Conceptual and contextual background of Industry 4.0: A literature review

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Abstract

In the present era of global competition, industrial development and innovation; industries, especially manufacturing, are forced to reconfigure their production processes and technology. Industry 4.0 and smart manufacturing are part of a manufacturing transformation, by which manufacturing and information technologies have been integrated to create innovative systems of manufacturing and management, which allow to maximum utilization, to achieve greater flexibility, well-organized production processes and generate a value added proposal, as well as to provide a timely response to the needs of market. Thus, the interest of this article is to explore the industry 4.0, from its conceptualization, development and implementation as well as their implications and future perspectives. For that, a literature search was made in recognized database such as the Web, Web of Science and Google Scholar in order to analyze the findings of previous research.

Keywords: Industry 4.0, Industrial Systems, Internet of things.

1. Introduction

This research gathers the conceptual and advanced developments on Industry 4.0, for which descriptive analysis methodologies [2] are used in order to characterize, recognize and illustrate the environments of Industry 4.0, the theories of Industry 4.0 and the requisite and differences of Industry 4.0 in different regions of the world; This descriptive analysis is accompanied by an exhaustive review of recent literature with the objective of determining the position of the art of the subject in the context of the research; This review was executed in specifically designed databases of the Science Direct and Web of Knowledge platforms, as consequent sources of search and inquest and taking as a search plan the developments, applications and conceptualizations in the subject matter of industry 4.0 and referencing categories such as: industry 4.0, cyber-physical systems ,internet of things, among others that emerge in the process

of search and inquest . The second section shows the most relevant theoretical background, the third section shows the literature review on the subject, and the fourth section discusses the preliminary findings and conclusions reached.

2. Conceptual and contextual background

The fourth industrial revolution or what has been called Industry 4.0, is preceded by a change not only technological, but also in the economic development models of the countries, mainly in the case of emerging economies, whose participation in the market, in contrast to traditional economies, has grown compared to a decrease in traditional economic models for the same period . In this way, it went from a quantified participation of 3.45 trillion dollars to 6.58 trillion dollars, with investments in industrial development, product differentiation and the achievement of competitive advantages [3].But these changes in the industrial and economic panorama are tinged by phenomena that according to [4] are due to a high complexity in production, given that "It is not at all feasible to explain all processes and products in an exact way", as this manifests itself as less predictable, highly flexible and sensitive to small externalities.

In this perspective, the question then arises: Why is it important to research on Industry 4.0? , a study [5], showed that all the important topics for 2015 as part of the process transition happened by industry 4.0. 31% of industries see the importance of digitization as an important topic of Industry 4.0 and in its immediate future; likewise, in an economy like the German one, industry 4.0, referring to all the products and services that need technology and communication to 2020, they have a market potential of 10.9 million Euros, with an annual added value of 1.7%, as stated [6], referring to what was stated in the initial question. According to [1] the term industry 4.0 was produced by the government of Germany in the 2nd decade of the 21st century and is part of the project known as: The future of "Industry 4.0". This concept is part of the so-called 4th Industrial Revolution, in which the virtual actual-physical and world come together in a system known as Cyber Physical-System (CPS), which is feasible through the so-called Internet of Things (IoT).

Likewise, [1] defines the Internet of Things (IoT) as a modern complementary notion of the advancement of communications and computing, applied to objects, which permits for improved interface between them. It refers to a daily network of things interlinked by means of the

Internet. On the other hand, in [7] Cyber Physical-System (CPS) is defined as the amalgamation of computing, networks and physical processes, with rooted computing and network monitoring for the control of physical processes; with feedback loops where physical processes influences computational ones and vice versa. CPS integrates rooted systems in devices that allow interaction with the dynamics of physical processes, providing abstractions, models, designs and analysis techniques for their integration.

However, [8], framed in the above, they outline the characteristics of future industrial production, in terms of: greater individualization of the product (with highly flexible mass production), greater and better integration of customers and suppliers in processes of business with high quality products and services resulting from hybrid products, optimization for standardization and reference architectures in the control of complex systems, internet infrastructure and its coverage in terms of security for the industry, organization and design of training of new jobs and the development of applications that meet the conditions of legal studies, resource efficiencies, low value-added vertical integration to networks, digital generalization of the supply chain and vertical integration with systems connected production lines.

3. Result

As mentioned before, an exhaustive review of latest literature has been executed with the objective of discovering the status of the art of the subject in the context of the research; This review was executed in specific databases of the Science Direct and Web of Knowladge platforms, as consequent sources of inquest and search, in a time horizon between 2010-2019 and taking as a search plan the developments, conceptualizations and applications in the subject matter of industry 4.0 and referencing categories like : industry 4.0, internet of things, cyber-physical systems, among others that emerge in the process of search and inquiry . In this sense, the conclusions are explained below. [9] States of the initial three industrial revolutions in terms of: The 1st industrial revolution nearly about 1750 with includes steam engine and combustion engines. The 2nd industrial revolution marked by the separation of labor and series production with the help of electric energy (Taylor, Ford) and the 3rd industrial revolution in the initial 1960s with the evolution of electronics and ICTs.

In this paradigm [9, 10], they elevate the magnitude of industry in the economy in terms of: innovation, productivity and exports, in addition to what is proposed by [9] and [11] on amend in production factors (energy , knowledge materials, and capital); In this same viewpoint [9, 12] they deal with the obstacle of complexity in production.

The complexity elucidated through the amount of elements of a system and their co relationship. It is not viable to describe all processes and products exactly. Since 1850 there has been an ascending link between the variety of products and the amount of products for each variety. They evaluate factors such as: diversity, efficiency, demand and delivery capacity, amplified availability, cost elasticity and inconsistency in production. Finally, [13] discusses about the evolution phase to the 4th industrial revolution with advancements in communications networks, development of systems and databases, improved productivity, lessen costs and digitization, decentralized control , the apply of the internet of things and services. Table 1 summarizes the main contributions of Industry 4.0 from the perspective of its conceptualization.

Table 1: Background to Industry 4.0 from its conceptualization

Author	Contribution
[9,10,11]	He talks about the initial three industrial revolutions in terms of: The 1st industrial revolution nearly about 1750 through the steam engine and combustion engines. The 2nd industrial revolution characterized by partition of labor and series production with the of support electrical energy (Taylor, Ford). The 3rd industrial revolution in the near beginning of 1960s with the evolution of electronics and ICTs.
[9, 10,13]	They state the significance of industry in the economy in terms of: innovation, productivity, and export.
[9, 11,14]	They talks about the changes in production factors (energy, materials, knowledge, and capital).
[9, 12,15]	Addresses the glitch of complexity in production. The complexity expound through the amount of elements of a system and their interconnections. It is not viable to explain all processes and products exactly. Since 1850 there has been an ascending relationship between the range of products and the quantity of products by variety. They examines factors such as: demand and delivery capacity, the increased availability, efficiency, diversity, price elasticity and variability.

[13]	It discusses the evolution phase to the fourth industrial revolution with developments in optimization of systems, communication networks, and databases, improved productivity, decreased costs and digitization, decentralized control, internet use of things and services.

On the other hand, [14] they elevate the discussion on three key groups referred to studies on Industry 4.0: the individuality in production (large scale customization, modularization, elastic and reconfigurable manufacturing systems, distributed administer, optimization oneself). , rapid manufacturing, and cloud computing); joint networks and horizontal combination (distributed manufacturing, elasticity in the supply chain, visibility of the supply chain, internet of things and services) and digital combination (virtualization of the process chain, traceability of personalized data, systems real-time functions, simulation and modeling of processes and products, concurrent planning of production processes and products); while [15] discusses about the factors of industry 4.0 in terms of industrial advancement: the employ of smart rooted production systems, mobile services and ubiquitous computing; with the internet as a business website and using web semantics and methods Web 2.0. found on the studies executed by [16] who discuss the Moore and Metcalfe laws, the 1st based on experimental observation on the density of components and alters in integrated circuits in the last fourty years and their impression on industry 4.0. And the 2nd which states that the advantages of communication systems develop exponentially with the development of its participants.

And, ultimately, [17] who discusses regarding the advances in the implementation and the exclusion of risks in Industry 4.0, changes in terms of IT security [18], excessive investment costs [19, 20], preservation of secrets from the company [21], you wait for technical solutions, breaks in stable structures and processes, complexity management, semantic unification in communication between machines; standards [22], legal insecurities [23] and inadequate skills of employees [24]. Table 2 summarizes the main contributions of Industry 4.0 from the perspective of its foundation.

Table 2: Background to Industry 4.0 from its foundation

Author	Contribution
[14,15,16]	They elevate the discussion on three key group referred to the analysis on Industry 4.0: the individualization of production (large scale customization, modularization, elastic and reconfigurable manufacturing systems, allocated control, optimization itself, rapid manufacturing and computing on the cloud); joint networks and horizontal combination (distributed manufacturing, flexibility in the supply chain, visibility of the supply chain, internet of things and services) and digital combination(virtualization of the process chain, traceability of individualized data, real-time operating systems, simulation and modeling of processes and products, concurrent planning of products and production processes).
[15,17,18]	They discuss about the operators of Industry 4.0 in terms of industrial evolution: the employment of smart rooted production systems, mobile services and ubiquitous computing; the employ of the internet as a business Web and the use of Web semantics and Web 2.0 methods.
[16,19,20]	They discuss the Moore and Metcalfe laws. Moore's Law based on experiential study on the density of the components and the amendment in integrated circuits in the last fourty years and their impression on Industry 4.0. Metcalfe's law which states that the advantages of communication systems rise exponentially with the progress of its participants.
[17,18]	They talk about progress in implementation and exclusion of threat in Industry 4.0, changes in terms of IT security [18], high investment costs [19, 20], preservation of company secrets [21], waiting in technical solutions, breaks in stable structures and processes, complexity management, semantic unification in communication between machines; standards [22], legal insecurities [23] and inadequate skills of employees [24].

There are also the works of [25, 26] who propose the evolution in industry 4.0 based on the advances in Computer Incorporated Manufacturing; the works of [27-29] who speak about evolution in terms of Lean systems; the works of [30] who discuss developments in technological terms: Internet of Things [31, 32], Auto-ID Automatic Identification Systems [33], RFDI [34] and [35], Embedded Systems [36] , wireless networks [37-39]. Additionally the evolution of industrial communication [40], [41] and control techniques like Ethernet, OPC UA [42] and Soft-PLC [43, 44]; the works of [45] who talk about the contents of industry 4.0 in production: smart products [46], the smart machine - planning, assembly, launch, operation and reconfiguration [47] and assistant operators [45]. There are also the works of [48], who propose the production having automation explained as the technology interrelated to the application of mechanical , computer-based and electronic systems for the functioning and control of

production [49-54] and systems cyber physicists [7, 55-60]; the works of [61] who speak of horizontal and vertical integration and its integration with the value chain. As well as the works of [62] those who propose security in industry 4.0 and the works of [63] who speak of human-machine interaction [64]. Table 3 summarizes the main contributions of Industry 4.0 from the perspective of its developments.

Table 3. Background to Industry 4.0 from its developments

Author	Contribution
[25, 6,27,28]	They outline the developments in Industry 4.0 based on the advance in Computer Incorporated Manufacturing.
[27,29,30]	They discuss about advancement in terms of Lean systems.
[31,32,33]	They discuss developments in technological terms: Internet of Things [31, 32], Auto-ID Automatic Identification Systems [33], RFDI [34, 35], and Embedded Systems [36], Wireless Networks [37-39]. Additionally the development of the industrial communication [40, 41] and control techniques like Ethernet, OPC UA [42] and Soft-PLC [43, 44].
[44,45]	They talk about the contents of industry 4.0 in production: smart products [46], the smart machine –Planning, assembly, launch, operation and reconfiguration [47] and the assistant operators ([45]
[48,49,50]	They propose production by automation defined as the technology referred to the application of computer-based, mechanical and electronic systems designed for the functioning and control of production [49-54] and cyber-physical systems[7, 55-60].
[60,61,62]	They talk about horizontal and vertical integration and its integration with the value chain.
[62,64,65]	They pose security in Industry 4.0
]66,67]	They speak of human-machine interaction [64].

4. Discussion and conclusions

The term industry 4.0 or connected industry 4.0, refers to the current evolution of systems, machinery, technologies and processes used in the industrial sector through the use of new technologies: sensors, internet, real-time communication between machines, manufacturing

additive, etc. It is the mode to entitle the phenomenon of digital revolution applying to manufacturing industries. Industry 4.0 consists of digitizing production procedure in factories through sensors and information systems to modify production operations and make them further competent. The purpose of Industry 4.0 is an ambitious high-tech project, which is to encourage the automation of manufacturing. Through such automation, the government would be able to construct smart factories characterized by great adaptability, high competence in the utilization of resources and good ergonomics, in addition to integrating customers and business partners into business and value operations.

The challenge for this new industrial revolution will then be the development of software, massive data analysis systems and their storage, the incorporation of electronics to the elements that interact in production processes and in the products derived from them, the coexistence of man with the machine and the availability of information for better and more effective decision making.

Industry 4.0 also aims to respond to current problems both in terms of energy saving and in the management of natural and human resources. With an organized system based on a communication and exchange network instant and permanent information, you will be much better prepared to make this management better and more effective, allowing improvements and, possibly, gains in productivity and economy of resources.

Finally, Industry 4.0 as such, is a concept of great complexity, which is not well known in the context of Small and Medium Enterprises; In this sense, only some topics related to the Internet of Things or CIM or CAD Manufacturing Systems have been recognized by experts in the field; which does not depend neither on the size of the company, nor on the range of operation, nor on the type of production. It is seen in the context that there is only knowledge of the subject at the level of middle managers and managers in administrative and Research and development departments that interact with new technologies.

Although the literature review has revealed multiple developments in the subject matter of Industry 4.0 and its contribution to the development of the economy and to industry in general; There is a lack in terms of methodological proposals that contribute to the generation of implementation strategies for Industry 4.0 in the local, regional and national context; recognizing

contributions like those of [65] in terms of some recommendations or steps for the implementation of Industry 4.0.

However, it is recognized as among the hurdles to the implementation of Industry 4.0, the following are evident: the lack of broadband connectivity, the training of highly qualified personnel, the culture of change and the return on investment (ROI). Likewise, given current legislation, investment risks are high at the technological level, the level of qualification of personnel and the organizational culture limit the incorporation of Industry 4.0 in business contexts.

In this sense, an Industry 4.0 Framework program is required in the country that promotes the incorporation of technology in search of competitive advantages, development and innovation from SMEs to large industry, which begins with training and foundation, the study of small pilot exercises and the generation of macro strategies that allow the country's access to international development.

5. Future Work

- Implementation of technologies such as, a group of solutions focused on different organizational areas, works as analytics of complex data and processes to help in real time decision-making.
- Development of methodologies and data analytics models in the framework of the implementation of solutions from Industry 4.0 for production, logistics and service companies, with Big Data, Internet of Things, Cloud Computing, etc.
- Scaling own developments in the production and logistics areas such as: MOCAFI-WEB.
- Optimization of the design of manufacturing components in distributed environments.
- Methodology for traceability of analysis and intelligence of processes oriented to the development of information systems.

- Implement an intelligent system for decision-making supported in a workflow-type environment and expert systems, which allow optimizing decision-making at the production level in the company.

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