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# INDUSTRY 4.0: CONCEPTS, CHALLENGES AND EXPECTATIONS

## *INDÚSTRIA 4.0: CONCEITOS, DESAFIOS E EXPECTATIVAS*

**Laédna Souto Neiva[1]*, Laura Nunes de Menezes[2], Marcela Cristine de Alencar Lira[3], & Maria Isabel Brasileiro[4]**

[1234] Centro de Ciência e Tecnologia da Universidade Federal do Cariri, Avenida Tenente Raimundo Rocha, S/N, Bairro Cidade Universitária, CEP 63.010-00, Juazeiro do Norte - CE.
[1]* laedna.neiva@ufca.edu.br [2] lauranunescangaiaa@gmail.com [3] marcela.alencar@aluno.ufca.edu.br
[4] isabel.rodrigues@ufca.edu.br

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***Autor Correspondente**: Neiva, L. S.

**RESUMO**

A manufatura inteligente, através do conceito Indústria 4.0, está se tornando a realidade de muitos segmentos da indústria hoje, e a tendência para o futuro é fortalecer esse conceito, tornando-se o modus operandi cotidiano usual dos ambientes industriais. Portanto, cabe aos profissionais e organizações da indústria investir em treinamento e qualificação avançados alinhados com os requisitos e desafios da Indústria 4.0. Alinhado neste contexto, o objetivo deste artigo é, através de uma revisão sistemática, apresentar às comunidades acadêmicas e industriais informações compiladas com base na literatura sobre os conceitos, requisitos e desafios elementares que esse novo e emergente estágio industrial apresenta e impõe ao mundo moderno de agora em diante. A partir das informações apresentadas neste artigo, pode-se concluir que a manufatura inteligente, a base de operação da Indústria 4.0, apresenta entre outros benefícios a capacidade de enfrentar eventos indesejáveis, uma vez que os sistemas podem contar com planos de operação alternativos para emergências imprevistas e a manufatura propõe sistemas inteligentes de classificação que visam minimizar os custos de produção, como desperdício de insumos. Finalmente, a Indústria 4.0 deve ser entendida como um sistema de gerenciamento de processos industriais que integra uma infinidade de conceitos, ideias e tecnologias, a fim de otimizar a eficiência das produções industriais.

**ABSTRACT**

Smart manufacturing, through the Industry 4.0 concept, is becoming the reality of many industry segments today, and the tendency for the future is to strengthen this concept by becoming the usual everyday modus operandi of industrial environments. Aligned this context, the aim of this paper is, through a systematic review, to present the academic as well as the industrial communities an informations compiled based on literature about the elementary concepts, requirements, and challenges that this new and emerging industrial stage presents and imposes on the modern world from now on. From the information presented in this article it can be concluded that smart manufacturing, the basis of operation of Industry 4.0, presents among other benefits the ability to face undesirable events since the systems can count alternative operation plans for emergency, unforeseen and In addition, smart manufacturing proposes smart sorting systems that aim to minimize manufacturing costs such as input wastage. Finally, Industry 4.0 should be understood as an industrial process management system that integrates a multitude of concepts, ideas and technologies in order to optimize the efficiency of industrial productions.

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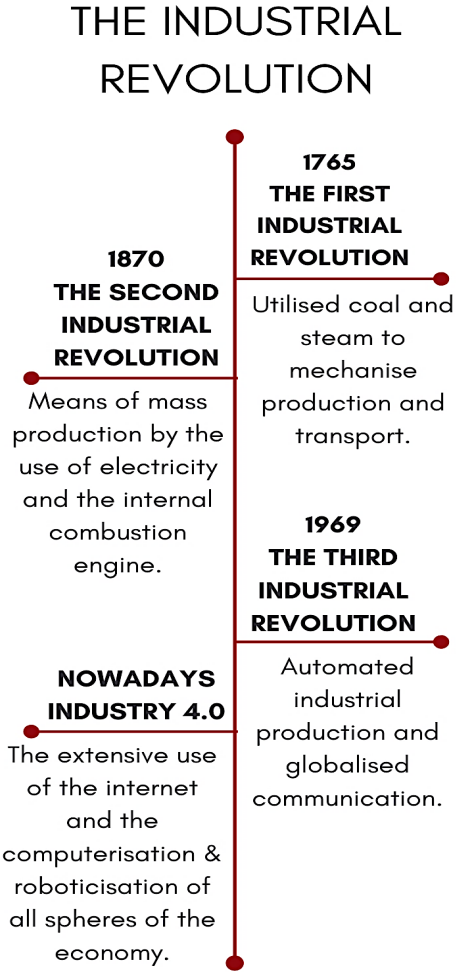
## 1. INTRODUCTION

The Fourth Industrial Revolution is characterized by the extensive use of the internet and the computerization & roboticization of all spheres of the economy. Its symbols today are smartphones and electric cars, but in the near future we will witness the creation and use of smart cities, smart electrical grids and smart factories. Today's industry is changing at an unprecedented rate.

The earlier industrial revolutions, i.e. periods of fundamental changes in the modes of production and communication, proceeded at a much slower pace than those we are observing today. The infographic shown in Figure 1 graphically summarizes the evolution of industrial revolutions.

**Figure 1**. The evolution of industrial revolutions.




Adapted from Poplawski & Bojczuk (2019).

The concept of Industry 4.0 is a new reality of the modern economy, because innovation and technological development play an important role in each organization. Industry 4.0 significantly changes products and production systems concerning the design, processes, operations and services. Certainly, the implementation of this concept has further consequences for management and future jobs through creating new business models (Ślusarczyk, 2018).

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Manufacturing industry profoundly impact economic and societal progress. As being a commonly accepted term for research centers and universities, the Industry 4.0 initiative has received a splendid attention of the business and research community. Although the idea is not new and was on the agenda of academic research in many years with different perceptions, the term "Industry 4.0" is just launched and well accepted to some extend not only in academic life but also in the industrial society as well (Oztemel & Gursev, 2018).

One of the culminating points of the well-known Industria 4.0 program is that it aligns customer-centric, demand-driven industrial production that is driving the progress of industrial automation or leveraging the consumer market. However, it is important to note that this does not mean that humans will be completely replaced by machines / robots. There is a growing awareness that human presence is not just a type of manufacturing capability, but that it plays an indispensable role in producing production roadmaps and managing the possible failures of automated systems in general (Kong, et al., 2019).

Industry 4.0 leads to the age of digitization. Everything is digital; business models, environments, production systems, machines, operators, products and services. Everything is interconnected within a digital setting with the corresponding virtual representation. Physical flows will be mapped to digital platforms on an ongoing basis. At a higher level of automation, many systems and software are enabling factory communications with the latest information and communication technology trends, leading factories, not only inside but also outside the factory, to compromise all elements. value chain in real time. In short, in this new paradigm of industrial process everything is intelligent (Alcácer & Cruz-Machado, 2019).

The objective of this paper is to provide an overview of the Industry 4.0 concept and the understanding of its modus operandi, identifying the possible challenges and problems that may be related to the implementation of Industry 4.0. Understanding Industry 4.0 as the emerging industrial new age scheme of operation and the expectations of the modern world for this subject is part of the objectives of this review article.

## 2. METHODOLOGICAL PROCEDURES

The present study is a systematic literature review and was carried out by means of a bibliographic survey carried out through the collection of academic articles based on keywords in portals and platforms for the dissemination and publication of international and national academic research.

### 2.1. SYSTEMATIC LITERATURE REVIEW METHODS

The present study is a systematic literature review and was carried out by means of a bibliographic survey carried out through the collection of academic papers from research on portals and platforms for the dissemination and publication of international and national academic research. The process of selecting the material to be used as a bibliographic reference for this research occurred through three stages, as can be seen in graphic scheme in Figure 2.

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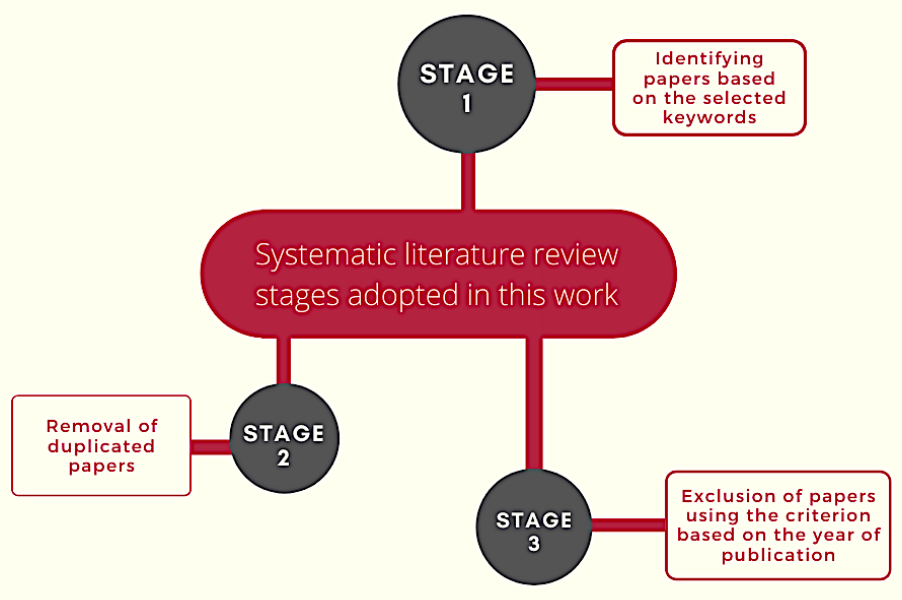
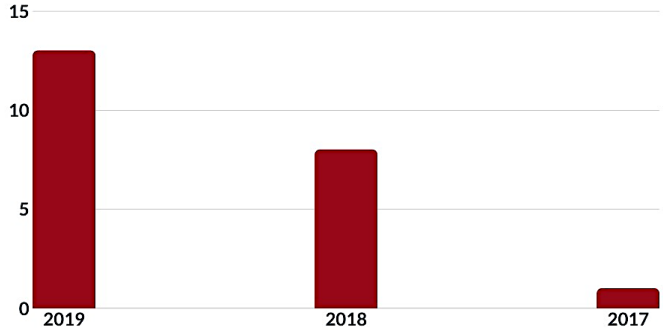
**Figure 2**. Graphic scheme representative of the bibliographic survey process carried out during this research.




The first stage consisted of searching using keywords. 49 articles were selected containing the pre-determined keywords, which are: "Industry 4.0", "smart manufacturing", "industrial production" and "new industrial age". The second stage consisted of reading the summary and excluding duplicate papers, also considering the alignment with the purpose of this study. The third stage was defined by the exclusion of articles according to the year of publication, as shown in graphic profile illustrated in Figure 3. After a complete analysis of the works mined in the literature, the 22 articles that were most aligned with the proposal of the theme studied in this research were selected to form the reference base.

**Figure 3**. Graphical profile of the quantity of articles used as a reference base in this research according to the year of its publication.




## 3. INDUSTRY 4.0: REQUIREMENTS AND CHALLENGES

Digitization and intelligentization of manufacturing process is the need for today's industry. The manufacturing industries are currently changing from mass production to customized production. The rapid advancements in manufacturing technologies and applications in the industries help in increasing productivity. The term Industry 4.0 stands for the fourth industrial revolution which is defined as a new level of organization and control over the entire value chain of the life cycle of products; it is geared towards increasingly individualized customer requirements (Vaidya, Ambad & Bhosle, 2018).

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For Moeuf, et al., (2017) in all cases relationed for Industry 4.0 concept is based on the emergence of new technologies such as cloud computing, Internet of things, cyber-physical-systems and big data. Such technologies should improve the transmission of information throughout the entire system, which enables better control and operations to be adapted in real time according to varying demand.

Some issues should be addressed with care: IT security, reliability and stability needed for critical machine-to-machine communication; a need to maintain the integrity of production processes, avoid IT snags, and protect industrial knowhow; and the lack of adequate skill-sets, general reluctance to change by stakeholders, and loss of many jobs to automatic processes and IT-controlled processes. To successfully transform Korean industry toward Industry 4.0, it is necessary to (1) refine and elaborate the strategies enacted by the central government to build economic and social systems that can flexibly respond to changes, (2) establish some kind of operational system to maximize the effectiveness of initiatives and policies, (3) develop concrete and workable action plans to transition toward economic and social systems that can accommodate innovative changes, and (4) establish infrastructure to lead all initiatives (Sung, 2018).

For Stachová, et al., (2019) the industry 4.0 requires and generates expectations regarding major changes in human resources management and processes such as education. Business and industrial organizations will benefit from new knowledge in the near future so it will need to be brought into the educational environment. However, this will require cooperation with the external environment and the resulting new educational opportunities, built on cooperation with external educational partners, organizations and institutions. According to an analysis by Coskun and his collaborators (2019), a crucial step in the process of preparing children and young people to face the age of Industry 4.0 is to adapt higher education to the requirements of this new vision by investing in the teaching of To this end, these researchers propose a generic framework for preparatory education for Industry 4.0 consisting of curriculum, laboratories aligned with the concepts and student club to adapt engineering education to industry 4.0 vision.

Considered one of the top priorities of industrial development in the modern world, Industry 4.0 has stood out as a concept that challenges the integration of two distinct sides, namely academic and practical. In this context, according to the review of the Industry 4.0 state of the art prepared by Mueller, Chen & Riedel (2017) it was revealed that one of the main shortcomings of the application of this concept in practice is the lack of applicable structure for the implementation of Industry 4.0. Thus, organizations can not only demand academic qualifications from professionals in line with the Industry 4.0 vision, but also invest in infrastructure that will allow effective and successful installation of smart engineering processes.

## 4. CURRENT WORLD POSITIONING ON THE INDUSTRY 4.0 CONCEPT

Following are some positions from researchers from different countries around the world on the concepts and implementation of the fourth industrial revolution or industry 4.0.

According to a South Korea case study by Lim & Kim (2019) some solutions to typical problems that may arise during the deployment of Industry 4.0 have been suggested. In this

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research it was found that there should be a non-conventional recruitment process in the future following the shape industry organization structure in question. Knowing the characteristic of the 4th industrial revolution which emphasizes connectiveness with information technology, countries that are aiming, by certain degrees, at reconfiguration of research institutions, whether they are public or private in their origin, may find similar problem definitions and solutions that have been described in this research.

For Indonesian researchers Hidayatno, Destyanto & Hulu (2019) the implementation of an industrial reality based on the concepts of Industry 4.0 involves different characters and social sectors, such characters or sectors are headed by the Indonesian government, appointed in this study as the owner of the problem at first.

A survey by Kohnova, Papula & Salajová (2019) performed comparative work involving the industrial reality of different European countries, specifically Slovakia, the Czech Republic, Austria, Germany and Switzerland regarding the new technologies characteristic of industry 4.0. According to the results of this research, the main obstacles to the success of the fourth industrial revolution orbit around the areas of education focused on training current employees and, especially, on future generations of professionals qualified for industrial environments. The research also pointed out that although each analyzed country needs its own strategic planning based on its longstanding cultural differences, on the other hand, there is something in common between them that is the need for urgent adaptation so that they can successfully face the wave of innovation. technological trends that is currently a trend for the industrial sectors.

Finally, this research highlighted that among the countries mentioned, Slovak and Czech companies were affected by the reality and consequences of the fourth industrial revolution, but they are one step lower than the other countries participating in the research in relation to investments in preparatory education for this new one industrial setting.

Analyzing the successful training experiences of industry 4.0 in various countries, he pointed out that for now the most successful experiences in this context are evident in first world countries like USA, UK, Germany and Japan. The results of this research associate the success of deployment to the huge investments that these countries direct in the areas of education. Thus, it is proven that one of the main pillars of Industry 4.0 support is the educational formation of children and young people for this purpose, that is, there will be no successful implantation without massive investments in the workers base of the great scheme of the fourth industrial revolution (Lobova, et al., 2018).

Yamada & Martins (2018) made a comparative study between Brazil and Germany regarding the realities of these two countries regarding Industry 4.0. In this study it became clear that Brazil is still far behind Germany, which already lives in its successful industrial centers of intelligent industrial productions, focusing on cost reduction. In this context, Brazil was pointed in this study as an emerging country not only in the economy but also socially. It was also concluded in this study that for Brazil to be equal to Germany in relation to the success of the successful results that this country has achieved there is no other way than investment in

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research and development, besides studies and long-term planning, with goals. real actions and incisive actions on problems to be overcome and potentialities to be explored.

In a comparative study that confronts the realities of Brazil and Canada in relation to the actions and public policies of these two countries in order to innovate and insert themselves in the context of industry 4.0. The results of this work showed that the secret of Industry 4.0 deployment lies in something called 'Information Literacy', that is, individuals can access or even interact with the policies of this new era of industrial work. This study, which relies on official government reporting data from the National Science, Technology and Innovation Strategy and Site, shows that the two countries compared in this study have been striving to make companies aware of the encouraging and motivating results of the 4th Industrial Revolution and the Business opportunities that this work model can bring.

The Brazil needs to spread the idea of Industry 4.0 to companies so that they can begin to adapt in this new era. Canada needs to target more investment, especially to small businesses. In addition, both countries can benefit from an international partnership between them to encourage export and information sharing. In short, this paper concluded that it is impossible to achieve high flights in the Industry 4.0 working model without the support of public policies for both education and economic growth (Ottonicar, Valentim & Mosconi, 2019).

All changes that have had far-reaching influences on human history have resulted in technological developments, demographic changes, globalization and a new pace of work. At present the fourth industrial revolution is the term that reflects these changes. This is the understanding of Israeli researchers who investigated the effects of the fourth industrial revolution on Israel's economy. This research work has been concluded with emphatic assertions that there is high expectation in Israeli society about the importance of government investment, as otherwise the growing implementation of this new concept of industrial labor could pose threats to the Israeli labor market in the future. Still according to this study without massive investments in basic education directed to the fourth industrial revolution, individuals coming from needy communities will not be able to enter the labor market once the technological foundations of the industrial sectors are strengthening. (Bercovici, Bercovici & Sandru, 2019).

## 5. BENEFITS OF SMART MANUFACTURING

The smart manufacturing is the main driving force of the operating base of the new industrial age of the modern world. Following is a compilation of smart manufacturing information from the literature to highlight the benefits of this new manufacturing paradigm and its positive implications for industrial organizations. Historically, the smart factory was initially studied with the introduction of the Internet of Things in manufacturing, and later became a key part of Industry 4.0. Also emerging are other related models such as cloud manufacturing, social manufacturing and proactive manufacturing with the introduction of cloud computing social networking and big data, respectively (Yao et al., 2019).

According to Supekar, et al., (2019) the transformative possibilities of smart manufacturing, which is defined by digitization, enhanced connectivity, advanced analytics, and integrated

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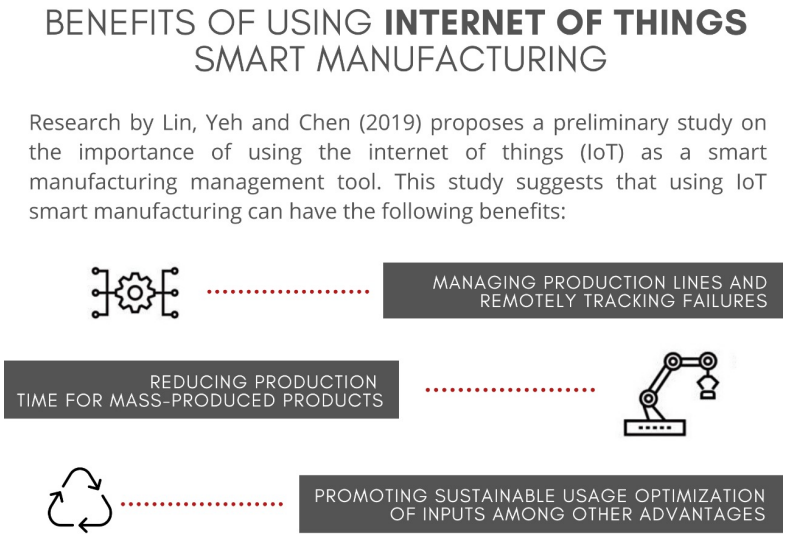
cyber-physical systems in manufacturing processes and systems, have been extensively discussed in the literature. Potential benefits underscored include cost reduction, production flexibility, shorter product times-to-market, energy efficiency, environmental impact reduction, and increased productivity. The benefits of using IoT has been studied by many authors around the world as can be seen in Figure 4.

Figure 4. Benefits of using IoT in smart Manufacturing.




Adapted from Lin, Yeh & Chen (2019).

IoT is understood as a technological core that integrates real-time data, operating systems and all the information necessary to supply the management of something. Thus, from the results collected in this study, it can be stated that the implementation of IoT may compensate for deficiencies of the conventional industrial production model, in addition to promoting improvements in customer service, since IoT increases control and situational awareness, allowing us to predict delays or technical infeasibilities.

The studies by Ren, et al., (2019) corroborate this information by stating that smart manufacturing has received the most attention from academia and industry in recent years as it provides a competitive advantage for manufacturing companies, making the industry more efficient and sustainable for them than IoT. Using big data can uncover hidden knowledge and other useful information such as relationships between lifecycle decisions and process parameters, helping industry leaders make more informed business decisions in complex management environments.

A case study investigated by Simeone, et al., (2019) demonstrates that modern industrial manufacturing demands are characterized by high fluctuations with negative impacts on resource efficiency. On the other hand, the results of that same study clearly showed the technical and economic advantages for the improvement of efficiency of industrial resources.

## 6. CONCLUSIONS

The fourth industrial revolution may at first appear to be a threat to the labor market of skilled industry professionals, but this is not true if such professionals become aware of being aligned

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with the new skills and competencies that this new era of the industrial sector will require from now on.

It is imperative that professionals for industrial organizations understand the modus operandi and type of workforce needed and responsible for conducting industrial production processes from the perspective of Industry 4.0, just as organizations must take their share of responsibility and seek adaptation to suit the necessary changes in their structures and facilities.

Obviously, the average value of the qualifications and professional competencies required in a sector governed by Industry 4.0 will vary depending on the type of service offered by the industry organization concerned.

Finally, it was understood that the fourth industrial revolution also known as Industria 4.0 generates changes in social, economic and political efforts. However, the implementation of this new form of operationalization of the industrial sectors will only happen smoothly and without harming or threatening the labor market through the existence of an extensive network of mutually supportive cooperation and support formed by government policies, business organizations, educational institutions and individuals in society. Public politics will play a prominent role in this collaborative network in favor of the implementation of these new technologies because without investments directed to education and to technological and entrepreneurial strengthening incentives there is no industry 4.0.

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