triangular Number Matrix in which rating scale from VL to VH describes from Very Low to Very High with three vertices as Very Low with 0.0, 0.0 & 0.17 Low with 0.0, 0.17 & 0.33 Medium Low with 0.17, 0.33 & 0.5, Medium stands for 0.17, 0.33 & 0.5 and medium high means 0.5, 0.67 & 0.83, High stands for 0.67, 0.83 & 1 and Very high stands for 0.83, 1.0 & 1.0. These Fuzzy sets will replace the rating scale for further Fuzzy CoPrAs Method calculation for ranking among the most probable readiness factors which was identified by Fuzzy Delphi study

Figure 04:- Triangular Fuzzy set-1



These linguistic variables are divided into 7 groups as mentioned in Figure 04 in which each group denotes an unique set of Triangular Fuzzy numbers which will be used for the calculation in Fuzzy Copras method for identifying the most appropriate readiness factors for implementation of Industry 4.0 in Production Planning and Control.

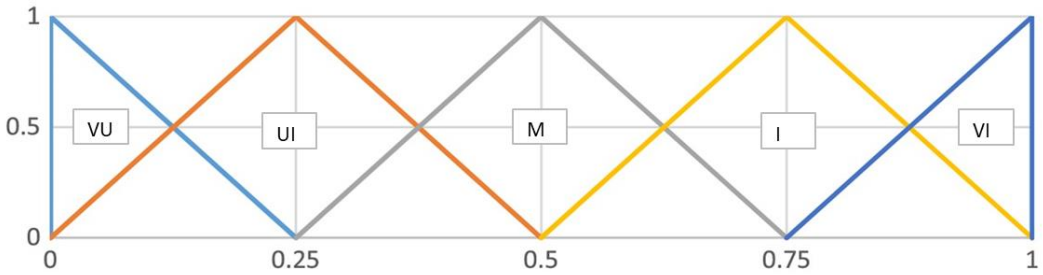
Linguistic variables and their corresponding TFNs for assessing the weights based on parameters.

Table 08:- Linguistic variables-2

ABB	MEANING	MAGNITUDE	MAGNITUDE	MAGNITUDE
VI	Very Important(VI)	0.75	1	1
I	Important(I)	0.5	0.75	1
M	Medium(M)	0.25	0.5	0.75
UI	Unimportant(U)	0	0.25	0.5
VU	Very Unimportant(VU)	0	0	0.25

The above Fuzzy set in Table 08 is the linguistic variables derived from the Fuzzy Triangular Number Matrix in which rating scale from VI to VU describes from Very Unimportant(VU) to Very Important with three vertices as Very Unimportant with 0.0, 0.0 & 0.25 Unimportant with 0.0, 0.25 & 0.5 Medium Important with 0.2, 0.5 & 0.75, Important stands for 0.5, 0.75 & 1.0 and Very Important means 0.75, 1.0 & 1.0. These Fuzzy sets will replace the rating scale for further Fuzzy CoPrAs calculation for finding out the parameters to rate the 21 most probable readiness factors.

Figure 05:- Triangular Fuzzy set-2



These linguistic variables are divided into 5 groups as mentioned in Figure 05 in which each group denotes an

unique set of Triangular Fuzzy numbers which will be used for the calculation in Fuzzy Copras method for identifying the most appropriate readiness factors for implementation of Industry 4.0 in Production Planning and Control.
Fuzzy Complex Proportional Assessment method has to have a fuzzy set of linguistic variables for evaluating the most appropriate readiness factors and for constructing the weights.
The assessment includes the survey of five senior leadership of different automobile industries in India which helped this study for construction of Decision matrix and Weighted Matrix.

3.7 Construction of Decision Matrix

$$D = \begin{bmatrix} x11 & \cdots & x1n \\ \vdots & \ddots & \vdots \\ xm1 & \cdots & xmn \end{bmatrix} \quad \text{.....(2)}$$

$W_j = [W_1 \ldots\ldots W_n]$, where $\sum_{j=1}^{n}(W1 \ldots \ldots Wn) = 1$

Before construction of Decision Matrix, few leading and lagging indicators were derived to measure the most appropriate readiness factors among 21 shortlisted readiness factors from Delphi study.

These leading and lagging indicators are

1. **Capability** – Capability means how much capable is the readiness factors for implementation of Industry 4.0 in Production Planning and Control.
2. **Stability** – Stability means even after many times the readiness factors gives the same result for implementation of Industry 4.0 in Production Planning and Control.
3. **Networking** – Networking refers to the connectivity between the hardware available for implementation of Industry 4.0 in Production Planning and Control
4. **Information Technology advantage** – IT means the flow of data in the digital format inside and outside the shop for implementation of Industry 4.0 in Production Planning and Control
5. **Extent of auto correct** – This means that the devices connected and performance of the devices or technologies should be in such a way that it will either give alarm or self-align itself towards the mean to give better result for implementation of Industry 4.0 in Production Planning and Control
6. **Ease of collaboration with new devices** – Collaboration of the devices means the compatibility of the hardware and software to feed the agile environment for implementation of Industry 4.0 in Production Planning and Control
7. **Decision making** – The readiness factors identified should be able to decide the preferences and sequence of its usage and maintenance for implementation of Industry 4.0 in Production Planning and Control
8. **Extent of Data Exchange** – This refers to the transfer of the digital data limit to which the exchange can happen smoothly for implementation of Industry 4.0 in Production Planning and Control
9. **Extent of forecasting** – This refers to the forecasting and predicting the future hazards or opportunities ability for implementation of Industry 4.0 in Production Planning and Control
10. **Extent of up gradation** – Up gradation is always required in this agile environment, the readiness factors should be capable of getting upgraded frequently and should not have any technology which could not be updated or upgraded for implementation of Industry 4.0 in Production Planning and Control
11. **Cost involved** – For every business, cost is the major contributor. The less the cost the more is the chances of any new ideas to get implemented.
12. **Time for implementation** – Now in agile environment, adaptive nature of the readiness factors should not take much time. Time required should be minimum with high result for implementation of Industry 4.0 in Production Planning and Control

Each parameters are presented as a survey to 5 different senior leadership of top automobile industries in India for their views on rating the parameters with respect to readiness factors which was derived from Delphi study among the given linguistic variables. There after super imposing the Fuzzy sets as per the Triangular Fuzzy Number relative to the linguistic variables. The final matrix is prepared by the Fuzzy Aggregation Technique for each of the parameters shown below.

3.8 Decision Matrix

Table 09:- Decision Matrix for Fuzzy CoPrAs

Readiness Factors	Capability			Stability			Networking			Information Technology advantage			Extent of auto correct			Ease of collaboration with new devices			Decision making			Extent of Data Exchange			Extent of forecasting			Extend of up gradation			Cost involved			Time for implementation		
Requirement of Industrial Internet of Things (IIoT)	0.70	0.87	0.97	0.70	0.87	0.97	0.67	0.83	0.97	0.67	0.83	0.93	0.00	0.07	0.23	0.77	0.93	1.00	0.00	0.07	0.23	0.77	0.93	1.00	0.00	0.14	0.30	0.80	0.97	1.00	0.33	0.50	0.67	0.03	0.10	0.27
Level of digitization	0.10	0.23	0.40	0.10	0.23	0.40	0.63	0.80	0.93	0.80	0.97	1.00	0.30	0.43	0.60	0.80	0.97	1.00	0.77	0.93	1.00	0.77	0.93	1.00	0.53	0.70	0.86	0.80	0.97	1.00	0.77	0.93	1.00	0.73	0.90	0.97
Digital Capabilities	0.73	0.90	0.97	0.73	0.90	0.97	0.67	0.83	0.93	0.66	0.83	0.90	0.70	0.87	0.93	0.73	0.90	0.97	0.77	0.93	1.00	0.80	0.97	1.00	0.80	0.97	1.00	0.80	0.97	1.00	0.70	0.87	0.97	0.77	0.93	1.00
Capacity of Data Storage	0.76	0.93	0.97	0.76	0.93	0.97	0.10	0.20	0.37	0.43	0.60	0.77	0.23	0.40	0.57	0.73	0.90	0.93	0.30	0.47	0.63	0.77	0.93	1.00	0.00	0.03	0.20	0.77	0.93	1.00	0.70	0.87	0.93	0.00	0.10	0.27
Machine communication - Hardware component	0.76	0.93	0.97	0.76	0.93	0.97	0.77	0.93	1.00	0.70	0.87	0.93	0.27	0.43	0.60	0.63	0.80	0.90	0.00	0.03	0.20	0.80	0.97	1.00	0.00	0.03	0.20	0.73	0.90	1.00	0.60	0.77	0.93	0.00	0.10	0.27
Requirement of Data Driven services	0.73	0.90	0.97	0.73	0.90	0.97	0.60	0.76	0.90	0.80	0.97	1.00	0.77	0.93	1.00	0.76	0.93	0.97	0.76	0.93	0.97	0.73	0.90	1.00	0.80	0.97	1.00	0.80	0.97	1.00	0.73	0.90	1.00	0.80	0.97	1.00
Requirement of IOT platforms	0.83	1.00	1.00	0.83	1.00	1.00	0.70	0.87	0.93	0.53	0.70	0.87	0.00	0.07	0.23	0.70	0.87	0.93	0.80	0.97	1.00	0.40	0.57	0.74	0.40	0.57	0.74	0.77	0.93	1.00	0.77	0.93	1.00	0.77	0.93	1.00

Availability of Internet and Communication Technology	0.67	0.83	0.97	0.67	0.83	0.97	0.57	0.73	0.90	0.77	0.93	1.00	0.77	0.93	1.00	0.76	0.93	0.97	0.77	0.93	1.00	0.80	0.97	1.00	0.80	0.97	1.00	0.80	0.97	1.00	0.77	0.93	1.00	0.77	0.93	1.00
Availability of IT Integration software	0.73	0.90	0.97	0.73	0.90	0.97	0.60	0.77	0.90	0.80	0.97	1.00	0.77	0.93	1.00	0.77	0.93	1.00	0.80	0.97	1.00	0.77	0.93	1.00	0.80	0.97	1.00	0.70	0.87	0.97	0.77	0.93	1.00	0.30	0.47	0.64
Requirement of Knowledge about technology	0.36	0.53	0.70	0.36	0.53	0.70	0.07	0.17	0.33	0.57	0.73	0.90	0.13	0.17	0.34	0.00	0.07	0.23	0.73	0.90	0.97	0.77	0.93	1.00	0.80	0.97	1.00	0.70	0.86	1.00	0.00	0.07	0.23	0.73	0.90	1.00
Requirement of Calculating the Cost of technology	0.80	0.97	1.00	0.80	0.97	1.00	0.03	0.07	0.24	0.13	0.20	0.37	0.00	0.03	0.20	0.00	0.03	0.20	0.00	0.07	0.23	0.17	0.25	0.42	0.80	0.97	1.00	0.70	0.87	0.97	0.33	0.50	0.67	0.77	0.93	1.00
Requirement of calculating the Implementation cost	0.77	0.93	1.00	0.77	0.93	1.00	0.00	0.10	0.27	0.00	0.03	0.20	0.00	0.03	0.20	0.00	0.03	0.20	0.00	0.03	0.20	0.07	0.10	0.27	0.77	0.93	1.00	0.70	0.87	0.93	0.36	0.53	0.70	0.77	0.93	1.00
Requirement of Financial aid	0.70	0.87	0.97	0.70	0.87	0.97	0.03	0.10	0.27	0.10	0.13	0.30	0.00	0.03	0.20	0.00	0.03	0.20	0.00	0.00	0.17	0.13	0.20	0.37	0.80	0.97	1.00	0.83	1.00	1.00	0.30	0.47	0.64	0.80	0.97	1.00
Requirement of technology Proficiency	0.33	0.50	0.67	0.40	0.57	0.74	0.03	0.13	0.30	0.60	0.77	0.93	0.00	0.03	0.20	0.00	0.07	0.23	0.80	0.97	1.00	0.77	0.93	1.00	0.80	0.97	1.00	0.67	0.83	0.97	0.00	0.03	0.20	0.73	0.90	1.00
Availability of Leadership	0.70	0.87	0.97	0.70	0.87	0.97	0.03	0.07	0.24	0.10	0.13	0.30	0.80	0.97	1.00	0.80	0.97	1.00	0.80	0.97	1.00	0.47	0.63	0.80	0.80	0.97	1.00	0.73	0.90	0.97	0.40	0.57	0.73	0.80	0.97	1.00

Presence of long term strategy	0.63	0.80	0.93	0.63	0.80	0.93	0.07	0.13	0.30	0.10	0.13	0.30	0.80	0.97	1.00	0.67	0.83	0.93	0.80	0.97	1.00	0.37	0.53	0.70	0.77	0.93	1.00	0.70	0.87	0.93	0.36	0.53	0.70	0.77	0.93	1.00
Requirement of Road map Strategy	0.83	1.00	1.00	0.83	1.00	1.00	0.07	0.13	0.30	0.13	0.20	0.37	0.80	0.97	1.00	0.66	0.83	0.90	0.80	0.97	1.00	0.27	0.43	0.60	0.80	0.97	1.00	0.77	0.93	1.00	0.37	0.53	0.70	0.77	0.93	1.00
Evaluation of digitization of supply chain	0.63	0.80	0.93	0.63	0.80	0.93	0.70	0.87	0.97	0.83	1.00	1.00	0.64	0.80	0.97	0.77	0.93	1.00	0.80	0.97	1.00	0.80	0.97	1.00	0.80	0.97	1.00	0.77	0.93	1.00	0.00	0.03	0.20	0.73	0.90	0.97
Requirement of Top management involvement and commitment	0.60	0.77	0.90	0.60	0.77	0.90	0.13	0.27	0.43	0.17	0.23	0.40	0.70	0.87	0.93	0.80	0.97	1.00	0.77	0.93	1.00	0.27	0.43	0.60	0.80	0.97	1.00	0.70	0.87	0.93	0.40	0.57	0.73	0.73	0.90	0.97
Requirement of Collaboration Network	0.73	0.90	1.00	0.73	0.90	1.00	0.60	0.77	0.93	0.73	0.90	0.97	0.73	0.90	0.97	0.70	0.87	0.93	0.73	0.90	1.00	0.67	0.83	0.90	0.73	0.90	1.00	0.80	0.97	1.00	0.73	0.90	1.00	0.33	0.50	0.67
Presence of change management	0.13	0.30	0.47	0.13	0.30	0.47	0.76	0.93	0.97	0.67	0.83	0.93	0.77	0.93	1.00	0.70	0.87	0.97	0.80	0.97	1.00	0.77	0.93	1.00	0.77	0.93	1.00	0.77	0.93	1.00	0.77	0.93	1.00	0.80	0.97	1.00

The Table 09 represents the decision matrix based on the decision maker's responses where the decision makers have made some leading and lagging parameters from which we can rate the readiness factors against. The ratings are then converted into Fuzzy sets as mentioned in table 7 and the average of 5 decision makers for that particular readiness factors. The above table consists of average value of 5 decision makers and then plotted on against each cell for calculation in decision matrix.

3.9 Normalized Matrix

$n_{ij} = \frac{x\,ij}{\sum_{j=1}^{n} xij}$ .....(3)

Table 10:- Normalized Matrix for Fuzzy CoPrAs

Readiness Factors	Capability			Stability			Networking			Information Technology advantage			Extent of auto correct			Ease of collaboration with new devices			Decision making			Extent of Data Exchange			Extent of forecasting			Extend of up gradation			Cost involved			Time for implementation		
Requirement of Industrial Internet of Things (IIoT)	0.05	0.05	0.05	0.05	0.05	0.05	0.09	0.08	0.07	0.06	0.06	0.06	0.00	0.01	0.02	0.07	0.06	0.06	0.00	0.00	0.01	0.06	0.06	0.06	0.00	0.01	0.02	0.05	0.05	0.05	0.03	0.04	0.04	0.00	0.01	0.01
Level of digitization	0.01	0.01	0.02	0.01	0.01	0.02	0.08	0.08	0.07	0.08	0.07	0.07	0.03	0.04	0.04	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.04	0.04	0.05	0.05	0.05	0.05	0.08	0.07	0.06	0.06	0.06	0.05
Digital Capabilities	0.06	0.05	0.05	0.05	0.05	0.05	0.08	0.08	0.07	0.06	0.06	0.06	0.08	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.07	0.07	0.06	0.06	0.06	0.06
Capacity of Data Storage	0.06	0.06	0.05	0.06	0.06	0.05	0.01	0.02	0.03	0.04	0.05	0.05	0.03	0.03	0.04	0.06	0.06	0.06	0.02	0.03	0.04	0.06	0.06	0.06	0.00	0.00	0.01	0.05	0.05	0.05	0.07	0.07	0.06	0.00	0.01	0.01
Machine communication - Hardware component	0.06	0.06	0.05	0.06	0.06	0.05	0.10	0.09	0.07	0.07	0.07	0.06	0.03	0.04	0.04	0.05	0.05	0.05	0.00	0.00	0.01	0.07	0.06	0.06	0.00	0.00	0.01	0.05	0.05	0.05	0.06	0.06	0.06	0.00	0.01	0.01
Requirement of Data Driven services	0.06	0.05	0.05	0.05	0.05	0.05	0.08	0.07	0.07	0.08	0.07	0.07	0.08	0.08	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.07	0.07	0.06	0.06	0.06	0.06

Requirement of IOT platforms	0.06	0.06	0.05	0.06	0.06	0.05	0.09	0.08	0.07	0.05	0.05	0.06	0.00	0.01	0.02	0.06	0.06	0.06	0.07	0.07	0.06	0.03	0.04	0.04	0.03	0.03	0.04	0.05	0.05	0.05	0.08	0.07	0.06	0.06	0.06	0.06
Availability of Internet and Communication Technology	0.05	0.05	0.05	0.05	0.05	0.05	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.07	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.08	0.07	0.06	0.06	0.06	0.06
Availability of IT Integration software	0.06	0.05	0.05	0.05	0.05	0.05	0.08	0.07	0.07	0.08	0.07	0.07	0.08	0.08	0.07	0.07	0.06	0.06	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.04	0.04	0.05	0.08	0.07	0.06	0.02	0.03	0.04
Requirement of Knowledge about technology	0.03	0.03	0.04	0.03	0.03	0.04	0.01	0.02	0.02	0.06	0.06	0.06	0.01	0.01	0.02	0.00	0.00	0.01	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.04	0.04	0.05	0.00	0.01	0.01	0.06	0.06	0.06
Requirement of Calculating the Cost of technology	0.06	0.06	0.05	0.06	0.06	0.05	0.00	0.01	0.02	0.01	0.02	0.02	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.02	0.02	0.06	0.06	0.06	0.05	0.04	0.04	0.05	0.03	0.04	0.04	0.06	0.06	0.06
Requirement of calculating the Implementation cost	0.06	0.06	0.05	0.06	0.06	0.05	0.00	0.01	0.02	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.06	0.06	0.05	0.04	0.05	0.05	0.04	0.04	0.04	0.06	0.06	0.06
Requirement of Financial aid	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0.01	0.02	0.01	0.01	0.02	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.06	0.06	0.05	0.05	0.05	0.05	0.03	0.04	0.04	0.06	0.06	0.06
Requirement of technology Proficiency	0.02	0.03	0.04	0.03	0.03	0.04	0.00	0.01	0.02	0.06	0.06	0.06	0.00	0.00	0.01	0.00	0.00	0.01	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.04	0.04	0.05	0.00	0.00	0.01	0.06	0.06	0.06

Availability of Leadership	0.005	0.005	0.005	0.005	0.005	0.005	0.000	0.001	0.002	0.001	0.001	0.002	0.009	0.008	0.007	0.007	0.007	0.006	0.007	0.007	0.006	0.004	0.004	0.005	0.006	0.006	0.005	0.005	0.005	0.005	0.004	0.004	0.005	0.006	0.006	0.006
Presence of long term strategy	0.005	0.005	0.005	0.005	0.005	0.005	0.001	0.001	0.002	0.001	0.001	0.002	0.009	0.008	0.007	0.006	0.006	0.006	0.007	0.007	0.006	0.003	0.003	0.004	0.006	0.006	0.005	0.004	0.005	0.005	0.004	0.004	0.004	0.006	0.006	0.006
Requirement of Road map Strategy	0.006	0.006	0.005	0.006	0.006	0.005	0.001	0.001	0.002	0.001	0.002	0.002	0.009	0.008	0.007	0.006	0.006	0.005	0.007	0.007	0.006	0.002	0.003	0.003	0.006	0.006	0.005	0.005	0.005	0.005	0.004	0.004	0.004	0.006	0.006	0.006
Evaluation of digitization of supply chain	0.005	0.005	0.005	0.005	0.005	0.005	0.009	0.008	0.007	0.008	0.008	0.007	0.007	0.007	0.007	0.007	0.006	0.006	0.007	0.007	0.006	0.007	0.006	0.006	0.006	0.006	0.005	0.005	0.005	0.005	0.000	0.000	0.001	0.006	0.006	0.005
Requirement of Top management involvement and commitment	0.005	0.005	0.005	0.005	0.005	0.005	0.002	0.003	0.003	0.002	0.002	0.003	0.008	0.007	0.007	0.007	0.007	0.006	0.006	0.006	0.006	0.002	0.003	0.003	0.006	0.006	0.005	0.004	0.005	0.005	0.004	0.004	0.005	0.006	0.006	0.005
Requirement of Collaboration Network	0.006	0.005	0.005	0.006	0.005	0.005	0.008	0.007	0.007	0.007	0.007	0.006	0.008	0.008	0.007	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.007	0.007	0.006	0.003	0.003	0.004
Presence of change management	0.001	0.002	0.002	0.001	0.002	0.002	0.010	0.009	0.007	0.006	0.006	0.006	0.008	0.008	0.007	0.006	0.006	0.006	0.007	0.007	0.006	0.006	0.006	0.006	0.006	0.006	0.005	0.005	0.005	0.005	0.008	0.007	0.006	0.006	0.006	0.006

The Table 10 represents the normalized matrix based on the decision maker's responses and calculation done with the Fuzzy CoPrAs calculation. Once the decision matrix is formulated by taking average of 5 decision makers against parameters identified by the decision makers, normalized matrix is tabulated by calculation of normalizing with the weights assigned by the decision makers.

3.10 Determining of Weighted Normalized Decision-Making Matrix

$N_{ij} = W_j \times n_{ij}$ .....(4)

Table 11:- Weighted Normalized Matrix for Fuzzy CoPrAs

Readiness Factors	Capability			Stability			Networking			Information Technology advantage			Extent of auto correct			Ease of collaboration with new devices			Decision making			Extent of Data Exchange			Extent of forecasting			Extend of up gradation			Cost involved			Time for implementation		
Requirement of Industrial Internet of Things (IIoT)	0.02	0.04	0.05	0.03	0.04	0.05	0.03	0.05	0.06	0.02	0.04	0.05	0.00	0.00	0.01	0.02	0.03	0.04	0.00	0.00	0.01	0.04	0.05	0.05	0.00	0.00	0.01	0.02	0.03	0.04	0.02	0.03	0.04	0.00	0.00	0.01
Level of digitization	0.00	0.01	0.02	0.00	0.01	0.02	0.03	0.05	0.06	0.03	0.04	0.06	0.00	0.01	0.02	0.02	0.03	0.04	0.00	0.01	0.03	0.04	0.05	0.05	0.00	0.00	0.02	0.02	0.03	0.04	0.04	0.06	0.06	0.03	0.04	0.05
Digital Capabilities	0.02	0.04	0.05	0.03	0.05	0.05	0.03	0.05	0.06	0.02	0.04	0.05	0.01	0.02	0.03	0.02	0.03	0.04	0.00	0.01	0.03	0.04	0.05	0.05	0.00	0.01	0.02	0.02	0.03	0.04	0.04	0.05	0.06	0.03	0.04	0.05
Capacity of Data Storage	0.03	0.04	0.05	0.03	0.05	0.05	0.01	0.01	0.02	0.01	0.03	0.04	0.00	0.01	0.02	0.02	0.03	0.04	0.00	0.01	0.02	0.04	0.05	0.05	0.00	0.00	0.00	0.02	0.03	0.04	0.04	0.05	0.06	0.00	0.00	0.01
Machine communication - Hardware component	0.03	0.04	0.05	0.03	0.05	0.05	0.04	0.06	0.06	0.02	0.04	0.05	0.00	0.01	0.02	0.01	0.02	0.04	0.00	0.00	0.01	0.04	0.05	0.05	0.00	0.00	0.00	0.02	0.03	0.04	0.03	0.05	0.06	0.00	0.00	0.01
Requirement of Data Driven services	0.02	0.04	0.05	0.03	0.05	0.05	0.03	0.05	0.06	0.03	0.04	0.06	0.01	0.02	0.04	0.02	0.03	0.04	0.00	0.01	0.03	0.04	0.05	0.05	0.00	0.01	0.02	0.02	0.03	0.04	0.04	0.05	0.06	0.03	0.04	0.05
Requirement of IOT platforms	0.03	0.04	0.05	0.04	0.05	0.05	0.04	0.05	0.06	0.02	0.03	0.05	0.00	0.00	0.01	0.01	0.03	0.04	0.00	0.01	0.03	0.02	0.03	0.04	0.00	0.00	0.01	0.02	0.03	0.04	0.04	0.06	0.06	0.03	0.04	0.05

Availability of Internet and Communication Technology	0.02	0.03	0.05	0.03	0.04	0.05	0.03	0.05	0.06	0.03	0.04	0.06	0.01	0.02	0.04	0.02	0.03	0.04	0.00	0.01	0.03	0.04	0.05	0.05	0.00	0.01	0.02	0.02	0.03	0.04	0.04	0.06	0.06	0.03	0.04	0.05
Availability of IT Integration software	0.02	0.04	0.05	0.03	0.05	0.05	0.03	0.05	0.06	0.03	0.04	0.06	0.01	0.02	0.04	0.02	0.03	0.04	0.00	0.01	0.03	0.04	0.05	0.05	0.00	0.01	0.02	0.02	0.03	0.04	0.04	0.06	0.06	0.01	0.02	0.03
Requirement of Knowledge about technology	0.01	0.02	0.03	0.02	0.03	0.04	0.00	0.01	0.02	0.02	0.03	0.05	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.03	0.04	0.05	0.05	0.00	0.01	0.02	0.02	0.03	0.04	0.00	0.00	0.01	0.03	0.04	0.05
Requirement of Calculating the Cost of technology	0.03	0.04	0.05	0.04	0.05	0.05	0.00	0.00	0.02	0.00	0.01	0.02	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.00	0.01	0.02	0.02	0.03	0.04	0.02	0.03	0.04	0.03	0.04	0.05
Requirement of calculating the Implementation cost	0.03	0.04	0.05	0.03	0.05	0.05	0.00	0.01	0.02	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01	0.02	0.02	0.03	0.04	0.02	0.03	0.04	0.03	0.04	0.05
Requirement of Financial aid	0.02	0.04	0.05	0.03	0.04	0.05	0.00	0.01	0.02	0.00	0.01	0.02	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.01	0.02	0.02	0.03	0.04	0.02	0.03	0.04	0.03	0.04	0.05
Requirement of technology Proficiency	0.01	0.02	0.03	0.02	0.03	0.04	0.00	0.01	0.02	0.02	0.04	0.05	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.03	0.04	0.05	0.05	0.00	0.01	0.02	0.01	0.03	0.04	0.00	0.00	0.01	0.03	0.04	0.05
Availability of Leadership	0.02	0.04	0.05	0.03	0.04	0.05	0.00	0.00	0.02	0.00	0.01	0.02	0.01	0.02	0.04	0.02	0.03	0.04	0.00	0.01	0.03	0.02	0.04	0.04	0.00	0.01	0.02	0.02	0.03	0.04	0.02	0.03	0.04	0.03	0.04	0.05
Presence of long	0.02	0.03	0.04	0.03	0.04	0.05	0.00	0.01	0.02	0.00	0.01	0.02	0.01	0.02	0.04	0.01	0.03	0.04	0.00	0.01	0.03	0.02	0.03	0.04	0.00	0.01	0.02	0.02	0.03	0.04	0.02	0.03	0.04	0.03	0.04	0.05

term strategy																																				
Requirement of Road map Strategy	0.03	0.04	0.05	0.04	0.05	0.05	0.00	0.01	0.02	0.00	0.01	0.02	0.01	0.02	0.04	0.01	0.03	0.04	0.00	0.01	0.03	0.01	0.02	0.03	0.00	0.01	0.02	0.02	0.03	0.04	0.02	0.03	0.04	0.03	0.04	0.05
Evaluation of digitization of supply chain	0.02	0.03	0.04	0.03	0.04	0.05	0.04	0.05	0.06	0.03	0.05	0.06	0.01	0.02	0.03	0.02	0.03	0.04	0.00	0.01	0.03	0.04	0.05	0.05	0.00	0.01	0.02	0.02	0.03	0.04	0.00	0.00	0.01	0.03	0.04	0.05
Requirement of Top management involvement and commitment	0.02	0.03	0.04	0.03	0.04	0.05	0.01	0.02	0.03	0.01	0.01	0.02	0.01	0.02	0.03	0.02	0.03	0.04	0.00	0.01	0.03	0.01	0.02	0.03	0.00	0.01	0.02	0.02	0.03	0.04	0.02	0.03	0.04	0.03	0.04	0.05
Requirement of Collaboration Network	0.02	0.04	0.05	0.03	0.05	0.05	0.03	0.05	0.06	0.02	0.04	0.05	0.01	0.02	0.03	0.01	0.03	0.04	0.00	0.01	0.03	0.03	0.05	0.05	0.00	0.01	0.02	0.02	0.03	0.04	0.04	0.05	0.06	0.01	0.02	0.04
Presence of change management	0.00	0.01	0.02	0.01	0.02	0.02	0.04	0.06	0.06	0.02	0.04	0.05	0.01	0.02	0.04	0.01	0.03	0.04	0.00	0.01	0.03	0.04	0.05	0.05	0.00	0.01	0.02	0.02	0.03	0.04	0.04	0.06	0.06	0.03	0.04	0.05

The Table 11 represents the weighted normalized matrix based on the decision maker's responses and calculated weights finalized by the decision makers. The weighted normalized matrix is the combination of weights formulated by giving the prioritizing the parameters to which these readiness factors will give the

ranking among themselves. The weighted normalized matrix is then averaged and then sent for final ranking calculation.

Calculate the sum B_i of the Benefit Criteria values,

$B_i = \sum_{j=1}^{k} N_{ij}$ .....(5)

Calculate the sum C_i of the Benefit Criteria values,

$C_i = \sum_{j=k+1}^{k} N_{ij}$ .....(6)

Calculating the relative significance Q_i of each alternative

$Q_i = B_i + \frac{\min(Ci).\sum_{i=1}^{n} Ci}{Ci.\sum_{i=1}^{n}(\frac{\min(Ci)}{Ci})}$ .....(7)

Determine the utility degree for each alternative as

$UD_i = \frac{Qi}{\max(Qi)} \times 100\%$ .....(8)

Table 12:- Final Ranking for Fuzzy CoPrAs

Readiness Factors	**FUZZY B_i BENEFIT VALUES**	**FUZZY C_i NON BENEFIT VALUES**	**FUZZY Min $(C_i)/C_i$**	**Q_i**	**UD_i**	**RANK**
Requirement of Industrial Internet of Things (IIoT) in Industry for implementation of I4.0 in PPC	0.830	0.108	1.00	1.22	98%	2
Level of digitization of the organization for implementation of I4.0 in PPC	0.752	0.278	0.39	0.90	72%	14
Digital Capabilities of the industry for implementation of I4.0 in PPC	0.935	0.273	0.39	1.09	87%	7
Capacity of Data Storage of the industry for implementation of I4.0 in PPC	0.737	0.164	0.66	1.00	79%	9
Machine communication-Hardware component for implementation of I4.0 in PPC	0.866	0.153	0.71	1.14	91%	3
Requirement of Data Driven services in industry for implementation of I4.0 in PPC	0.940	0.282	0.38	1.09	87%	6
Requirement of IOT platforms for implementation of I4.0 in PPC	0.829	0.283	0.38	0.98	78%	10
Availability of Internet and Communication Technology in industry for implementation of I4.0 in PPC	0.930	0.283	0.38	1.08	86%	8
Availability of IT Integration software for implementation of I4.0 in PPC	0.940	0.224	0.48	1.13	90%	4
Requirement of Knowledge about technology in industry for implementation of I4.0 in PPC	0.606	0.141	0.77	0.91	72%	12
Requirement of Calculating the Cost of technology for implementation of Industry 4.0 in PPC	0.480	0.213	0.51	0.68	54%	19
Requirement of calculating the Implementation cost for implementation of Industry 4.0 in PPC	0.431	0.219	0.49	0.62	50%	21

Requirement of Financial aid given for implementation of Industry 4.0 in PPC	0.455	0.211		0.51		0.66		52%		20
Requirement of technology Proficiency in industry for implementation of Industry 4.0 in PPC	0.595	0.137		0.79		0.90		72%		13
Availability of Leadership in industry for implementation of Industry 4.0 in PPC	0.681	0.228		0.47		0.87		69%		16
Presence of long term strategy in industry for implementation of Industry 4.0 in PPC	0.647	0.219		0.49		0.84		67%		18
Requirement of Road map Strategy in industry for implementation of Industry 4.0 in PPC	0.685	0.219		0.49		0.88		70%		15
Evaluation of digitization of supply chain in industry for implementation of Industry 4.0 in PPC	0.940	0.135		0.80		1.25		100%		1
Requirement of Top management involvement and commitment in industry for implementation of Industry 4.0 in PPC	0.658	0.220		0.49		0.85		68%		17
Requirement of Collaboration Network in industry for implementation of Industry 4.0 in PPC	0.919	0.224		0.48		1.11		88%		5
Presence of change management in industry for implementation of Industry 4.0 in PPC	0.796	0.286		0.38		0.94		75%		11

The Table 12 represents the final ranking calculation based on the decision maker's responses and Fuzzy CoPrAs calculation where benefit values and non benefit values are calculated and then with the statistical calculation we get the most desirable ranks for the 21 readiness factors

4.0 RESULTS

In order to implement Industry 4.0 in Production planning and control, the study to generate the skeleton from which any industry should start their journey towards the implementation of Industry 4.0 in PPC. After detailed analysis and applying MCDM technique, the study finalized the ranking of the most preferable readiness factors. Initially the study prepared 182 readiness factors for Delphi study which reduced to 21 most preferable readiness factors after multiple rounds of Delphi Study. For MCDM technique, Fuzzy CoPrAs technique was introduced for ranking of all the most preferable readiness factors. Having 18 different experts from different Automotive Industries and their survey reports as Decision Makers (DM) After all analysis and calculations the study concluded that Digitization of Supply Chain should be the First priority for any industry for implementation of Industry 4.0 in Production Planning and Control. Second rank was derived for availability of Industrial internet of things which helps collecting the data digitally in the form of scanners, barcode readers etc. to support digitization of Supply Chain. Third rank was derived for availability of Hardware line data storage, clouds, hard drives, super computers, etc. for connectivity of IIOT and Digital Supply Chain. Fourth rank was derived for IT Integration software for the IIOT's which we try to incorporate from the digital supply chain from various location and various clubbed parts for implementation of Industry 4.0 in Production Planning and Control. Fifth rank was derived for Collaboration network for all the parent and Tier1 and Tier2 industries to alarm the on time feedback and feed forward for implementation of Industry 4.0 in Production Planning and Control. Sixth rank was derived for data driven services for industries for sharing of schedule changes, drawing changes, delivery feedback, priority changes, interlinking of Purchase order based on priority of vehicle build, etc. Seventh rank was derived for evaluating the competencies of upgrading the industry in digital platform so as to know the on time processing of the child parts, vendors knowing the updated live rollout for their production planning and dispatch. Parent plant knowing the constraints of the particular supplier and adjust the plan accordingly. Eighth rank was derived for Internet and Communication technology for all the machines, running lines, dispatch systems, challan generation system, etc. Ninth rank was derived for evaluating and upgrading the capacity of data storage for all the data collected and analysis done. Tenth

rank was derived for availability of IIOT platform after every step of processes at parent plant and at vendor plant as Tier1 and Tier 2. Eleventh rank was derived for availability of vertical which takes care of change management for effective planning and implementation of Industry 4.0 projects. Twelfth rank was derived for skill development of all the employees related to the application of Industry 4.0 in Production Planning and Control. Thirteenth rank was derived for collaboration with external expert for enhancing the skills and upgrading the technology for usage of Industry 4.0 in Production planning and control. Fourteenth rank was derived for Digitization of the whole organization of parent plant and Vendors from which each and every data can be captured for implementation of Industry 4.0 in Production Planning and Control. Fifteenth rank was derived for developing the road map strategy for target implementation and developing the Gantt chart to keep the track on time and success. Sixteenth rank was derived for availability of some senior leader to drive the whole digital platform of Industry 4.0 for production planning and Control. Seventeenth rank was derived for including the KPI of Industry 4.0 in Production planning and control for top management of the company. Eighteenth rank was derived for development of long term strategy for implementation of Industry 4.0 in Production Planning and Control. Nineteenth rank was derived for calculation of cost involved for technology setup which could be beneficial and readily available for next projects. Twentieth rank was derived for calculating the financial aid requirement for the maintenance and up keeping of the technology implemented for implementation of Industry 4.0 in Production Planning and Control. Twenty-first rank was derived for calculation of total project cost vs benefits for each domain of Industry 4.0 in Production planning and control which could be made useful for breakeven calculation and business case presentation to higher management.

Table 13:- Ranking of Readiness Factors

Readiness Factors	RANK
Evaluation of digitization of supply chain in industry for implementation of Industry 4.0 in PPC	1
Requirement of Industrial Internet of Things (IIoT) in Industry for implementation of I4.0 in PPC	2
Machine communication- Hardware component for implementation of I4.0 in PPC	3
Availability of IT Integration software for implementation of I4.0 in PPC	4
Requirement of Collaboration Network in industry for implementation of Industry 4.0 in PPC	5
Requirement of Data Driven services in industry for implementation of I4.0 in PPC	6
Digital Capabilities of the industry for implementation of I4.0 in PPC	7
Availability of Internet and Communication Technology in industry for implementation of I4.0 in PPC	8
Capacity of Data Storage of the industry for implementation of I4.0 in PPC	9
Requirement of IOT platforms for implementation of I4.0 in PPC	10
Presence of change management in industry for implementation of Industry 4.0 in PPC	11
Requirement of Knowledge about technology in industry for implementation of I4.0 in PPC	12
Requirement of technology Proficiency in industry for implementation of Industry 4.0 in PPC	13
Level of digitization of the organization for implementation of I4.0 in PPC	14
Requirement of Road map Strategy in industry for implementation of Industry 4.0 in PPC	15
Availability of Leadership in industry for implementation of Industry 4.0 in PPC	16
Requirement of Top management involvement and commitment in industry for implementation of Industry 4.0 in PPC	17
Presence of long term strategy in industry for implementation of Industry 4.0 in PPC	18
Requirement of Calculating the Cost of technology for implementation of Industry 4.0 in PPC	19
Requirement of Financial aid given for implementation of Industry 4.0 in PPC	20
Requirement of calculating the Implementation cost for implementation of Industry 4.0 in PPC	21

The Table 13 represents the final readiness factors ranking based on the decision maker's responses and Fuzzy CoPrAs calculation. These ranks are the final output of the Fuzzy CoPrAs calculation which will decide the steps which are most important and mandatory for implementation of Industry 4.0 in Production Planning and Control.

4.1 Research Implication-

This research was specially done for the automobile industries to cope with the changing demands in Production Planning and Control model. This research will help the industries to implement Industry 4.0 approach in Production planning and control. This research has been exclusively extracted from the pilot project from one of the top auto industries in India which will help the other auto industries and their Tier 1, 2,

3 etc industries to start with the implementation of Industry 4.0 for Production Planning and Control in their organization which will help them get up to date with all the Supply chain operations and plan their productions accordingly. It will be tagged as "Connected Organization" for future endeavors. This research has derived all the possible factors which could be directly or indirectly related for the implementation of Industry 4.0 in PPC in any industry and this paper specifically focuses on those parts of area where any industry if wants to start their journey for implementing Industry 4.0 in their organization and PPC as well. This research will give a step by step guidelines for all the industries irrespective of their domain if they belong to auto or non-auto to kick start their Industry 4.0 journey in PPC and SCM as well. This research will also give a broader picture to all the Tier 1,2,3 industries linked with parent industries about their constraints and planning for production in much effective and resourceful manner. All industries when connected with each other, every industries connected to parent industry will be in lined with the production plan and can prepare and dispatch their product "Just In Time".

4.4 Conclusion Limitation and Future Scope

In this paper we have used in depth literature review to find out 182 readiness factors which could be related directly or indirectly for implementation of Industry 4.0 in PPC. Secondly, we used Fuzzy Delphi to identify the critical factors among all the 182 factors identified from the intensive literature reviews and used Fuzzy CoPrAs method to conclude the ranking and priority of the critical factors to be focused on for implementation of Industry 4.0 in Production Planning and Control. These ranking will help any industry to kick start their journey of implementation of Industry 4.0 in PPC.

This research has only given the direction and importance to those parameters which is required in initial stages of implementation of Industry 4.0 in Production Planning and Control. There is lot of scope in finding out the barriers and drivers for implementation of Industry 4.0 in Production Planning and Control.

This study was taken among top auto manufacturer in which very less amount of experts have participated to narrow down the listed factors as per their experience and priorities.

5. References

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APPENDIX

Table 14:- Readiness Factors for Delphi study

Sr. No	Parent group	Readiness Factors	1	2	3	4	5
1	Technology	Requirement of Industrial Internet of Things (IIoT) in Industry for implementation of I4.0 in PPC					
2	Technology	Requirement of Big Data Analytics in Industry for implementation of I4.0 in PPC					
3	Technology	Industries should be doing Horizontal and vertical integration of systems for implementation of I4.0 in PPC					
4	Technology	Industries having Simulation facility of production for implementation of I4.0 in PPC					
5	Technology	Requirement of Clouds & Computing for implementation of I4.0 in PPC					
6	Technology	Requirement of Augmented Reality in Industry for implementation of I4.0 in PPC					

7	Technology	Requirement of Autonomous Robots in industry for implementation of I4.0 in PPC					
8	Technology	Requirement of 3D printing and Cyber Security in industry for implementation of I4.0 in PPC					
9	Technology	Requirement of any Degree of automation in industry for implementation of I4.0 in PPC					
10	Technology	Usage of Right technology for Industry 4.0 in Industry for implementation of I4.0 in PPC					
11	Technology	Level of digitization of the organization for implementation of I4.0 in PPC					
12	Technology	Digital Capabilities of the industry for implementation of I4.0 in PPC					
13	Technology	Level of Data Quality of the industry for implementation of I4.0 in PPC					
14	Technology	Capacity of Data Storage of the industry for implementation of I4.0 in PPC					
15	Technology	Technology required for Data Sharing for implementation of I4.0 in PPC					
16	Technology	Technology required for Data Processing for implementation of I4.0 in PPC					
17	Technology	Machines readiness- Hardware component for implementation of I4.0 in PPC					
18	Technology	Machine communication- Hardware component for implementation of I4.0 in PPC					
19	Technology	IT security- Software component for implementation of I4.0 in PPC					
Sr. No	**Parent group**	**Readiness Factors**					
20	Technology	Product design and development – Software Component for implementation of I4.0 in PPC					
21	Technology	Smart material planning – Software Component for implementation of I4.0 in PPC					
22	Technology	Smart production – Software Component for implementation of I4.0 in PPC					
23	Technology	Smart maintenance- Software Component for implementation of I4.0 in PPC					
24	Technology	Smart logistic- Software component for implementation of I4.0 in PPC					
25	Technology	Technology required for Information Sharing for implementation of I4.0 in PPC					
26	Technology	Level of Automation in industry for implementation of I4.0 in PPC					
27	Technology	Presence of Flexible Manufacturing System for implementation of I4.0 in PPC					
28	Technology	Requirement of Human-Machine Integration for implementation of I4.0 in PPC					
29	Technology	Requirement of CPS- Cyber Physical Systems for implementation of I4.0 in PPC					
30	Technology	Requirement of Data Connected Information f2 for implementation of I4.0 in PPC					
31	Technology	Requirement of Data usage Distribution control for implementation of I4.0 in PPC					
32	Technology	Availability of Real Time Data analytics in industry for implementation of I4.0 in PPC					
33	Technology	Availability of Self optimization and tracking system in industry for implementation of I4.0 in PPC					
34	Technology	Requirement of Data Driven services in industry for implementation of I4.0 in PPC					

35	Technology	Requirement of Data Driven Decision Making in industry for implementation of I4.0 in PPC					
36	Technology	Requirement of Digital Products in industry for implementation of I4.0 in PPC					
37	Technology	Requirement of Digital Modelling in industry for implementation of I4.0 in PPC					
38	Technology	Requirement of Mobile devices in industry for implementation of I4.0 in PPC					
39	Technology	Requirement of IOT platforms for implementation of I4.0 in PPC					
40	Technology	Requirement of Location detection technologies for implementation of I4.0 in PPC					
41	Technology	Requirement of Advance human machine interface in industry for implementation of I4.0 in PPC					
42	Technology	Availability of Authentication and fraud detection system in industry for implementation of I4.0 in PPC					
Sr. No	**Parent group**	**Readiness Factors**					
43	Technology	Requirement of Smart sensors in industry for implementation of I4.0 in PPC					
44	Technology	Availability of Internet and Communication Technology in industry for implementation of I4.0 in PPC					
45	Technology	Requirement of Data Governance system in industry for implementation of I4.0 in PPC					
46	Technology	Evaluation mechanism of Data Readiness system in industry for implementation of I4.0 in PPC					
47	Technology	Availability of Data Storage and Computing facilities for implementation of I4.0 in PPC					
48	Technology	Availability of IT Integration software for implementation of I4.0 in PPC					
49	Technology	Availability of IT Maturity systems for implementation of I4.0 in PPC					
50	Technology	Evaluation mechanism of IT Readiness in industry for implementation of I4.0 in PPC					
51	Technology	Availability of Complementary IT Systems in industry for implementation of I4.0 in PPC					
52	Technology	Evaluation of ICT Readiness in industry for implementation of I4.0 in PPC					
53	Technology	Requirement of Technology based Smart Products in industry for implementation of I4.0 in PPC					
54	Technology	Requirement of integrating digital twins in industrial processing for implementation of I4.0 in PPC					
55	Technology	Requirement of Digital Product Portfolio in industry for implementation of I4.0 in PPC					
56	Technology	Requirement of Digitally-enabled Operations in industry for implementation of I4.0 in PPC					
57	Technology	Requirement of Digitization of Product and Service Offerings in industry for implementation of I4.0 in PPC					
58	Technology	Requirement of RFID Implementation in industry for implementation of I4.0 in PPC					
59	Technology	Use of Analytical CRM Software in industry for implementation of I4.0 in PPC					
60	Technology	Requirement of Employees having Remote Access to IT System in industry for implementation of I4.0 in PPC					
61	Education	Requirement of Knowledge about technology in industry for implementation of I4.0 in PPC					
62	Education	Requirement of knowledge about Method of production in industry for implementation of I4.0 in PPC					

63	Education	Awareness of Benefits of technology in industry for implementation of I4.0 in PPC					
Sr. No	**Parent group**	**Readiness Factors**					
64	Education	Requirement of Understanding the technology in industry for implementation of I4.0 in PPC					
65	Education	Requirement of upgrading the Technical skills in industry for implementation of I4.0 in PPC					
66	Education	Evaluation of Competencies in industry for implementation of I4.0 in PPC					
67	Education	Requirement of enhancing digital skills in industry for implementation of I4.0 in PPC					
68	Education	Requirement of Learning from Pilot project in industry for implementation of I4.0 in PPC					
69	Education	Evaluating Employee skill sets in industry for implementation of I4.0 in PPC					
70	Education	Mapping Skill acquisition in industry for implementation of I4.0 in PPC					
71	Education	Building Team expertise in industry for implementation of I4.0 in PPC					
72	Education	Evaluating level of awareness in industry for implementation of I4.0 in PPC					
73	Education	Evaluating the qualification of work force in industry for implementation of I4.0 in PPC					
74	Education	Assessing Information Connectivity Maturity in industry for implementation of I4.0 in PPC					
75	Education	Requirement of Information-Seeking Skills in industry for implementation of I4.0 in PPC					
76	Education	Acceptance and Application of New Technology and Media in industry for implementation of I4.0 in PPC					
77	Education	Incorporating Information-Sharing Behaviour in industry for implementation of I4.0 in PPC					
78	Education	Requirement of RFID Knowledge in industry for implementation of I4.0 in PPC					
79	Education	Requirement of Employee Adaptability with Industry 4.0 in PPC					
80	Education	Knowledge and capability of Vertical and Horizontal Integration in industry for implementation of I4.0 in PPC					
81	Education	Requirement of Operational Model in industry for implementation of I4.0 in PPC					
82	Finance	Requirement of Calculating the Cost of technology for implementation of Industry 4.0 in PPC					
83	Finance	Requirement of calculating the Implementation cost for implementation of Industry 4.0 in PPC					
84	Finance	Requirement of introduction of Industry 4.0 in Financial KPI for implementation of Industry 4.0 in PPC					
Sr. No	**Parent group**	**Readiness Factors**					
85	Finance	Readiness of Finance and Investments related to implementation of Industry 4.0 in PPC					
86	Finance	Requirement of evaluating the Infrastructure and Equipment for implementation of Industry 4.0 in PPC					
87	Finance	Requirement of having a Share of revenues towards implementation of Industry 4.0 in PPC					
88	Finance	Requirement of calculating the Break even for implementation of Industry 4.0 in PPC					
89	Finance	Requirement of Financial aid given for implementation of Industry 4.0 in PPC					

90	Finance	Requirement of evaluation of Financial resources for implementation of Industry 4.0 in PPC					
91	Finance	Requirement of Funding strategy for implementation of Industry 4.0 in PPC					
92	Finance	Requirement of ICT(Information and Communication Technology) Infrastructure for implementation of Industry 4.0 in PPC					
93	Sales & Marketing	Requirement of Integrating Marketing Channels for implementation of Industry 4.0 in PPC					
94	Sales & Marketing	Requirement of accessing market and customer access for implementation of Industry 4.0 in PPC					
95	Sales & Marketing	Requirement of Multilevel customer interaction and customer profiling for implementation of Industry 4.0 in PPC					
96	Sales & Marketing	Requirement of Digital Marketing for implementation of Industry 4.0 in PPC					
97	Sales & Marketing	Requirement of Digital Media Awareness to customers for implementation of Industry 4.0 in PPC					
98	Capacity	Requirement of mapping the Variety of products in the industry for implementation of Industry 4.0 in PPC					
99	Capacity	Requirement of mapping Number of employees in the industry for implementation of Industry 4.0 in PPC					
100	Capacity	Requirement of mapping the turnover of industry for implementation of Industry 4.0 in PPC					
101	Capacity	Requirement of evaluating the Industry 4.0 Operations in PPC					
102	Capacity	Requirement of mapping the availability of Smart product and services in industry for implementation of Industry 4.0 in PPC					
103	Capacity	Requirement of checking the availability of Product Customization for implementation of Industry 4.0 in PPC					
Sr. No	**Parent group**	**Readiness Factors**					
104	Capacity	Requirement of Product and Process Integration for implementation of Industry 4.0 in PPC					
105	Capacity	Requirement of Autonomous processes for implementation of Industry 4.0 in PPC					
106	Capacity	Requirement of Mass production for implementation of Industry 4.0 in PPC					
107	Capacity	Capability of Process Transformation practices in industry for implementation of Industry 4.0 in PPC					
108	HR & Culture	Presence of Suggestions & Kaizen department in industry for implementation of Industry 4.0 in PPC					
109	HR & Culture	Incentives based on successful implementation of projects in industry for implementation of Industry 4.0 in PPC					
110	HR & Culture	Integration of the organizational structure in industry for implementation of Industry 4.0 in PPC					
111	HR & Culture	Requirement of assessment of Competitive pressures to change in industry for implementation of Industry 4.0 in PPC					
112	HR & Culture	Mapping Workforce with different ages in industry for implementation of Industry 4.0 in PPC					
113	HR & Culture	Mapping Employee adaptability with Industry 4.0 in industry for implementation of Industry 4.0 in PPC					
114	HR & Culture	Requirement of assessment of Empowerment in industry for implementation of Industry 4.0 in PPC					
115	HR & Culture	Mapping of Labour Market Obstructing Factors in industry for implementation of Industry 4.0 in PPC					

116	HR & Culture	Requirement of Professional Competence in industry for implementation of Industry 4.0 in PPC					
117	HR & Culture	Requirement of technology Proficiency in industry for implementation of Industry 4.0 in PPC					
118	HR & Culture	Requirement of assessment of Technical Competencies in industry for implementation of Industry 4.0 in PPC					
119	HR & Culture	Requirement of assessment of Learning Competencies in industry for implementation of Industry 4.0 in PPC					
120	HR & Culture	Requirement of evaluating Employees and Digital Culture in industry for implementation of Industry 4.0 in PPC					
121	HR & Culture	Requirement of Organization Employees Digital transformation in industry for implementation of Industry 4.0 in PPC					
122	HR & Culture	Requirement of Culture Strategic Alignment in industry for implementation of Industry 4.0 in PPC					
123	HR & Culture	Requirement of Innovation Culture in industry for implementation of Industry 4.0 in PPC					
Sr. No	**Parent group**	**Readiness Factors**					
124	HR & Culture	Requirement of Innovation Ecosystem in industry for implementation of Industry 4.0 in PPC					
125	HR & Culture	Assessment of Innovation Implementation Effectiveness in industry for implementation of Industry 4.0 in PPC					
126	HR & Culture	Global Measures of Organizational Readiness for Digital Innovation in industry for implementation of Industry 4.0 in PPC					
127	HR & Culture	Availability of Creativity Management in industry for implementation of Industry 4.0 in PPC					
128	HR & Culture	Availability of Idea Management in industry for implementation of Industry 4.0 in PPC					
129	Strategy	Availability of Leadership in industry for implementation of Industry 4.0 in PPC					
130	Strategy	Availability of Customer Centric approach in industry for implementation of Industry 4.0 in PPC					
131	Strategy	Mapping the Priorities in industry for implementation of Industry 4.0 in PPC					
132	Strategy	Involvement of all levels of Management in industry for implementation of Industry 4.0 in PPC					
133	Strategy	Availability of Decision making in industry for implementation of Industry 4.0 in PPC					
134	Strategy	Integration with Org Structure in industry for implementation of Industry 4.0 in PPC					
135	Strategy	Balance between tactical and Strategic goal in industry for implementation of Industry 4.0 in PPC					
136	Strategy	Requirement to Improve automation of individual or even all business processes in industry for implementation of Industry 4.0 in PPC					
137	Strategy	Requirement of Reengineering existing business models in industry for implementation of Industry 4.0 in PPC					
138	Strategy	Readiness of organizational strategy in industry for implementation of Industry 4.0 in PPC					
139	Strategy	Requirement of Partnership with I4.0 Consultant in industry for implementation of Industry 4.0 in PPC					
140	Strategy	Requirement of having Smart factory in industry for implementation of Industry 4.0 in PPC					
141	Strategy	Requirement of Smart operations in industry for implementation of Industry 4.0 in PPC					
142	Strategy	Requirement of Smart products in industry for implementation of Industry 4.0 in PPC					

143	Strategy	Requirement of collaboration with expert in industry for implementation of Industry 4.0 in PPC					
144	Strategy	Creating Good preconditions in industry for implementation of Industry 4.0 in PPC					
Sr. No	**Parent group**	**Readiness Factors**					
145	Strategy	Requirement of Mass communication in industry for implementation of Industry 4.0 in PPC					
146	Strategy	Readiness Requirement specification to be highlighted in industry for implementation of Industry 4.0 in PPC					
147	Strategy	Presence of long term strategy in industry for implementation of Industry 4.0 in PPC					
148	Strategy	Requirement of evaluation of Business performance in industry for implementation of Industry 4.0 in PPC					
149	Strategy	Requirement of Strategic Readiness in industry for implementation of Industry 4.0 in PPC					
150	Strategy	Requirement of vertical with Strategy Innovation and Growth in industry for implementation of Industry 4.0 in PPC					
151	Strategy	Requirement of vertical with Strategy Management and Regulatory requirement in industry for implementation of Industry 4.0 in PPC					
152	Strategy	Requirement of linkage with Corporate Strategy in industry for implementation of Industry 4.0 in PPC					
153	Strategy	Requirement of vertical with Management Strategy and Organization in industry for implementation of Industry 4.0 in PPC					
154	Strategy	Requirement of HR Development Strategy in industry for implementation of Industry 4.0 in PPC					
155	Strategy	Requirement of Analysis and Strategy in industry for implementation of Industry 4.0 in PPC					
156	Strategy	Requirement of Market Strategy in industry for implementation of Industry 4.0 in PPC					
157	Strategy	Requirement of Business Strategy in industry for implementation of Industry 4.0 in PPC					
158	Strategy	Requirement of Strategy driven by Digital Vision in industry for implementation of Industry 4.0 in PPC					
159	Strategy	Requirement of evaluation of Smart Business Processes in industry for implementation of Industry 4.0 in PPC					
160	Strategy	Requirement of Road map Strategy in industry for implementation of Industry 4.0 in PPC					
161	Governance	Requirement of Regulatory pressure in industry for implementation of Industry 4.0 in PPC					
162	Governance	Requirement of Industrial Pressure in industry for implementation of Industry 4.0 in PPC					
163	Governance	Availability of Government influence in industry for implementation of Industry 4.0 in PPC					
164	Governance	Availability of Governmental support in industry for implementation of Industry 4.0 in PPC					
Sr. No	**Parent group**	**Readiness Factors**					
165	Supply Chain Management	Evaluation of digitization of supply chain in industry for implementation of Industry 4.0 in PPC					
166	Supply Chain Management	Availability of Smart product and services in industry for implementation of Industry 4.0 in PPC					
167	Supply Chain Management	Assessment of Supply chain constraints identification in industry for implementation of Industry 4.0 in PPC					
168	Supply Chain Management	Requirement of Supply Chain Integration in industry for implementation of Industry 4.0 in PPC					

169	Supply Chain Management	Assessment of Supply Chain Visibility in industry for implementation of Industry 4.0 in PPC					
170	Supply Chain Management	Assessment of Supply Chain flexibility in industry for implementation of Industry 4.0 in PPC					
171	Supply Chain Management	Evaluation of value chains and processes in industry for implementation of Industry 4.0 in PPC					
172	Supply Chain Management	Requirement of In time supply in industry for implementation of Industry 4.0 in PPC					
173	Supply Chain Management	Availability of Smart logistics in industry for implementation of Industry 4.0 in PPC					
174	Leadership	Requirement of Top management involvement and commitment in industry for implementation of Industry 4.0 in PPC					
175	Leadership	Requirement of Collaboration Network in industry for implementation of Industry 4.0 in PPC					
176	Leadership	Requirement of Innovation Management in industry for implementation of Industry 4.0 in PPC					
177	Leadership	Presence of change management in industry for implementation of Industry 4.0 in PPC					
178	Leadership	Requirement of Digital Practices in industry for implementation of Industry 4.0 in PPC					
179	Leadership	Requirement of Change Leadership in industry for implementation of Industry 4.0 in PPC					
180	Leadership	Requirement of Top Management Ability in industry for implementation of Industry 4.0 in PPC					
181	Leadership	Requirement of Top Management Commitment in industry for implementation of Industry 4.0 in PPC					
182	Leadership	Requirement of Top Management Involvement in industry for implementation of Industry 4.0 in PPC					

TABLE DETAILS

Sr No	Table No	Details
1	Table 1	Tools and methodology adopted
2	Table 2	Fuzzy Set for Delphi Study
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4	Table 4	Triangular Fuzzy scale matrix
5	Table 5	Threshold matrix
6	Table 6	Readiness factors after Fuzzy Delphi study
7	Table 7	Linguistic variables-1
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GRAPH DETAILS

Sr No	Table No	Details
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2	Figure 2	Levels of management involved
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4	Figure 4	Triangular Fuzzy set-1
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