SCIENTIA CUM INDUSTRIA, V. 9, N. 1, PP. 10 — 15, 2021

IoT and knowledge Economy: Two Strong Pillars of Industry 4.0

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Abstract

The Industry 4.0 concept incorporates technologies from a wide range of domains and this inevitably requires massive changes in processes of innovation, production, logistics and services. Such innovations and transformations cannot be impelled in practice without the support of a tool known as Internet of Things or simply IoT. The objective of this research is to present an overview on two strong and influential pillars of Industry 4.0, which are the IoT and the knowledge economy. For several authors who have dedicated themselves to the study of the fourth industrial revolution, IoT is considered an indispensable pillar for the implementation of the concepts of the referred industrial revolution. However, it has not been common in the literature to see references correlating the almost inherent relationship that exists between IoT and the knowledge economy. In summary, it is possible to state that the greater the valuation and investments directed towards the knowledge economy, the better the quality of the operation of the emerging technique or mechanism known as IoT. From the perspective of industry 4.0 concepts, both the IoT and the knowledge economy have strong beneficial influences on industrial production organizations. Still according to the information compiled in this research, the knowledge economy can be seen as the great asset in favor of ensuring the employability of qualified professionals for all kinds of organizations of an industrial nature.

Keywords

Internet of Things, Knowledge economy, Industry 4.0, New industrial age.

I. INTRODUCTION

Internet of Things is a generic term that has started being used between the end of the 90's and beginning of the 00's to characterize objects that are connected to the internet, producing or processing data in an autonomous way in real time. It is therefore a phenomenon that involves a diverse and complex context, consisting of several agents, including the society as a whole [1].

For a particular group of researchers [2] in the industrial context, the internet of things is also known by the nickname IoT and this interconnection of physical devices with computational capabilities of data detection and communication is not a new concept, but the understanding of IoT as an ecosystem is real. However, its applicability in everyday life is very fledgling. In short, the IoT must be understood as a network that promotes the interconnection between large and small devices that in turn have hardware limitations and also where physical architectures or security techniques are difficult or impossible [3]. That is, it is a state where "things" or small devices and machines located in certain environments or in cities will be able to communicate with each other in real time. This connection network includes communication with human beings inserted in the ecosystem or scenario in question.

In an economy driven by innovations, the trends of the transformation of society as a whole develop at the expense of the complex nature of the process of exchange and use of knowledge both in production and outside it; a significant role is given to the formation, accumulation and effective use of intellectual capital [4].

In the '90s, the 'knowledge economy', also known as KE, was hailed as a key driver of future prosperity by progressive policymakers in developed democracies. According to its proponents, in the knowledge economy, companies and countries alike would succeed by cultivating workers' knowledge – as opposed to traditional forms of capital such as plant and machinery [5]. As of 2013, knowledge economy has held more than 10% of U.S. employment, generated nearly 20% of national GDP and expect to increase to 25% during the next 20 years this same country [6].

Currently, information and communication technologies play a huge role not only in the lives of individuals, but also transform economic processes, modernize entire industries and various types of social and economic activity, and become drivers of innovation, economic growth and competition [7].

Due to the scarcity of references in the literature that correlate the IoT with the knowledge economy, this research aims to try to compile information that minimally remedy this gap in the literature, showing the close connection that exists between these two terminologies that are two important sides of the fourth industrial revolution. Therefore, the purpose of this article is to present the academic and industrial communities with an overview of two important aspects of industry 4.0, which is the internet of things and the knowledge economy. It is part of the purpose of this review work to present an explanation on the influences that these two concepts have on the new industrial age of the current world.

II. INTERNET OF THINGS (IOT)

The adoption of emerging technological trends and applications of the Internet of Things (IoT) in the industrial systems is leading towards the development of Industrial IoT (IIoT). IIoT serves as a new vision of IoT in the industrial sector by automating smart objects for sensing, collecting, processing and communicating the real-time events in industrial systems. The major objective of IIoT is to achieve

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Data de envio: 07/07/2020
Data de aceite: 14/01/2021

http://dx.doi.org/10.18226/23185279.v9iss1p010

high operational efficiency, increasing productivity, and better management of industrial assets and processes through product customization, intelligent monitoring applications for production floor shops and machine health, and predictive and preventive maintenance of industrial equipment [8].

The great acceptance in the rise of the IoT concept in recent years has created an impetus for digitization and automation of countless day-to-day processes, this includes industrial processes but it is not just for that. Briefly, IoT can be described as the interconnection with data exchange between devices, sensors, objects and everyday items in any environment in the Internet through the use of radio frequency identification system (RFID) with minimal human intervention [9]. However, it is very important to keep in mind that the interconnection between things or devices can be accomplished by several means other than RFID technology. It is possible to mention the following examples as providers of this interconnection: cables, Wi-Fi, Bluetooth, among others means [10].

At this point it is worth noting that the concepts of intelligent manufacturing must be differentiated from that of the intelligent factory. By intelligent factory, it is understood as a complete concept of a manufacturing system fully integrated with the promises of the new industrial era known as Industria 4.0. The success of this new industrial age depends to a large extent on adherence and successful adaptation to emerging technologies such as IoT.

The current generation is witnessing the digital revolution driven by industry 4.0 whose goal is to optimize manufacturing processes while maximizing profits and minimizing waste [11]. There is no denying that seeing the fourth industrial revolution or Industry 4.0 from this perspective can raise concerns about ensuring the demand of the human workforce in the manufacturing process - that is, it is inevitable not to associate the fourth industrial revolution with a threat to the employability of workers. in the near future even aware of all the economic advantages and benefits associated with this new and emerging concept.

At the same time that IIoT presents itself as a powerful tool for planning and managing an industrial production workshop using radio frequency identification technologies, bringing to the workshop a real-time connection between senior management and this tool is almost completely autonomous and capable of managing a large amount of data, information and commands previously programmed without constant supervision [12]. However, it is pertinent to note that IIoT is not capable of handling alone a large amount of data. Precisely to remedy this limitation, the need to create other technologies that are also essential for the success of Industry 4.0, examples of these supporting and essential technologies are: big data, cloud computing, information technology, among others.

Analyzing the dependence that the new and emerging industrial age has on IIoT and all the economic benefits that this will bring, it is possible to arrive at a conclusion that a fascinating future is drawn in the scenario of the industrial sector of the modern world in which the systems and processes of production will all be digital and interoperable, reliable, secure, error-free, efficient and communicating, all linked together by appropriate communication technologies [13].

The advantages of implementing the IoT are many, besides the significant cost reduction in the production lines, the interconnected data processing systems will introduce the industries that still operate in traditional production systems in a new level of industrial existence. At this new level, wireless remote monitoring will be possible, simultaneous coordination of multiple production stages, wireless operation of mobile robots and autonomous transport vehicles, as well as the location and tracking of items at any time or stage of the manufacturing process or logistics [14].

In Fig. 1, a summary of the advantages that the tool known as IoT can add to the new industrial age is shown in the form of an infographic.

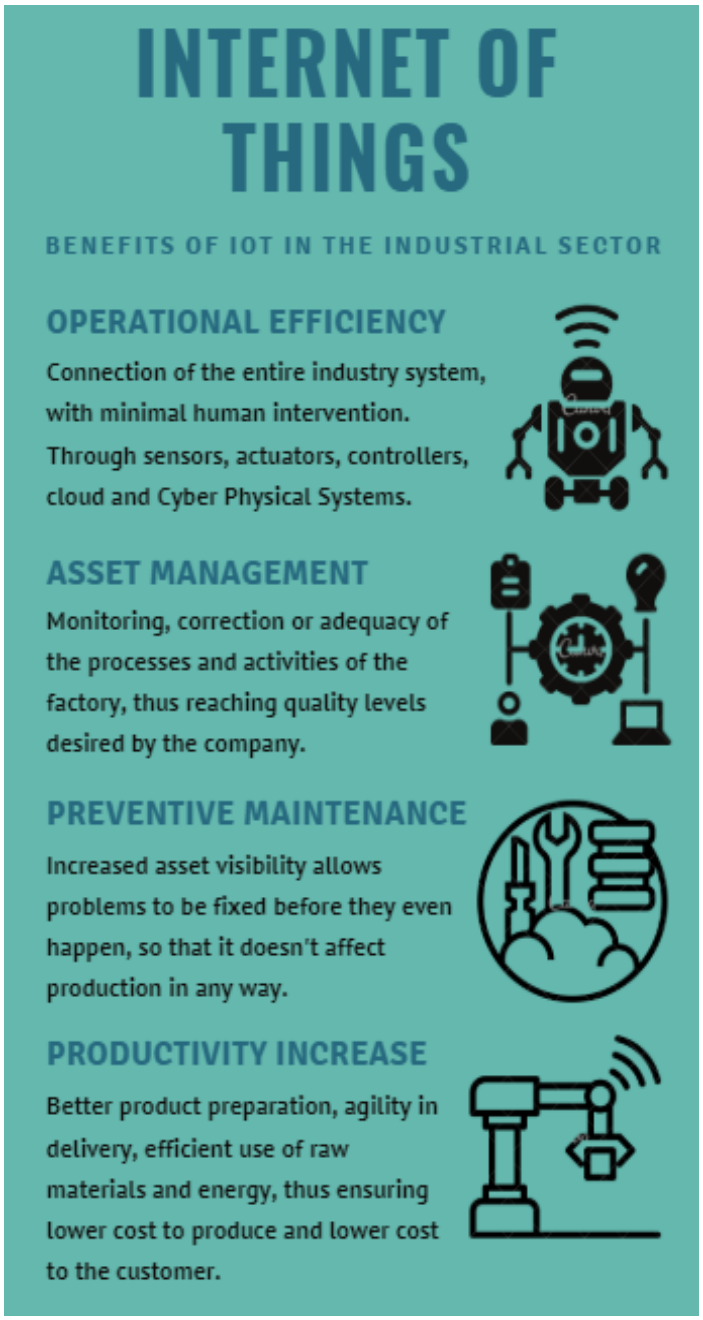

Fig. 1: Infographic representing the advantages of IoT for the new industrial age.

III. KNOWLEDGE ECONOMY

The Knowledge Economy can be defined as the productive process of goods or services based intensively on human knowledge in favor of technical and scientific advancement. The key point of the knowledge economy is a massive dependence on the intellectual capacities of individuals, that is, in a knowledge-based economy, raw materials are not physical inputs or natural resources, but immaterial and non-consumable resources [15]. In other words, we could understand the Knowledge Economy as the art of carrying out or knowing how to do something in favor of the production, generation or distribution of goods or services with high added value.

The knowledge economy still can be understood as a platform for the new and emerging industrial revolution, known as Industry 4.0. The process of implementing and developing business activities in this sphere are totally dependent on the knowledge economy. This means that the knowledge economy and Industry 4.0 do not develop in parallel, but form a single system - i.e., they are mutually supportive process [16]. In other words, it can be mentioned that although the IoT and the knowledge economy are two different sides of Industry 4.0, they both complement and strengthen each other.

The knowledge economy can also be seen as an important factor that could increase the worker's qualification value, since it can be a factor of tiebreaker or competitive advantage. This is what the study carried out by a group of experts [17] reports when it states that, from the perspective of the knowledge economy, the level of productivity of a worker varies between two processes that involve knowledge management, creation and application. of knowledge. Surprisingly, according to the same study, professional productivity does not vary or depends on knowledge sharing. It is very important to note that in knowledge-based societies the importance of higher education to facilitate people's employability is generally recognized. For universities, one of the main challenges is how to identify the right balance of specific knowledge (i.e., the knowledge specifically needed for a specific task) and generic knowledge (i.e., general skills and abilities) conducive to employability [18].

If we consider that the knowledge economy is the great asset in favor of the employability of the worker, we will reach the same conclusion obtained by Thorley (2020) [19] who affirms that from now on Universities will face challenges never seen before, since societies hope that the academic development will solve the great challenge to maintain the indispensable and attractive work for the industry's labor market. Thanks to the knowledge economy, the focus of Industry 4.0 will continue to focus on valuing the skilled worker and not just on an efficient automated production line.

The development of human capital involves an increase in intellectual skills, accumulation of knowledge, productivity in training and specializations and, above all, people's interest in their own processes of growth and professional training [20]. Following this same understanding, a group of Brazilian researchers concluded in their study that the success of the implementation and development of Industry 4.0 is directly proportional to the degree of investment in education by the government in favor of the academic training of children and young people [21]. Still in that same study, the Brazilian researchers affirm that it is not by chance that the concept of Industry 4.0 is already a reality in the daily lives of developed countries such as Germany and Japan in which the referred concept is already in an advanced stage of operation while in underdeveloped countries the same concept is being implemented and in certain cases it still represents a possibility for the future. There are some reports of conclusions from different studies published in the literature corroborating this reasoning, i.e., stating that the chances of success of a knowledge-based economy are directly linked to the intellectual potential of its population [22]. It also states that the literature presents a robust support of information with bibliography reviews and case studies of between developed and developing countries. In the case of the first group, the quality of business institutions is guaranteed by the seriousness of how the country's education is conducted, thus it becomes totally viable to maintain the level of its skills in the face of rapid technological changes and remain confident in face of the international competitiveness.

In a particular study that analyzed the complexity of human capital management, it was suggested by way of conclusion that it is a great challenge for a business organization to assume that the knowledge economy is one of its faces, because this type of management requires skills and competences that are needed. in addition to the typical technical activities of industrial production environments [23]. In these cases, the management of intellectual capital is a set of activities interconnected in a coherent system of knowledge management, human resources, talents, interpersonal and commercial relations, information and communication, innovation, motivation and modeling of organizational behavior.

Given all the information compiled in this work on the knowledge economy and its influences on the Industry 4.0 concept, it can be understood that intellectual capital significantly affects organizational performance and the capacity for innovation in manufactured products, services and processes offered. The importance of organizational innovation through the use of emerging technological maneuvers has received a lot of attention in the academic and industrial literature over the years, which suggests that the ability to innovate in products, services and processes is a vital key to generate and maintain the competitive advantage in an increasingly demanding and diversified market and none of these desired and indispensable innovations of the new industrial era will be possible without the proper valuation of intellectual capital [24]. From the perspective of the concepts pertinent to Industry 4.0, the relevance that the knowledge economy represents for the new industrial age is illustrated in summary form in an infographic shown in Fig. 2.

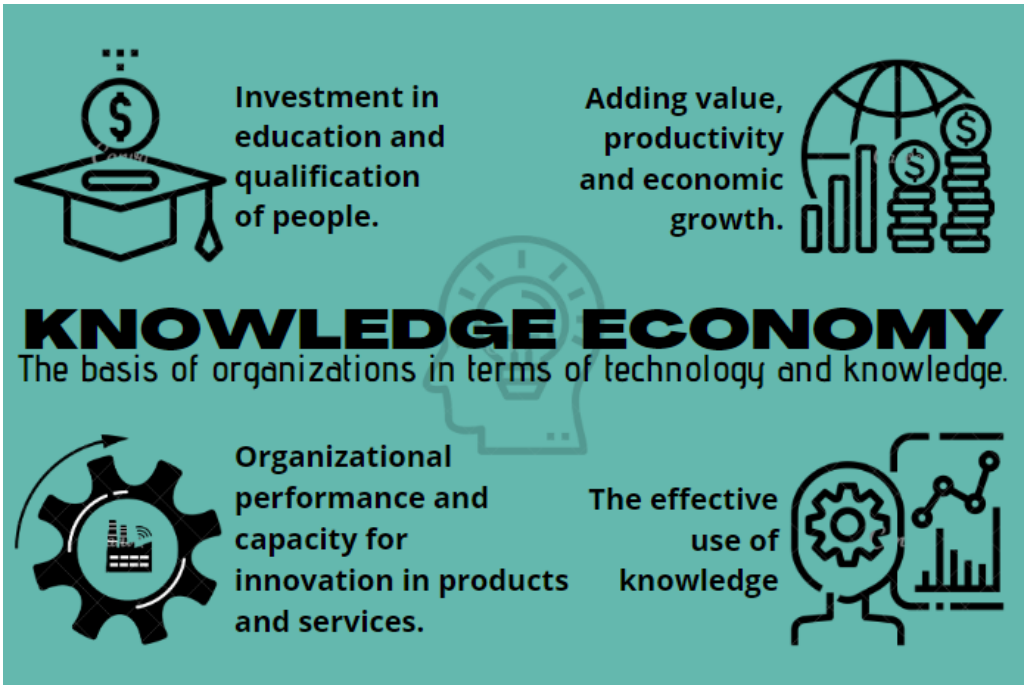

Fig. 2: Infographic representative of information about the relevance that the knowledge economy represents for the new industrial age.

IV. METHODOLOGICAL PROCEDURES

The present work is a systematic review of the literature and was carried out through a bibliographic research carried out mainly through the collection of academic and scientific articles published in portals, platforms and databases appropriate for the dissemination and publication of international and national academic research, such as: Capes' journals portal, Scientific Electronic Library Online (SciELO), Science Direct, Emerald Insight and Google academic. According to Sony and Naik (2020), a systematic review is a research methodology to answer the specific research question on a specific topic by identifying all relevant studies and summarizing the state of art [25].

The systematic research carried out in this review work established, initially, as a work proposal to seek the most recent information or results possible about the importance of IoT and the Knowledge Economy within the context of the new industrial era. It was pre-defined as a research objective or proposal to seek empirical or scientific evidence to prove the almost inherent relationship that exists between the terms IoT and Knowledge Economy. In this way, searches were carried out using the following keywords: Internet of things, Knowledge economy, Industry 4.0 and new industrial era.

Although the terms IoT and Knowledge Economy are still little related to each other in the literature, it was possible to compile information from the different studies collected as initial results of systematic research. From a screening analysis, only the bibliographic references that presented information aligned with the proposal initially established as the objective of this research were selected and that their contents or results complemented each other, allowing a connection that makes it implicitly evident that there is a directly proportional relationship between the two terms object of study of this research, i.e., that the greater the valorization and the investment directed to the Economy of the knowledge better will be the quality of the service provided by the technology IoT in favor of Industry 4.0.

The process of selecting of the references base used in this research occurred through three stages, as can be seen in representative flowchart presents in Fig. 3.

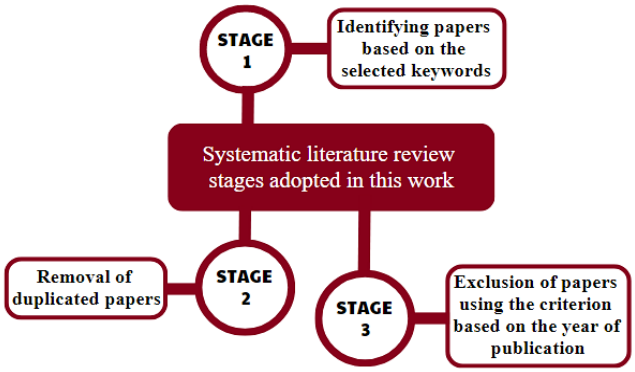

Fig. 3: Representative flowchart of the research bibliographic process carried out during this review work.

The first stage consisted of searches for scientific articles based on the keywords of this work, Internet of Things, Knowledge economy, Industry 4.0, New industrial age, and, thus, 57 papers were found at first containing the pre-established keywords this work. The second stage consisted of reading the abstract and excluding articles duplicate or not so aligned with the theme of this work. The third and last stage was defined through screening to select the articles most aligned with the main proposal of this research, always

prioritizing the latest manuscripts in relation to their years of publication to ensure the updating of the information compiled and recorded in this review work. Thus, 25 papers were selected from all those initially found in the research. Figure 4 shows the number of papers selected to form the reference base for this review work according to the year of its publications.

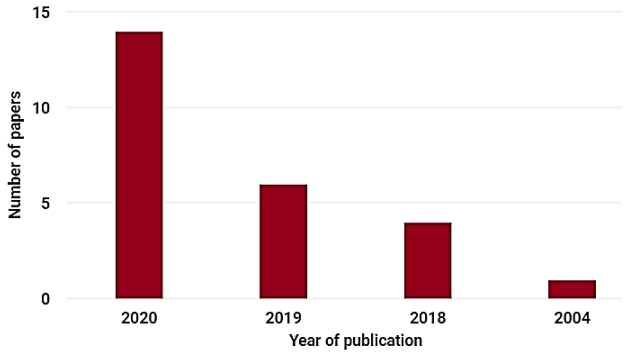

Fig. 4: Graphic profile representative of the reference base used for the construction of this literature review work.

V. CONCLUSIONS

The fourth industrial revolution could be seen as a digital revolution that will inevitably require the incorporation of a wide range of technological domains that will affect all spheres that constitute an industrial production organization. It is in this sense that IoT represents as one of the main pillars of Industry 4.0, being considered as a powerful tool that can exert only a complementary or totally transforming influence in the industrial scenario, depending on where and how it is applied.

The advent of the new industrial age will inevitably face all industries, sooner or later, a need to adapt to a totally digital reality that will bring with it new or unknown challenges for peculiar or mandatory issues of industrial daily life. And that is where the importance of the Knowledge Economy comes in, offering support in order to bring solutions to face such challenges.

In this context, the knowledge economy proves to be one of the main pillars of support for industrial organization in the face of market competitiveness, in addition to being a source of economic growth because it represents a non-consumable immaterial resource, it proves to be a driving force for guarantee the advancement of technological innovations.

The conviction that the employability of qualified professionals will always be guaranteed in the scenario of Industry 4.0 is linked to the strong and irreplaceable meaning that intellectual or human capital represents for a knowledge-based economy.

Finally, although the terms IoT and Knowledge Economy are not yet commonly seen in the literature as interconnected or codependent terms, the information compiled in this systematic research showed that there is undoubtedly a close relationship between these two terms, terms that can be considered as two strong pillars of support for Industry 4.0; however, they are not the only pillars of support within this theme or context.

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