# An Empirical Examination of Benefits, Challenges, and Critical Success Factors of Industry 4.0 in Manufacturing and Service Sector


## Abstract

Industry 4.0 marks a new paradigm and has expanded its domain from theoretical concepts to real-world applications. Industry 4.0 is, however, still in the state of infancy and conceptual state wherein it is not clear as to how to incorporate many dynamic technological concepts in different sectors. Previous studies have conceptually delineated the benefits, challenges, and CSFs of Industry 4.0, however, there is yet to be an empirical study that critically examines the differences in benefits, challenges, and critical success factors (CSFs) of Industry 4.0 in both manufacturing and service industries and rank them. This study through an online survey captures the view of senior management professionals who have experience in Industry 4.0 implementation in major companies in Asia, Europe, and North America. 96 senior management professionals participated in this study through an online survey. The qualitative data on benefits and challenges were analysed using thematic analyses. The quantitative data on critical success factors were ranked using the normalisation of the mean to find the most important factors. Further agreement analysis was conducted in the manufacturing and service sectors for the CSFs. This study identifies the top five benefits and challenges in the manufacturing and service industries. The CSFs for Industry 4.0 was put forward and ranked in both the manufacturing and service industries.


**Keywords:** Benefits, challenges, Critical Success Factors, Industry 4.0, Manufacturing, Service, Survey

## 1. Introduction

Industry 4.0 has attracted exponentially increasing attention among academics, managers and government officials because its successful implementation will lead to competitive advantages

for companies as well as for national economies [1], [2]. Industry 4.0 originated in Germany to promote manufacturing development [3], [4]. Other countries have followed this paradigm by launching "Smart Manufacturing" in the USA, "Made in China 2025", "Future of Manufacturing" in the UK, "Smart Advanced Manufacturing and Rapid Transformation Hub (SAMARTH)- Udyog Bharat 4.0" in India, etc. [5], [6]. It is targeted at making intelligent organizations through modern technologies such as Cyber-physical systems (CPS), cloud computing and the Internet of Things (IoT)[7], [8][9]. To convince traditional organizations of the value of such large-scale digital transformation, the benefits of implementing Industry 4.0 should outweigh the efforts both in non-financial and financial aspects. Besides, the organizations should also understand the challenges for its implementation, so that they can better plan to mitigate against them. Previous researchers have studied the benefits and challenges for the Industry 4.0 implementation [1], [10]–[13]. The benefits and challenges in the manufacturing and service sector are different when implementing Industry 4.0 [14]. In manufacturing organizations the products are tangible, can be inventoried, customers are not present during manufacturing, low customization, measuring productivity is easy, the opportunity to correct problems are high, quality evaluation is easy compared to services[15]. These structural differences in both sectors warrants and an empirical study, which compares the benefits and challenges for both these sectors. In addition, there is a need to understand empirically those important success factors, which must go correct, for successful implementation of Industry 4.0 in both sectors. Previous studies have also explored CSFs of Industry 4.0 [16]–[21], however, these studies have not explored sector-wise differences empirically. Besides, Sony and Naik [16] suggest that CSFs of Industry 4.0 might differ across sectors and there is a need to empirically examine the differences. The recent years also saw various reference architectures published for Industry 4.0[22]. A reference architecture is a general architecture that will allow, to construct specific models will be constructed. It also

allows deriving system architecture, based on which common terminology and structure between different stakeholders can be further developed[23]. The fundamental objective of this architecture is a uniform virtual representation of technical systems. However, the extent of usage of this architecture by organizations are not known[23], [24] and also Industry 4.0 is a socio-technical system wherein social and technical systems work in tandem in a joint optimized goal-directed manner[25]. Thus, in addition to technical systems, other aspects need to be considered for the successful implementation of Industry 4.0[26]. These factors may also vary across both manufacturing and service sectors. Therefore, the main purpose of this study is to critically examine the differences in benefits, challenges and CSFs in both manufacturing and service industries. Consequently, in this study, we seek to answer the following research questions:

1. *What are the differences in benefits of Industry 4.0 in the Manufacturing and Service sectors?*
2. *What are the differences in challenges of Industry 4.0 in the Manufacturing and Service sectors?*
3. *What are the differences in CSFs of Industry 4.0 in the manufacturing & service sectors and how important are these CSFs?*

This study will contribute to helping to manufacture and service organizations to implement Industry 4.0. Because now the organizations will be able to understand the benefits, challenges & CSFs and hence devise strategies for effective implement Industry 4.0. Besides, the ranking of CSFs will help organizations to understand which are the most critical factors. The article is organized as follows. Section 2 examines the related literature. The research methodology is presented in section 3. Section 4 is devoted to key findings of the study and discussion and ultimately concluded with further work suggestions in section 5.

## 2. Literature review

Industry 4.0 is defined by various authors in different contexts. One of the predominant definitions of Industry 4.0 has been "*I4.0 facilitates interconnection and computerisation into the traditional industry. The goals of I4.0 are to provide IT-enabled mass customization of manufactured products; to make an automatic and flexible adaptation of the production chain; to track parts and products; to facilitate communication among parts, products, and machines; to apply human-machine interaction (HMI) paradigms; to achieve IoT-enabled production optimisation in smart factories; and to provide new types of services and business models of interaction in the value chain*"[1][27], [28]. Open architecture products have one platform. It also allows for the integration of various modules, from multiple sources, to tailor the product to user needs.[29]. One needs to differentiate between mass individualization and mass customization. In mass individualization, the products are developed with an open architecture. Further, it requires consumers to be involved in the product. In mass customization, the specification for adapting the product is given by the manufacturers. The customer plays a major role in individualization and in mass customization the onus lies on the manufacturers. To facilitate it, an open product is designed such that the hardware components can be easily added to its original structure. This will help the user to adapt the product features as per the needs of the user[30]. Social manufacturing is a new paradigm in manufacturing that uses the crowdsourcing idea to better manufacture products and services. This made it a reality by designing cyber-physical–social connections. Such a system can bring various communities together through complex integration to co-create products and services to meet user needs[31].In Industry 4.0 both mass customization and mass individualization can be achieved by the organization using technology. It also calls for the organization to accurately study the existing business models and take strategic steps to achieve these concepts in their organization[30].

## 2.1 Industry 4.0 Architectures

The reference architecture models are designed to accommodate the increase in processing devices and systems. Two well-known models are 1) Reference Architecture Model Industry 4.0 (RAMI 4.0) from the International Electrotechnical Commission, and 2) Industrial Internet Reference Architecture(IIRA) [32]. The RAMI 4.0 model diagrammatically depicts the implementation of Industry 4.0 in a structured manner. It consists of three-axis, the first is responsible for the Hierarchy Levels, the second is responsible for the Product Life-cycle, and the last one is Architecture Layers[33], [34]. The next architecture is IIRA. It consisted of four viewpoints business, usage, implementation, and functional viewpoint. The business viewpoint captures business views, values, and objectives in IIoT systems[35], [36]. The other well-known architecture is 5C architecture[37]. The extent of usage of this architecture in organizations is not known. These architectures need further improvement in terms of self-characteristics, Future Internet (FI) proposals, Softwarisation, servitisation and software-control and inclusion of digital ledger technologies (DLTes)[32]. Besides, this architecture focus on the technical aspects of implementation[24] and Industry 4.0 being socio-technical systems [23], [36], the social elements should be also considered in this architecture.

## 2.2 Industry 4.0 Technologies

Some of the technologies which have helped in the Industry 4.0 implementation are augmented reality, virtual reality, digital twins, COBOTS, advanced simulations, etc. [1]. Frank et al classifies technologies into two layers 1) Front end technology and 2) Base technologies. The four front end technologies are used to carry out tasks that help the organization meet the customer or market needs. These technologies help in designing smart working, smart supply chain, smart manufacturing, and smart products. The base technologies are used primarily to

provide intelligence and connectivity for front-end technologies [8]. During the implementation of Industry 4.0, the digital twins can help in validating system performance. It further helps to directly conduct validation/test that can quickly locate the inefficiency or malfunction or monitor flaws within the system. To cite some instances, digital twins are used in smart manufacturing [39]; optimising a production line [40]; manufacturing system reconfiguration [41]; and smart workshop control and monitoring[42]. The four technology pillars known as ABCD (artificial intelligence(AI), blockchain, cloud computing, big data analytics) have been used for the digital transformation of the organization [43]. AI will help businesses to achieve a competitive advantage. To cite an instance Airbus using AI to investigate the production issues using a large amount of data and come with innovative solutions[44]. Bridgewater associates have used AI to automate key parts of their operations. KPMG has even gone to the extent of automating some parts of auditing services[45]. To be more effective in the usage of AI the first step is to use big data, second, apply analytics and third predictions[43]. Blockchains are difficult to be hacked and there is one of the powerful tools for business transformation [46]. Besides, it can reduce costs of verification and the cost of intermediaries[47]. Some of the typical applications of blockchains in business are cross border payments[48], blockchain for asset management[49], business-led collaborations [50], business development[51], product lifecycle management [52]; smart manufacturing [53];[54].

### 2.3 Benefits and Challenges of Industry 4.0

Industry 4.0 implementation has been reported to be more efficient in the value creation, customisation of products and services, flexibility and better mapping of manufacturing costs [55]–[58]. The quality of the manufactured products are also improved, long-run operational costs and lead times are reduced due to increased automation, digitisation and increased connectivity [59]. Customer satisfaction is also enhanced due to new business models which create new value-creating mechanisms [58]. The challenges for the implementation of Industry

4.0 has been the large investment required and uncertainty about future profitability [57]. Customers are not always willing to pay for products and services which have increased industrial internet of things (IIoT) based features [58]. Most of the previous studies have been case studies of shorter duration or theoretical articles on customer expectations of Industry 4.0 and the costs of implementing Industry 4.0[12], [60]. There have been some theoretical articles on the benefits and challenges of Industry 4.0 implementation [58], [61]. One empirical study has also examined the benefits and challenges of Industry 4.0. To cite an instance one study in SMEs found that the benefits of Industry 4.0 were a competitive advantage, improved manufacturing quality, reduced operation cost, operational efficiency, and manufacturing flexibility[1]. The challenges were implementation costs, technology knowledge, implementation time[1]. In a study of challenges comparing between developed and developing countries, Raj et al (2020) collated 15 challenges from the literature, however. The 'low maturity level' of the desired technology was a cause of concern for Industry 4.0 in developed economies [62]. There have been few studies that have examined the benefits or challenges to Industry 4.0 using empirical data[1], [63]–[65]. Besides, none of these studies has examined what are the differences between benefits and challenges in the manufacturing and service sector.

### 2.4 Critical success factors of Industry 4.0

CSFs are those factors which if present in an organisation will enable the success of the implementation of an initiative [66]. The CSFs for implementing Industry 4.0 were studied [16]. They delineated 10 CSFs for the implementation of Industry 4.0. They are aligning Industry 4.0 initiative with the organizational strategy, top management shall support the Industry 4.0 initiative, employee's involvement and engagement for Industry 4.0, make your products and services smart, make efforts to digitize the supply chain, make efforts digitise the organization, change management, project management, managing cybersecurity and

operational, economic, environmental, and social sustainability of Industry 4.0[16]. A Delphi analysis of the critical success factor in SME's was also carried [19]. However, there is yet to be an empirical study on CSFs which has comparatively analysed the differences between the manufacturing and service sector.

### 2.5 Contextual Factors

Industry 4.0 implementation in manufacturing and service organisations differs significantly, as the inputs and the output of both these sectors are considerably different [67]. The outputs in both these sectors vary significantly concerning characteristics such as intangibility, inseparability, heterogeneity and perishability [68]. Another point to consider is that traditional manufacturing organizations will have an opportunity to include product servitization in their business models [69], [70]. Other differences in both these sectors are in terms of the planning, strategies, technologies used, environment, and delivery methods[71], [72]. Considering these inherent differences, it is very essential to examine the critical differences in the benefits, challenges, and CSFs in Industry 4.0 implementation.

## 3. Research Methodology

An online survey was designed for data collection. The participants targeted in the study were senior management professionals working in both service and manufacturing sectors. As the objective was to understand the differences of benefits, challenges, and CSFs in both sectors, it was decided to conduct an online survey. This was because the online survey has flexibility, global reach, technological innovations, speed & timeliness, ease of data entry, convenience, and large samples easy to acquire[73]. Another advantage of an online survey is that it can be delivered and submitted electronically, as such a great amount of information can be obtained in a short time from the respondents [74]. Senior management in large manufacturing and

service organizations devise strategies for improving the organizations and hence capturing their viewpoints will help in understanding the benefits, challenges, and CSFs of Industry 4.0.

### 3.1 Questionnaire Design

To facilitate easy responses, the questionnaire was demarcated into three parts. The first part was devoted to gleaning the information as regards to the demographic profile of participants. The second part had open-ended questions regarding the benefits and challenges of Industry 4.0 implementation. The third section was devoted to identifying the CSFs of Industry 4.0. The ten CSFs were tabulated and given to respondents. The 5-point Likert scale "Strongly Disagree" to "Strongly Agree" was used. A five-point Likert scale is easy to comprehend by the respondents. Also, it has good psychometric properties[75]. The Senior managers are busy professionals and hence short questionnaire was designed to get maximum responses in a short time.

### 3.2 Questionnaire Validation

The online questionnaire was piloted with 10 respondents to obtain preliminary information about the experience of answering the designed questionnaire. The piloting process in the survey helps to gain a detailed understanding of the instrument [76]. Ten experts five from academics having at least five articles on Industry 4.0 and the remaining five were from senior management practitioners who had considerable experience in the field of digital transformation of the organization and have used Industry 4.0 technologies. They were recruited from the personal acquaintance of the researchers. The respondents gave minor suggestions such as simplifying some questions for easy understanding. After incorporating all the minor changes, the instrument was shown to the ten experts who finally suggested we can go ahead with the study.

### 3.3 Questionnaire Distribution

The final questionnaire was sent to 300 experts. The experts were senior professionals working in different roles such as Senior Manager, Vice Presidents and Directors in Asia, Europe and North America. The details of the respondents were obtained from LinkedIn. To obtain good quality responses a criteria was set as regards to participants should have at least five years of experience in Industry 4.0 projects and they should hold very senior management positions in the organization. This methodology was adopted in previous studies [77], [78]. At first, the respondents were contacted and briefed about the study. If they agreed to participate, they were sent the online questionnaire.

| **Table 1:** Sample Description | | | |
|---|---|---|---|
| **Row Labels** | **Count of Gender** | **Type of Organization** | **Continent** |
| **Female** | **32** | | |
| Manufacturing | 23 | SME – 7 Large organization - 16 | Europe - 12<br>Asia -3<br>North America - 8 |
| Service | 9 | Large Organization- 9 | Europe - 6<br>North America - 3 |
| **Male** | **64** | | |
| Manufacturing | 45 | SME-12<br>Large Organization-33 | Europe - 27<br>Asia -9<br>North America - 9 |
| Service | 19 | Large organization -19 | Europe – 12<br>North America -7 |
| **Grand Total** | **96** | | |

### 3.4 Sample Description

All the questionnaires were sent at the same time and a total of 96 responses were received. The survey was kept open for 12 weeks. The response rate for the survey was 32% In an online survey a response rate of 20% is considered to be sufficient[79]. Industry 4.0 is a new field, and to get a large sample size of senior managers is extremely difficult. Besides, to study the

benefits and challenges in both the manufacturing and service sector, we have set a criterion of inclusion, and hence getting a large sample size is difficult. Studies have been conducted with sample sizes less than 100, in an emerging phenomenon[80]–[82]. Table 1 elucidates the sample characteristics. Cronbach Alpha was used to obtain the internal consistency of the 10 CSFs and was found to be 0.807. A value of above 0.7 indicates higher internal consistency of the scale [83]. To test for non-response bias a time tested time-trend extrapolation method was used [84]. The respondent was classified into two groups early and late respondents. The early respondents were classified as respondents who responded with the first four weeks. The late respondents were those who were respondents in the last four weeks. To check for non-response bias Chi-Square test was conducted between both these groups in demographic variables and it was found to be not significant ($p>0.05$).

### 3.5 Data Analysis

To determine what the benefits and challenges are for implementing Industry 4.0, the respondents were asked open-ended questions. In the first phase, the individual responses on benefits and challenges of Industry 4.0 were coded as it is. This was the first order coding, and a theme name was attached to it. These first-order codes were subsequently grouped in second order with a category name[85]. The authors independently analysed the second-order codes and inter-rater reliability was calculated among them. It was found to be 85%. The differences were settled through discussion with authors to capture the reason for disagreement and through discussion, it was amicably resolved. The themes were then analysed for frequency in terms of how many respondents suggested this theme. This was carried out using various Excel functions. For critical success factors, 5- point Likert scale was used hence were ranked based on the mean. Agreement analysis was conducted to find the degree of agreement of the CSFs in manufacturing and service organizations.

## 4. Key findings and Discussion

The analyses plan is depicted in Figure 1. First, the analysis on benefits is carried out, followed by challenges and at last the critical success factors.

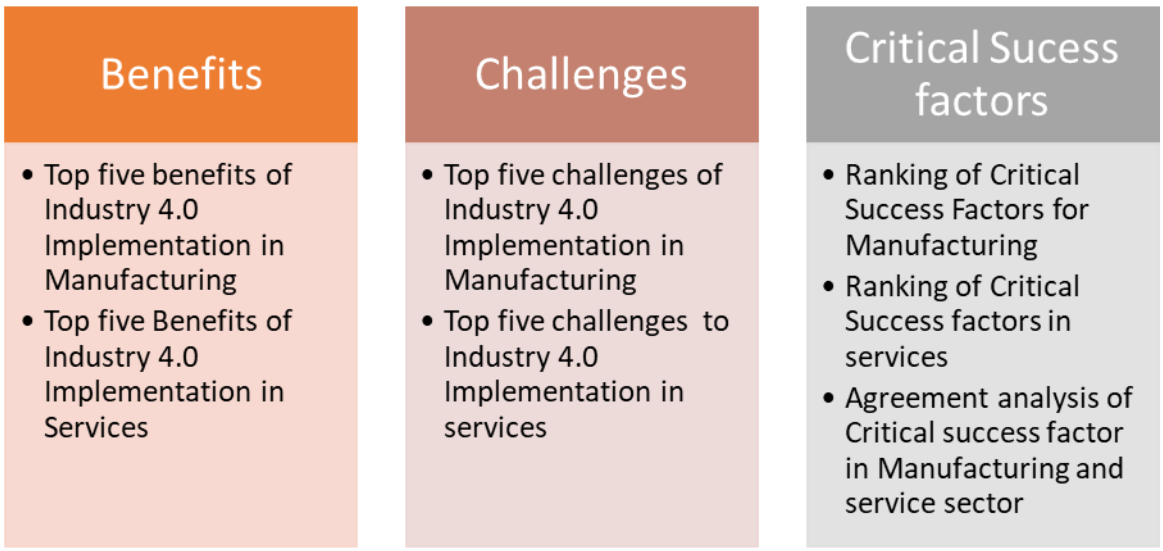


**Figure 1:** Analysis Plan

### 4.1 Benefits for implementation of Industry 4.0

The top five benefits of Industry 4.0 implementation in the manufacturing sector are explicated in Figure 2.

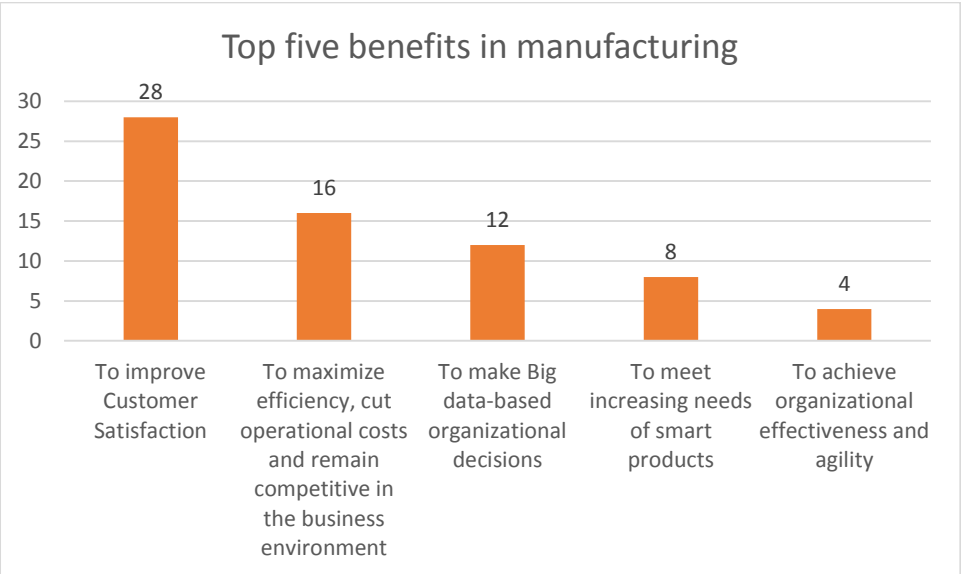

**Figure 2:** Top five benefits of Industry 4.0 Implementation in Manufacturing

In a survey of manufacturers who have implemented smart manufacturing, it was found that 49% had fewer product defects and 45% of respondents experienced increased customer satisfaction [86]. Customers will be happy with the products if there is a reduction in product defects, improved customer service, increased product features to meet customer needs etc[87]. Industry 4.0 implementation can impact all these dimensions; therefore, respondents have chosen customer satisfaction as the first benefit for its implementation. Industry 4.0 implementation makes an organization efficient by the optimum deployment of resources to meet organizational goals and objectives. Industry 4.0 implementation will create the digital transformation of the organization, to create a competitive advantage in terms of meeting customer needs, smart products and services, cost-effectiveness, organizational agility and effectiveness, product safety and reliability, improved quality etc [88]–[90]. Business decisions can make or break an organization. Management is getting things through people and hence employees are the pivotal link in management [91]. People also bring in variation and uncertainty. A manager as a rational human being is advocated in organizational theory, however, the business decisions could be irrational. Many management procedures have a belief that once a particular method or technique is applied the results will follow[92]. Some of these management procedures are held at a higher pedestal like a gospel truth without objective testing [93]. Hard techniques such as business process reengineering can be sometimes in search of magical salvation[94]. One way business decisions can be made rational is by using data in the decision-making process. Decision making is a rational process, however, due to the lack of big data managers sometimes make irrational decisions[91]. Implementing Industry 4.0 enables big data-driven business decisions from strategic levels to operational levels [95]. The respondents from the manufacturing sector have voted big data-based organisational decisions

as to the third important benefit for implementation of Industry 4.0. Customer needs are increasing, and organizations must manufacture smart products and enhance service to meet their needs [96]. Industry 4.0 implementation will help to gather customer needs by capturing the customer usage data [97]. Besides, there is manufacturing flexibility in terms of the dynamic configuration of production systems to manufacture personalised products [98]. Therefore, respondents have voted in fourth place that the need of meeting smart products is one of the benefits of Industry 4.0. In fifth-place respondents have suggested that the benefit of Industry 4.0 is to achieve organisational effectiveness and agility. The organization effectiveness is " *the degree to which an organization realizes its goals*"[99]. The total implementation of horizontal, vertical and end-to-end integration while implementing Industry 4.0 creates a competitive advantage for the organization. Besides, it also makes the organization to be agile to customer needs and the business environment. The automation and digital integration will enable organizations to meet their goals effectively, as resources will now be better utilised [100].

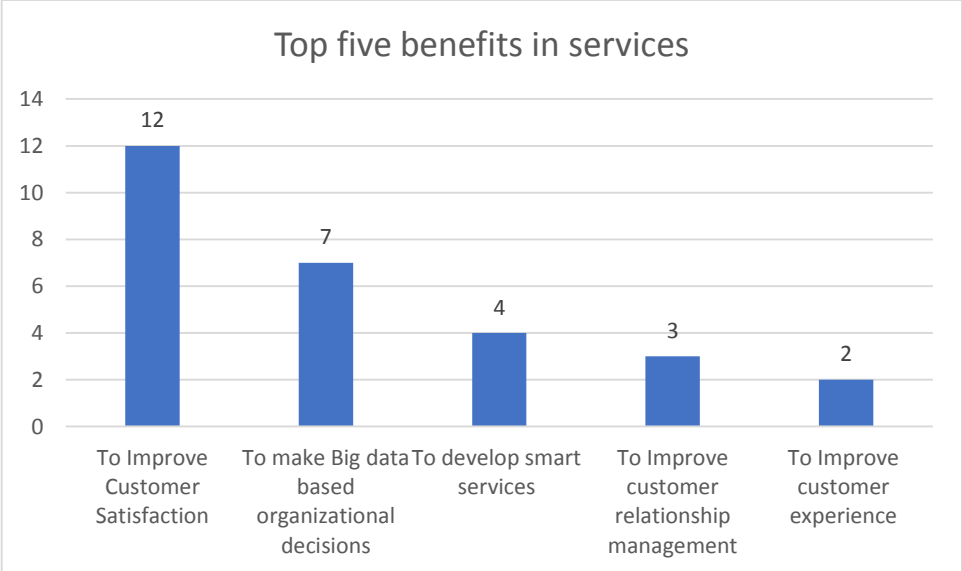


**Figure 3:** Top five Benefits of Industry 4.0 Implementation in Services

The top five benefits of Industry 4.0 in the service sector are elucidated in Figure 3. The respondents in both manufacturing and service sectors have suggested improved customer satisfaction as the top benefit of Industry 4.0 implementation. Big data-based organizational decisions are the second most important benefit. The moment of truth is one of the important phases of service decisions [101] because this is where the customer and service provider interacts to create the service [102]. Organizations can make use of big data to design, build quality into the service design and development process [103]. The big data will help service organizations in taking improved organizational decisions dynamically, to meet the customer needs, by intelligent customer segmentation algorithm for personalisation[104], which will lead to customer satisfaction. Using big data product servitization can be carried out to design customised services for the traditional manufacturing organization [105]. Therefore, Industry 4.0 implementation will provide service organizations with new tools to design new service products which will be customised for customers. Industry 4.0 implementation will afford the service providers the ability to manage the customer needs, preferences, relationships using big data throughout the customer life cycle [106]. A better customer relationship with an organization will drive sales, customer retention and promote customer loyalty. In the era of stiff competition, service providers who can provide improved customer experience will be able to thrive in the marketplace [107]. The big data insights after implementation of Industry 4.0 will result in automated and assisted processes at key customer touchpoints, which will give customers a new experience [108]. Service organizations after implementing Industry 4.0 can benefit from improved customer experience which may impact their sales positively.

### 4.2 Challenges in the implementation of Industry 4.0

The challenges of Industry 4.0 implementation in manufacturing and services were similar and is depicted in Figure 4 and 5. Only ranking of challenges differed in both manufacturing and services. The high cost of implementation was a challenge in both the manufacturing and

service sectors. Industry 4.0 implementation requires the digital transformation of the organization using IoT, cloud computing and CPS [109]. Besides, in organizations, the implementation of Industry 4.0 will result in horizontal, vertical and end to end integration using modern ICT technologies. Implementing Industry 4.0 in an organization incurs a high initial investment. The next challenge in the implementation of Industry 4.0 is data security. It was ranked second by respondents in manufacturing and third in services. Industry 4.0 implementation results in data sharing within and external to the organization [100]. Therefore, hyperconnected organizational data systems about product and services, strategic data, customer data, business transaction data etc leave an organisation vulnerable to cyber-attacks and data protection issues [110]. In manufacturing organizations, data security is highly rated by the respondents as compared to service organizations. This could be because most of the product manufacturing details are codified. In services, because of intangibility, heterogeneity and perishability of service products, there is an element of tacit knowledge[111] and therefore, data security concerns may be slightly lower than that in manufacturing organizations. The next barrier faced by the organization is an employee's resistance to change. Industry 4.0 is a joint optimisation of social and technical systems to meet the organization goals and objectives [25]. Therefore, in addition to technology employees are the key to the success of Industry 4.0 [112]. However, Industry 4.0 implementation being a radical change initiative [17] employees will have to undergo a drastic change from the erstwhile way of doing work[113]. With the service sector being employee intensive compared to manufacturing [114], employees resistance to change is very important in service compared to manufacturing and respondents have correctly classified its importance by ranking it at the second position in services compared to fifth in manufacturing. The next barrier seen by both service and manufacturing organizations was the lack of Industry 4.0 skills and know-how. Industry 4.0 is a common buzzword in academia and industry, however, what constitutes

Industry 4.0 is still a debate. Many organizations want to implement Industry 4.0, however, there is still no clarity as regards how to implement Industry 4.0 [14]. This could be due to a lack of unanimous understanding as regards which reference architecture is best while implementing Industry 4.0. In academic research, one study suggests that there are "12 design principles" and "14 technology trends" which are the key pillars of Industry 4.0 implementation [115]. However, another study suggests the importance of 64 technologies while implementing Industry 4.0 [116]. This lack of coherence in terms of technologies, implementation frameworks, reference architecture creates confusion. The know-how required to implement Industry 4.0 is a complex mixture of socio-technological and cultural skills, which are difficult for organizations. Therefore, both service and manufacturing organizations have included a lack of industry 4.0 skills and know-how in the top five challenges. The next barrier or hurdle was unreliable internet connectivity. Industry 4.0 requires a large amount of data being transmitted over the network. Internet connectivity could be a challenge considering in developing countries. Also, in the developed countries a large amount of data transmission over industrial ethernet is a challenge due to the vast adaptation of heterogeneous IoT devices.

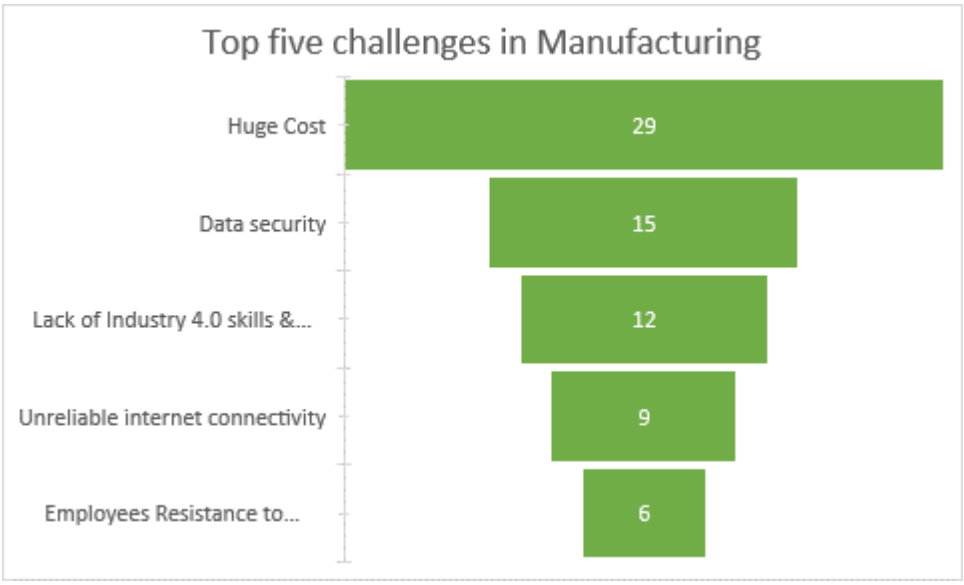


**Figure 4:** Top five challenges of Industry 4.0 Implementation in Manufacturing

This results in a radical increase in data volume which needs to be processed and transmitted. The field-level devices such as the sensors and actuators, which are integrated into programmable logic controllers, which in turn will be connected to SCADA systems. The SCADA systems will be connected to Manufacturing Execution systems, and this will be connected to Enterprise resource planning systems, which will be connected to Business intelligence systems. Such integration will exponentially increase the data volume and transmission, processing, availability and storage of these data is a challenging task [117].

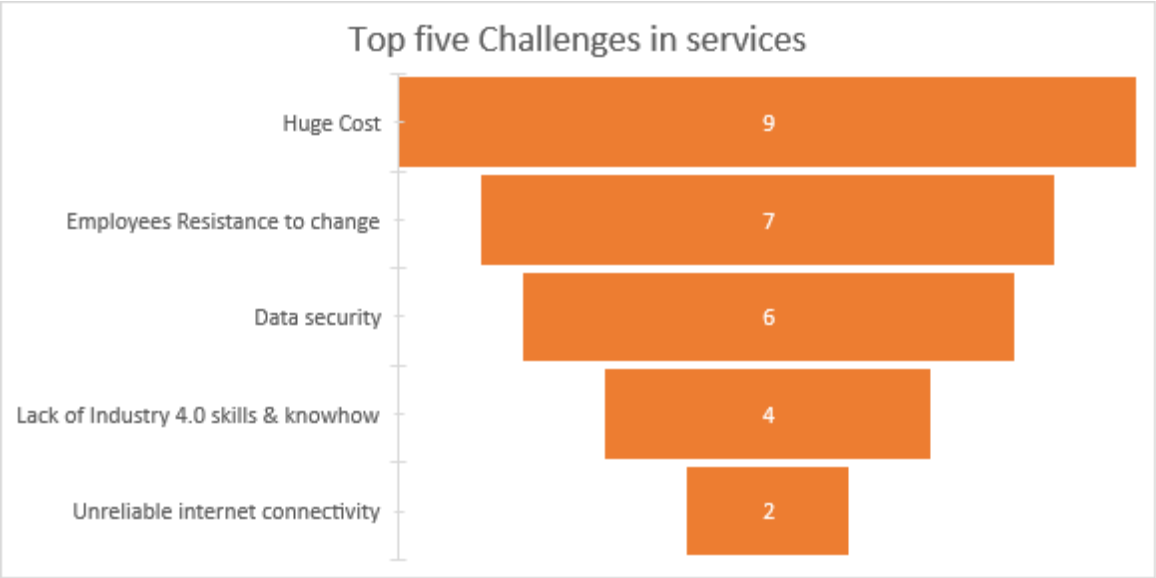


**Figure 5:** Top five challenges to Industry 4.0 Implementation in services

### 4.3 Critical Success Factors

The CSFs were examined for both manufacturing and service organizations. The ten critical success factors were as follows:

#### 1. Aligning the Industry 4.0 initiatives with Organizational Strategy

The success of Industry 4.0 begins with devising strategies. These strategies could be short, medium and long term so that organizational vision is met[118]. It is estimated that 70% of digital transformation failed. One of the main reasons for failing are these technologies provide means of productivity, efficiency or better customer management, however, if there is no right

mindset nothing works[119]. Besides, Industry 4.0 implementation changes the relationship with the employees, customers, nature and value chains[120]. In addition, the technology allows optimization, and customization of production, digitization of organization; improved human-machine interaction (HMI), automation and adaptation of organizational processes; improved value-added services, and improved integration and automatic data exchange and communication within various stakeholders [121]. Therefore, there there is a need for organizations to align Industry 4.0 with organizational strategy.

**2. Top management shall support the Industry 4.0 initiatives**

Industry 4.0 implementation in organizations to be a success the resources such as technology, human, knowledge, project management, logistics, production systems etc [122], [123]. This warrants top management support in terms of resources required for technology management. There is an increased human resource requirement due to the implementation of Industry 4.0, as traditional roles and jobs will have to undergo a sea change [113]. There would be reallocation, retraining and right-sizing of employees in an organization [124]. The existing management functions with an organization will undergo a radical change for managing the horizontal, vertical and end-to-end integration, and top management support will be desired to meet this goal[17]. Hence, top management support will help in the implementation of Industry 4.0.

**3. Employees will be important for the success of Industry 4.0**

The implementation of Industry 4.0 creates a smart working environment for employees, with changed job descriptions, roles and responsibilities [113], [125]. The repetitive jobs will be conducted by automated systems such as CPS [126]. The employees will need big data-based decision-making skills to manage the business operations due to increased automation and integration of business systems [127], [128]. The desired employee skills in this era would be higher-order skills such as problem-solving, conflict resolution, creativity, tolerance for ambiguity, service orientation [124][112]. Therefore, how well employees adapt will be the key requirement for the success of Industry 4.0.

**4. Make your products or services smart**

Industry 4.0 success t be realised at a large scale the products and services of the organization should be smart [129], [130]. The three aspects of smart products are one the basic products which consist of either electrical, electronic and mechanical components in the desired

combination to carry out the functions of the product. The second aspect of the smart product would be elements such as microprocessors, data storage, sensors, programable logic & controls, software and human-machine interfaces which does the functions of self-configuration, self-diagnosis, self-monitoring etc. The third aspect of the smart product would be communication such as Wi-fi, 5G, ports, antennae which facilitates communication between the product and cloud, product- organization etc.[89]. Smart products & services will help organizations to design better business models which will help in organizations success.

**5. Make efforts to digitize the supply chain**

Modern supply chains are vulnerable to various supply chain risks because they are global supply chains, and the business environment is volatile, uncertain, ambiguous, and complex. For the supply chain to be responsive and efficient digitization will play a major role [131]. To meet the ever-changing needs of customers in terms of mass customization and mass personalization, the supply chains need to be a dynamic structure [132]. The success of Industry 4.0, therefore, would be dependent on the collective efforts of supply chain partners and the first step in this regard is to collaborate and digitise the supply chain [107]. The information-sharing due to the digitization in the supply chain will help in creating new business models for the successful collaboration of supply chain partners [95].

**6. Digitise the organization**

The organization uses various types of assets to carry out different functions. The digitization of assets provides the organization with an ability to sense and communicate various parameters of interest which will help through intelligent systems to meets the goals of the organization [130]. The three types of integration in Industry 4.0 warrant digitization of various functions within an organization [133]. The extent to which the organizational functions are digitised will help the organizations to use the big data in real-time for improving the functions management such as directing, planning, controlling, organizing, and coordinating the various tasks in the organization. Besides, the improved real-time data availability of these resources will help in designing a smart factory [118].

**7. Change management**

Industry 4.0 implementation changes structures, processes, procedures, working methods, job descriptions etc within an organization [17],. This happens because of the three forms of integration such as the vertical, horizontal and end-to-end integration [134]. Implementing

Industry 4.0 is a radical change initiative as there will be a change from business models to organizational strategy [26], [135], [136]. The change management initiatives have to be systematically implemented within the organization and external to the organization.

**8. Project management**

Industry 4.0 implementation will be successful if the project-based approach is taken for its implementation [136]. The key to the successful implementation of Industry 4.0 is strategically dealing with these projects [137]. The challenges of Industry 4.0 implementation in different phases of the project life cycle. Some of the challenges on Industry 4.0 would be project integration, procurement, time, communications, scope, risk, human resources, quality, and cost[118]. Therefore, managing projects would be critical for the successful implementation of Industry 4.0

**9. Managing cybersecurity**

Industry 4.0 digitally transforms the organization and creates a network of stakeholders such as the organization, customers and employees [56]. The integration is devoted to various functional aspects of business[118]. The information transparency and digital availability of information about various functions of the organizations may expose organizations to cyber-attacks. These attacks are sometimes targeted to steal information, money, destabilise the smooth flow of various business processes [34]. For this reason, managing cybersecurity will be the utmost requirement of the successful implementation of Industry 4.0.

**10. Operational, economic, environmental, and social sustainability of Industry 4.0**

There are increasing pressures on modern organizations due to regulatory requirements, civil society, non-governmental organizations etc for implementing sustainability in the business [138]. Industry 4.0 initiatives to succeed the organization should be sustainable on multiple dimensions[139]. Industry 4.0 implementation should help to succeed in various corporate dimensions such as economic, operational, environmental and social [140].

The 10 success factors were ranked based on the mean scores and are depicted in Tables 2 and 3. To find the criticality of the success factor, a methodology suggested by Adabre et al [141] was followed. The mean score was normalised. The success factors whose normalised score

was above 0.5 were considered to be a critical success factor but anything under 0.5 was considered a success factor but not critical [141], [142]. Normalised value = (mean – minimum mean)/(maximum mean - minimum mean). In the manufacturing sector, the two success factors are a) Employees will be important for the success of Industry 4.0 b) Managing cyber security were found to be non-CSFs. However, in services a) Project management and managing cyber security were not CSFs. Industry 4.0 implementation will result in total automation of the manufacturing process, and hence the traditional roles of manufacturing employees will have to be redistributed or re-examined[143]. However, services would require human intervention and therefore it is a critical success factor in the service sector.

**Table 2:** Ranking of Critical Success Factors for Manufacturing

| **Critical Success Factors** | **Mean** | **Normalization** | **Rank** |
|---|---|---|---|
| Top management shall support the Industry 4.0 initiatives | 4.79 | 1.00 | 1 |
| Operational, economic, environmental, and social sustainability of Industry 4.0 | 4.68 | 0.87 | 2 |
| Aligning the Industry 4.0 initiatives with organizational strategy | 4.67 | 0.86 | 3 |
| Change management | 4.63 | 0.81 | 4 |
| Digitize the organization | 4.6 | 0.78 | 5 |
| Make efforts to digitize the supply chain | 4.58 | 0.75 | 6 |
| Make your products or services smart | 4.57 | 0.74 | 7 |
| Project management | 4.51 | 0.67 | 8 |
| Employees will be important for the success of Industry 4.0 | 4.22 | 0.33 | 9 |

| **Table 2:** Ranking of Critical Success Factors for Manufacturing | | | |
|---|---|---|---|
| **Critical Success Factors** | **Mean** | **Normalization** | **Rank** |
| Managing cyber security | 3.94 | 0.00 | 10 |

However, project management in the manufacturing sector is a critical success factor. In the manufacturing sector, projects may play a more significant role than in services. This could be because in the service sector the simultaneous production consumption, would reduce the significant role of projects in services compared to manufacturing. However, future research should explore why project management is a critical success factor in manufacturing than in services.

| **Table 3:** Ranking of Critical Success factors in services | | | |
|---|---|---|---|
| **Critical Success Factors** | **Mean** | **Normalization** | **Rank** |
| Top management shall support the Industry 4.0 initiatives | 4.56 | 1.00 | 1 |
| Operational, economic, environmental, and social sustainability of Industry 4.0 | 4.41 | 0.89 | 2 |
| Employees will be important for the success of Industry 4.0 | 4.33 | 0.83 | 3 |
| Aligning the Industry 4.0 initiatives with organizational strategy | 4.21 | 0.74 | 4 |
| Change management | 4.13 | 0.68 | 5 |
| Make your products or services smart | 4.11 | 0.67 | 6 |
| Digitize the organization | 4.04 | 0.61 | 7 |
| Make efforts to digitize the supply chain | 3.98 | 0.57 | 8 |

| **Table 3:** Ranking of Critical Success factors in services | | | |
|---|---|---|---|
| **Critical Success Factors** | **Mean** | **Normalization** | **Rank** |
| Project management | 3.38 | 0.13 | 9 |
| Managing cyber security | 3.21 | 0.00 | 10 |

To calculate the per cent of disagreement on the ranking between the manufacturing and service sector, we use agreement analysis. By lowering the percentage of disagreement between the ranking of the CSFs in both these two sectors, the criticality of these success factors is identical in both the manufacturing and service sector. This study uses a technique of "rank agreement factor analysis" [141], [144]. Table 4 depicts the agreement analysis.

| **Table 4 :** Agreement analysis of Critical success factor in Manufacturing and service sector | | | | | |
|---|---|---|---|---|---|
| **Critical Success factors** | Rank Manf | Rank Ser | Ri1 - Ri2 | Rj =10-i+1 | Ri1-Rji |
| Top management shall support the Industry 4.0 initiatives | 1 | 1 | 0 | 10 | 9 |
| Operational, economic, environmental, and social sustainability of Industry 4.0 | 2 | 2 | 0 | 9 | 7 |
| Aligning the Industry 4.0 initiatives with organizational strategy | 3 | 3 | 0 | 8 | 5 |
| Change management | 4 | 5 | 1 | 7 | 3 |
| Digitize the organization | 5 | 7 | 2 | 6 | 1 |
| Make efforts to digitize the supply chain | 6 | 8 | 2 | 5 | 1 |
| Make your products or services smart | 7 | 6 | 1 | 4 | 3 |
| Project management | 8 | 9 | 1 | 3 | 5 |

| **Table 4 :** Agreement analysis of Critical success factor in Manufacturing and service sector | | | | | |
|---|---|---|---|---|---|
| **Critical Success factors** | Rank Manf | Rank Ser | Ri1 - Ri2 | Rj =10-i+1 | Ri1-Rji |
| Employees will be important for the success of Industry 4.0 | 9 | 3 | 6 | 2 | 7 |
| Managing cyber security | 10 | 10 | 0 | 1 | 9 |
| | | RAF | 1.3 | RAFmax | 5 |
| | | | | PD | 26% |

Rank Agreement Factor (RAF) is defined as "the average absolute difference in the ranking of factors between two groups" [144]. The two groups, in this case, is the manufacturing and service sector. Ri1 be the rank of i$^{th}$ success factor in manufacturing. Ri2 be the rank of i$^{th}$ success factor in service. N = total number of the item. J = N-i+1.

$$RAF = \frac{\sum_1^n R_{i1} - R_{i2}}{N} \quad \ldots\ldots(1)$$

The high value of RAF indicates the agreement between the group is low. A low value indicates high levels of agreement and a value of 0 indicates perfect agreement [141].

$$\text{RAF max is defined as} = \frac{\sum_1^n R_{i1} - R_{j2}}{N} \quad \ldots\ldots\ldots (2)$$

Percentage disagreement is calculated as shown in Equation 3.

$$PD = \frac{\frac{\sum_1^n R_{i1} - R_{i2}}{N}}{\frac{\sum_1^n R_{i1} - R_{j2}}{N}} \times 100 \quad \ldots\ldots\ldots(3)$$

In this study, the percentage of disagreement is 26%. In other words, it indicates 74% agreement in ranking between the ranking of CSFs in both the manufacturing and service sector. Three CSFs, which are Top management, shall support the Industry 4.0 initiatives,

Operational, economic, environmental, and social sustainability of Industry 4.0 and Aligning the Industry 4.0 initiatives with organizational strategy are in perfect agreement of rank in both sectors. This suggests that these three CSFs are most important in both sectors. Employees will be important for the success of Industry 4.0 and as a factor, it varies in rank between the manufacturing and service sectors. Employees are a pivotal element for the success of any service[15]. Even in Industry 4.0 designing new services will require employees to exhibit both in the role and extra-role behaviours, to analyse the big data and customise services for customers based on their needs. Therefore, respondents in service sectors ranked it as a higher critical success factor than in the manufacturing sector.

In the manufacturing sector, the CSFs of digitise the organization and digitize the supply chain has higher ranks compared to the service sector. As the manufacturing sector focuses on tangible products [145], the higher the digitization within the organization or in the supply chain will help to acquire, deploy, coordinate, and control the resources of production because these are physical goods as compared to intangible services. Managing cybersecurity is seen as a success factor and is ranked at position number 10. Cyber security knowledge has grown in leaps and bounds[146]. The increased usage of digital monetary transactions at both organizational and individual levels [144], is a testimony of confidence both individuals and organizations have in the cyber security system. Therefore, in this study respondents considers cyber security as a success factor, however, they do not consider it as a critical success factor, because the advances in cybersecurity have instilled confidence in them regarding its trustworthiness and they perceive it as a success factor. This suggests that respondents struggle with the concept of the advances in cyber security and they consider it as a success factor, but not critical.

## 5.0 Conclusion, implications, limitations, and future work

This study critically evaluated the top five benefits and challenges for the implementation of Industry 4.0 in both manufacturing and service organizations. Further, the CSFs for the implementation of Industry 4.0 is examined and ranked in both sectors.

This study contributes to theory in terms of critical evaluation of benefits & challenges in both the manufacturing and service sector. In addition, the study empirically ranks the CSFs in both the manufacturing and service sectors. The critical difference of CSFs in both sectors is found.

The findings of this study can be used by organizations to understand the benefits of the implementation of Industry 4.0 are. This study will, therefore, help the organizations to better plan their implementation in respective sectors. The challenges uncovered in this study will help managers to understand sector-specific challenges and devise better strategies to mitigate these challenges. The CSFs and ranking of these will further help organizations to first analyse the existence of these factors in their organisations. Secondly, it will help to attach importance to the CSFs based on the rank unearthed in this study.

This is a cross-sectional study and future studies will be conducted longitudinally to understand the time-varying impact on benefits and challenges Besides, studies may also be conducted based on the size of the organization, about benefits, challenges, and CSFs of industry 4.0. To investigate the country-specific impact on benefit, challenges, and CSFs a global study may be conducted. Studies should also be carried out to develop a scale for CSFs so that organizations can use it to discover the present status of their position and make efforts to bridge the gap. Empirical studies should also explore sub-sector specific benefits & challenges, to cite an instance in the manufacturing sector automotive sector may have inherent benefits & challenges for the implementation of Industry 4.0. Another interesting area of future research would be to develop an analytical framework of benefits & challenges in different sectors. One

of the limitations of this study is the sample size from different continents, hence continent and country-specific analyses could not be conducted.

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