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# The Role and Impact of Industry 4.0 on the Development of Manufacturing-as-a-Service (MaaS) Model: An Analytical View

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**ABSTRACT**

**Industry 4.0 is contributing to the development of new manufacturing models such as on-demand manufacturing, cloud manufacturing and cyber-physical production systems. The present study aims to understand the impact of Industry 4.0 on the global manufacturing industry and the role played by Industry 4.0 in the creation of new manufacturing models. It determines the purpose of mass customisation, including, in particular,the challenges and opportunities presented by Industry 4.0 to manufacturing-as-a-service (MaaS) model and other significant findings revealed through the review of the literature.**

**Keywords:** ***Service-oriented manufacturing, on-demand manufacturing platform, cloud manufacturing, manufacturing service platform, digital manufacturing, factory-on-demand, on-demand design, digitalisation of manufacturing, Industry 4.0., mass customisation, manufacturing, machines, manufacturing processes, manufacturing systems.***

## 1. INTRODUCTION

The importance of manufacturing to national economies tomorrow is receiving growing attention due to its role as the main driver of business R&D expenditure and as a critical enabler of the industrialisation of emerging technologies. Governments around the world are increasingly emphasising on the interplay between manufacturing, innovation and economic growth.

*The digitalisation of Manufacturing:* It includes the review on digitally-enabled and data-driven intelligent systems for industrial applications such as machinery, assembly, packaging, material handling and warehouse management. It includes broad areas such as smart factories, rapid prototyping, distributed manufacturing, supply chain optimisation, or delivering complex services with real-time asset monitoring systems.

*Fourth Industrial Revolution:* This will emphasize on next industrial era where a fusion of technologies that are blending the lines between physical, digital, and biological spheres, such as smart factories where materials, people and machines seamlessly collaborate to drive productivity and efficiency of manufacturing companies.

## 2. RESEARCH AIMS AND OBJECTIVE

The paper shall include the following objectives:

i. To study the impact of Industry 4.0 on the global manufacturing industry

ii. To explore the role of Industry 4.0 in the creation of new manufacturing models

iii. To evaluatechallenges and opportunities presented by Industry 4.0 to manufacturing-as-a-service (MaaS) model

## 3. LITERATURE REVIEW

This chapter provides a critical analysation on the results based on their implications, significance and challenges faced by the researchers during the study. The section is going to cover the following:

**(i) Trends driving change in advanced global manufacturing**

This section reflects upon recent social, economic and technological developments around the world to provide an updated view of the megatrends that are evolving and shaping the future of advanced manufacturing as reviewed in the 2013 report Emerging Trends in Global Manufacturing Industries.

Data frameworks are being built by assuming a significant job in the present time of digitisation of manufacturing and assembly production system, which is otherwise called smart manufacturing. **Ivezic et al., (2014)** found that designing of data frameworks is spread over the life cycle of an item by giving interchangeability of programming subsystems through a mix of open and restrictive trade of information. In any case, innovative work endeavours are in progress to supplant this worldview with designing data benefits that can be formed progressively to address changing issues in the task of acute assembly production frameworks. This paper portrays the chances and difficulties in architecture, such as building data administrations and forming them to empower smartmanufacturing.

The manufacturing process has been a significant activity throughout the ages. The old assembly production strategies were followed by fashioning, welding, heat treatment, powder metallurgy and crushing. The manufacturing business got automated after the development of the steam motor in the eighteenth century. A few machine apparatus, for example, machining, processing, penetrating, exhausting, planer, sharper, processor and control hack-saw, were created to achieve fast production rate **(Singh, 2016).** With the progression of time, automation of industrial process was a noteworthy development by the business.

According to **Singh, (2016)** hardware computerisation such as programmed turrets and particularlyreasoning machines contributed a great deal towards large-scale manufacturing. Delicate robotization as numerical control has diminished cluster size for exact assembly production leading to incessant worth economically. Improvement of non-customary assembly production forms, and propelled estimation and instrumentation methodologies contributed towards further progression in the assembly production industry. Various instruments of manufacturing are business-focused. This article displays a short record of the improvement and ongoing patterns in the assembly production business.

**(ii) Industry 4.0**

This section discusses science and engineering domains in the perspective of Industry 4.0 that have gained increased policy attention as per the publication of the 2013 report Emerging Trends in Global Manufacturing Industries.

According to **Brettel et al., (2014)** the German manufacturing industry needed to withstand an expanding global challenge on product quality and production costs. As manufacturing expenses are high, a few businesses have endured seriously under the migration of production factories towards developing nations, which have figured out how to close the profitability and quality gap considerably. Organizations have perceived that clients are not willing to pay a hefty price premium for regular quality upgrades. As a result, numerous companies from the German manufacturing industry alter their strategy to instant time innovation. Utilizing the benefits of novel production processes, for example, Spry Manufacturing and Mass Customization, production organizations change into incorporated systems, in which organizations join their centre abilities. Thus, virtualization of the process and store network guaranteed smooth tasks between organizations giving continuous access to an important item.

The expanded use of data and communication innovation permits advanced designing of products and production in synchronous with demand circumstances. Isolated re-creation and demonstrating processes enable decentralised units to adapt to changing products and along these lines empower fast product development (**Zhou et al. 2015)**. The present article portrays the improvements of Industry 4.0 in surveys related to research streams. They utilize bunch investigations to survey the common implications with supervisors from businesses or just as from the consulting businesses using an organised meeting rule. The results provide explanations behind the adoption and refusal of Industry 4.0 from an administrative perspective. Results add to the research of Industry 4.0 and bolster decision-makers to survey their requirements for change towards Industry 4.0 practices.

**Zhou et al., (2015)** stated that Industry 4.0 (the fourth industrial revolution) drives the future trend in industry developmentpatterns to accomplish progressiveassembly production forms, including dependence on Cyber-Physical Systems (CPS), development of Cyber-Physical Production Systems (CPPS), and usage of production plants. This paper presents the significance of Industry 4.0 in connection to vital arranging, key innovations, openings, and difficulties. Vital arranging incorporates the development of a CPS arrangement in terms of two noteworthy subjects that depend on an industrial facility and accomplishing three combinations (level joining, vertical reconciliation and start to finish mix) and accomplishing plans that comprise of the definition of framework institutionalisation and production administration. At last, the study specified for China's manufacturing business to incorporate China's Industry 4.0.

**(iii) Digitalisation, scale-up and value capture**

This section is going to focus on the aspect of digitisation. The digitalisation of manufacturing has emerged as one of the most critical themes in the manufacturing and innovation policies (and R&D portfolios) of major economies.

According to **Brecher, (2015)** amid the challenges of the manufacturing industry, there is an utmost requirement of smart manufacturing that can resolve the existing issues. Individual products that match the specific customer demands have become the main scope of digitisation of manufacturing platforms and strategic processes, whichgenerally result in reduced unit costs, scaling of mass production and on-demand manufacturing for meeting the real-time demand of the consumers on a mass scale. Moreover, the optimisation of resources with sophisticated planning tools and highly automated production systems require planning orientation for mitigating the adaptability issues, which is achievable with robust and straightforward value-based process chains leading to value orientation. An efficient approach of production is to foresee and control the conduct of complex manufacturing frameworks that consolidate deterministic and computerised models to empower an integrative appreciation and learning process. For example, robotic methodologies that coordinate deterministic models or deterministic models, which are enhanced with the feedback within computerised structures.

**Brecher et al., (2011)** suggested that the research within the excellence is to provide a sustainable form of manufacturing strategy that can aim for the resolution of meeting on-demand criteria with competitiveness. They are intended to resolve the prevailing conflicts between scale and scope that exists between plan and value orientation. Therefore, there is the adoption of advanced key technologies by combining expertise from various fields of manufacturing engineering and materials science that can enhance the scope to provide technologically advanced solutions for increasing productivity, adaptability and speed of production based on on-demand strategy (Brecher et al. 2011).

**Kagermann et al., (2013)** suggested that computerised structures are necessary to empower an organisation for adjusting to the rapidly changing manufacturing criteria, which often contained unexpected interruptions and unstable limit conditions. These robotic structures begin with traditional control hypothesis, self-enhancement and robotic administration methodologies prompting auxiliary adaption, learning capacities, model-based choices, computerised reasoning, vertical correspondence and human-machine association. The brilliant manufacturing plant with regards to "Industry 4.0" can be viewed as a dream in this specific situation **(Kagermann et al. 2013)**

**(iv) The emergence of new manufacturing models from the development efforts of Industry 4.0**

This section is intended to discuss the emergence of new manufacturingmodels within the context of real-time consumer demands. **Zhong et al., (2017)** examined the coming age of Industry 4.0, whichholds the guarantee of expanded adaptability in assembly production, along with mass customisation, better quality, and improved profitability. It is a way that empowers organisations to adapt to the difficulties of delivering progressively individualised items with a short lead-time and higher quality. To completely comprehend smart assembly production with regards to Industry 4.0, this paper gives a far-reaching survey of related themes, in terms of service-oriented manufacturing, Internet of Things (IoT) empowered assembly production, and cloud fabricating.

**Lasi et al., (2014)** expressed that Industrial growth is the key parameter of any economy that produces physical products and is profoundly automated in nature. At the start of industrialisation, the innovative transformation has prompted to change the conventional outlook using "modern insurgencies" in the field of automation. Based on a propelled digitisation inside processing plants, the mix of Internet innovations and updated technology development in the consumer demand scenario of "smart" objects (including machines and products) appears to bring about another significant change in the perspective of industrial product creation. The vision of future production contains particular and proficient assembly production frameworks and describes situations in which products are controlled.

**Jiang et al., (2016)** inspected that the assembly production industry is making an initiative towards socialisation and personalisation, with mass cooperation. Inspired by the penetration of Cyber-Physical Systems (CPS) and web-based media utilisation in the assembly production industry, this paper provides a social Manufacturing (SocialM) worldview and gives a hypothetical premise to future production association in terms of mass demand and service-oriented manufacturing. Definitions and authoritative rationale of SocialM isprovided. Three centre parts of SocialM related to design, task and the boardwere discussed. It is normal that SocialM would add to the production model.

**Zhou, et al., (2015)** suggested that Industry 4.0 (the fourth modern transformation) drives future industry development patterns to accomplish progressive insight into assembly production forms, including dependence on Cyber-Physical Systems (CPS), development of Cyber-Physical Production Systems (CPPS) and execution and activity of smart processing plants. This paper presents essential parts of Industry 4.0 in connection to key arranging, key innovations, openings, and difficulties. Vital arranging incorporates the development of a CPS that organises savvy industrial facility and canny production, accomplishing their reconciliations and accomplishing plans that comprise of detailing of institutionalization framework and proficient administration. The study discussed their contribution in the context of smart manufacturing for China's manufacturing enterprisestowards Industry 4.0.

**Wan et al., (2015)** stated that they examined the implementation of Cyber-Physical Systems (CPS), with the application of the modern remote system and some other empowering advancement in the improvement of enterprises. This paper introduces an outline of the foundation, idea, essential techniques, real development and application situations for Industry 4.0. In their opinion, Industry 4.0 as a dynamic idea can intently incorporate the physical world with the virtual world. The typical methodology for Industry 4.0 is social assembly production. The social assembly production can legitimately interface their clients' need and their businesses, yet it must be founded on the empowering innovations, for example, installed frameworks, remote sensor organisation, mechanical robots, 3D printing, distributed computing, and massive information. Accordingly, this paper, in detail, clarifies these ideas, favourable circumstances and their relationship to businesses. We can predict that our life will be changed to be progressively proficient, quick, protected and helpful because of the improvement of Industry 4.0 sooner rather than later.

**(v) Challenges and opportunities presented by Industry 4.0 to manufacturing-as-a-service (MaaS) model**

This section is intended to discuss the existing challenges and scope in Industry 4.0 in terms of manufacturing-as-a-service model and opportunities for the upcoming startups in the national and global scenario. **Stock et al., (2016)** presented globalisation, which is facing challenges with the global demand for capital and customer products to be guaranteed with a durable involvement of human presence in its social, ecological and financial measurements. As of now, the industrial value creation in the early industrialized nations is moulded by the development towards the fourth phase of industrialization, with Industry 4.0. This improvement gives tremendous chances to the acknowledgement of smart manufacturing operations. This paper will exhibit a class audit of Industry 4.0 dependent on late improvements in research and practice. In this manner, an outline of various feasible production assemblies in Industry 4.0 is presented for the retrofitting of the manufacturing unit as an opportunity for sustainable manufacturing platform.

**Livesey, (2012)** stated that new models of manufacturing have changed the conventional manufacturing processes and brought favourable changes in the form of opportunities to emerging economies. As far as the improvement is concerned, assembly scale production would enable nations to interface legitimately to cutting edge production, with possibly lower levels of speculation required for every production factory. Multilateral funders may likewise need to refresh their manufacturing pattern in the ways the U.S. and the UK governments do, and that may be a key feature for future mechanical advancement in rising economies. At last, every industry will have an alternate direction after some time, and adjusting to those progressions after some time will be a consistent test for national policymakers. The limit with regards to creating procedure inside government with respect to assembly production has dissolved essentially in the course of recent years. Financial displaying is expected to give the sort of input that the adjustments in the manufacturing scenario demand.

**Saldivar et al., (2015)** explained how the foreseeable changes are taking place gradually in the manner in which organisations fabricate items and conduct administrations or provide accessibility, with future patterns developing in terms of model structure and production pattern. Together with the development of web applications and innovations associated with the cloud technology, another industrial revolution, named "Industry 4.0", incorporates digital-virtual and digital-physical frameworks to help smart manufacturing, as exhibited in this paper. Industry 4.0 accomplishes association of data with physical apparatus. Another age of remote association with 5G can assist and quicken the process. Followed by the examination of the present digital-physical coordination for the 4th Industrial Revolution, this paper is likely to form future research strategies for the production process, structure and development.

## 4. RESEARCH GAP

Based on a literature review, a research gap has been derived to ascertain the ways in which the current research can contribute towards filling this gap.

**Table 1: Research gap**

| S. No | Paper Title | Methods | Results |
|---|---|---|---|
| | | | |
| 1. | Emerging Trends in Manufacturing (Singh, 2016) | Soft automation in the form of numerical control, advanced measurement and instrumentation approaches. | Enabled precise manufacturing. |
| 2. | The need for a new understanding of manufacturing and industrial policy in leading economies (Livesey, 2012) | Consistent model test for national policymakers. | Resolving issues for government interfaces. |
| 3. | Umsetzungsempfehlungen für das Zukunftsprojekt Industrie 4.0 (Kagermann et al. 2013) | Cybernetic structures, self-optimisation and cybernetic management approaches. | Adapt quickly and robustly |
| 4. | Integrative Production Technology for High-Wage Countries (Brecher et al. 2011) | Strategies focusing on resolving issues of scale and scope | Increase productivity, adaptability and innovation speed. |
| 5. | Industry 4.0. *Business & information systems engineering* *(*Lasi et al. 2014) | Combination of Internet technologies and future-oriented technologies in the field of “smart” objects. | Modular and efficient manufacturing systems and characterizes scenarios in which products control. |
| 6. | Industry 4.0 with cyber-physical integration: A design and manufacture perspective. (Saldivar et al. 2015) | To integrate cyber-virtual and cyber-physical systems. Connecting information and physical machinery. | To aid smart manufacturing. |
| 7. | Towards a cyber-physical-social-connected and service-oriented manufacturing paradigm: Social Manufacturing. (Jiang et al. 2016) | Social Manufacturing (SocialM) paradigm (SocialM) worldview | Production mode transformation and social innovation. |
| 8. | Intelligent manufacturing in the context of industry 4.0: a review. (Zhong et a. 2017) | Comprehensive review | Mass customization, better quality, and improved productivity |
| 9. | Industry 4.0: Towards future industrial opportunities and challenges. (Zhou, et al.2015) | Cyber-Physical Production Systems (CPPS), and implementation and operation of smart factories | Enlightenment for China's manufacturing industries, to build China's Industry 4.0. |
| 10. | Industrie 4.0: enabling technologies. (Wan et al. 2015) | Industrie 4.0 enabling service manufacturing. | legitimately interface our clients' need and our businesses |

## SUMMARY

The summary of results, techniques and findings are presented based on the shortcomings of the research, and the major findings are interpreted under this section. The review reflects onthe overall factors governing the sector of Industry 4.0 in the global perspective.

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