GOVERMENT INITIATIVES 4.0: A COMPARISON BETWEEN INDUSTRIAL INNOVATION POLICIES FOR INDUSTRY 4.0

INICIATIVAS GOVERNAMENTAIS 4.0: UM COMPARATIVO ENTRE AS POLÍTICAS DE INOVAÇÃO INDUSTRIAL PARA A INDÚSTRIA 4.0

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Recebido em: 25 de setembro de 2020
Aprovado em: 28 de novembro de 2020
Sistema de Avaliação: Double Blind Review
RGD | v. 18 | n. 1 | p. 119-147 | jan./abr. 2021
DOI:https://doi.org/10.25112/rgd.v18i1.2411

Revista Gestão e Desenvolvimento

e-ISSN: 2446-6875
p-ISSN: 1807-5436

ABSTRACT

In recent years, the fourth industrial revolution has attracted increasing attention around the world. However, efforts are still lacking to systematically review the state of the art of this new wave of industrial revolution. In the second decade of the 21st century, the rapid proliferation of technology and the intensification of global competition created a sense of urgency for governments of developed and developing countries to engage in a major industrial revitalization, leading to the global emergence of something generically known as Industry 4.0. These critical government programs are expected to dramatically alter the global structures of major industrial sectors. The World Economic Forum took the lead in discussing the Fourth Industrial Revolution, adding the issue to its 2016 agenda, and found that many governments were concerned about how to support their country's participation in the Fourth Industrial Revolution and were pursuing programs to support these efforts. Based on this context, this literature review aims to analyze global government initiatives, making a comparison between industrial innovation policies of Industry 4.0. Prisma methodologies were used to compose the final portfolio, which made it possible to find the most relevant works for the research. This study contributes to the clarification of innovation policies for the development of Industry 4.0, presenting to emerging economies that it is essential to develop policies that guide the direction of revitalization of the development of industry using demand-side policies. Thus, the study presents how through good governance, the Fourth Industrial Revolution can better promote sustainable development that meets the needs of the present without compromising its capacity to meet the needs of future generations.

Keywords: Fourth Industrial Revolution. Industry 4.0. Industrial innovation policies. Government initiatives.

RESUMO

Nos últimos anos, a quarta revolução industrial atraiu cada vez mais atenção em todo o mundo. Entretanto, ainda faltam esforços para revisar sistematicamente o estado da arte dessa nova onda da revolução industrial. Na segunda década do século XXI, a rápida proliferação da tecnologia e a intensificação da concorrência global criaram um senso de urgência para que governos de países desenvolvidos e em desenvolvimento se engajem em uma grande revitalização industrial, levando ao surgimento global de algo genericamente conhecido como Indústria 4.0. Espera-se que esses programas críticos do governo alterem drasticamente as estruturas globais dos principais setores industriais. O Fórum Econômico Mundial assumiu a liderança na discussão da Quarta Revolução Industrial, acrescentando a questão a sua agenda de 2016, e constatou que muitos governos estavam preocupados em como apoiar a participação de seu país na Quarta Revolução Industrial e estavam perseguindo programas para apoiar esses esforços. Com base nesse contexto, esta revisão de literatura tem como objetivo analisar as

Revista Gestão e Desenvolvimento

e-ISSN: 2446-6875
p-ISSN: 1807-5436

iniciativas governamentais globais, realizando um comparativo entre as políticas de inovação industrial da Indústria 4.0. Para composição do portfólio final, foi utilizada a metodologia PRISMA, que possibilitou encontrar os trabalhos mais relevantes para a pesquisa em relação à temática. Este estudo contribui para o esclarecimento sobre as políticas de inovação para o desenvolvimento da Indústria 4.0, apresentando para as economias emergentes que é fundamental desenvolver políticas que orientem a direção da revitalização do desenvolvimento da indústria usando políticas do lado da demanda. Evidenciando assim a importância da assistência do Estado e considerar como por meio da boa governança, a Quarta Revolução Industrial pode promover melhor o desenvolvimento sustentável que atenda às necessidades do presente sem comprometer sua capacidade de atender às necessidades das gerações futuras.

Palavras-chave: Quarta Revolução Industrial. Indústria 4.0. Políticas de inovação industrial. Iniciativas governamentais.

Revista Gestão e Desenvolvimento

e-ISSN: 2446-6875
p-ISSN: 1807-5436

1 INTRODUCTION

With the evolution in the field of manufacturing, science, technology and the Internet, manufacturing intelligence has become an important measure of response to rising labor costs and changing consumption habits, continuously supporting the development of industrialization worldwide. Although it is in its initial stage, Industry 4.0 announces a transformation in traditional business models and manufactures. In general, Industry 4.0 is defined as a system that covers several interactive and integrated subsystems, the result of a new industrial revolution (KUO; SHYU; DING, 2019).

Although there is still no universal agreement on what constitutes this new industrial revolution, technological evolution is seen as four commonly identified stages (KAGERMANN; WAHLSTER; HELBIG, 2013a). The first revolution is characterized by the introduction of mechanical facilities for the manufacture of water and steam, the second describes the application of electrically driven mass production technologies from the division of labor. The use of electronics and information technology (IT) that support additional manufacturing automation characterizes the third revolution. Finally, the use of the Internet of Things (IoT) and Cyber-Physical Systems (CPS) according to Khaitan and McCalley (2014) design the new industrial revolution. The term Industry 4.0 arose in the context of an innovation policy that according to Borrás and Edquist (2013) is defined by the combination of advanced technologies, where the Internet is widely used to support other technologies, such as the integration of intelligent machines, humans, physical objects, throughout the organizational value chain (SCHUMACHER; EROL; SIHN, 2016; TAY et al., 2018).

Soltovski et al. (2020) affirm that the concept of industry 4.0 is a topic that is on the rise both in the academic environment and in an industrial context, which is a more practical context for companies. Da Silva and Olave (2020) point out that Industry 4.0 has been transforming production systems through the digitization of processes as well as its business models, and also through automation, disseminating the use of technologies associated with Industry 4.0.

Often, the prospects for improvement in Industry 4.0 are discussed by companies, especially in terms of productivity, flexibility and efficiency. CPS are enabling technologies that enable multiple innovative applications in organizational business models. CPS are regulated to the extent of their integration with human actors and other devices, both locally and globally (SENDLER, 2009; REISCHAUER; LEITNER, 2016; REISCHAUER, 2018 2009).

In this evolutionary perspective, the recent literature on Schwab's fourth industrial revolution (2017) explores how quickly scientific discoveries in general are reshaping economies and societies and whether government policies and interventions are keeping up with rapid technological advances to take advantage of opportunities to achieve inclusive economic growth, in addition to digital technologies (LELE;

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e-ISSN: 2446-6875
p-ISSN: 1807-5436

GOSWAMI, 2017). Innovations are essential for an effective introduction in the era of the Fourth Industrial Revolution, so many countries have put forward plans to boost industrial innovation, which differ from country to country (KAGERMANN; WAHLSTER; HELBIG, 2013b; KUO et al., 2019).

However, corporate leaders cannot easily determine innovative initiatives because they are time-consuming, costly and likely to fail, which is called a "leadership gap" (YANG; KIM; YIM, 2019). Innovation is a major driver of the development of national science and technology, but the risks are high due to uncertain return on investment rates, mainly related to high-tech products. The implementation of policies for the progress of science and technology not only affect the scientific and technological development and the industrial environment of a country, but also speed up the formation of national industrial competitiveness (KUO et al., 2019). Government policies for industrial innovation can reduce business difficulties (BRIEF, 2014; DUTTA; LANVIN; WUNSCH-VINCENT, 2015) and thus corporate leaders can strengthen their leadership skills to take risks and innovate (YANG et al., 2019).

However, it is notorious that the adoption of advanced technologies can be more challenging for emerging countries (KUMAR; SIDDHARTHAN, 2013; MUKKAMALA et al., 2015), due to the historical concentration in the extraction and marketing of commodities by companies in these countries, causing a delay in terms of technology adoption when compared to developed countries (CASTELLACCI, 2008). Other factors such as ICT infrastructure, culture, level of education, economic and political instability can also interfere with the perception of value and the consequent level of investments in advanced technologies (DALENOGARE et al., 2018; FRANK et al., 2016).

There are still few farms to elucidate how policymakers in developing countries are responding to the technological revolution and affecting prospects for inclusive growth (LELE; GOSWAMI, 2017). The literature on industrial revitalization for Industry 4.0 is mainly focused on the development of industrial technology, business models, market analysis and case analysis, and mostly deal with initiatives from developed countries. Lee, Bagheri and Kao (2015) note that recent advances in the manufacturing industry have paved the way for the deployment of CPS, within which information from all related perspectives is closely monitored and synchronized between the physical factory floor and the national computational cyber space (KUO et al., 2019).

Therefore, the objective of this work is to analyze the global governmental initiatives, making a comparison between the industrial innovation policies of Industry 4.0. To achieve the proposed objective, the aim is to answer the following questions:

(1) What is the global perspective on industrial innovation initiatives related to Industry 4.0?

(2) What are the conditions of emerging countries in the face of the development of the Fourth Industrial Revolution?

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e-ISSN: 2446-6875
p-ISSN: 1807-5436

In this context, this study examined the innovation policies involved in the implementation and development of Industry 4.0, summing up how governments prioritize their innovation policies to fulfill the vision of industrial innovation.

The rest of this article is organized as follows: Section 2 presents the systematic method of literature review; Section 3 illustrates the main governmental initiatives identified in the literature. Later, section 4 discusses how industrial innovation policies affect emerging countries. Finally, the main conclusions of this article are presented.

2 METHODS AND PROCEDURES

To ensure that all papers can be consistently evaluated with less subjective opinions, explicit criteria for inclusion and exclusion of collected documents should be clearly outlined. Thus, for the selection of the portfolio of articles of this work, we chose to use the PRISMA methodology, as can be seen in Figure 1 the four steps of research filtering, together with their subsets were described.

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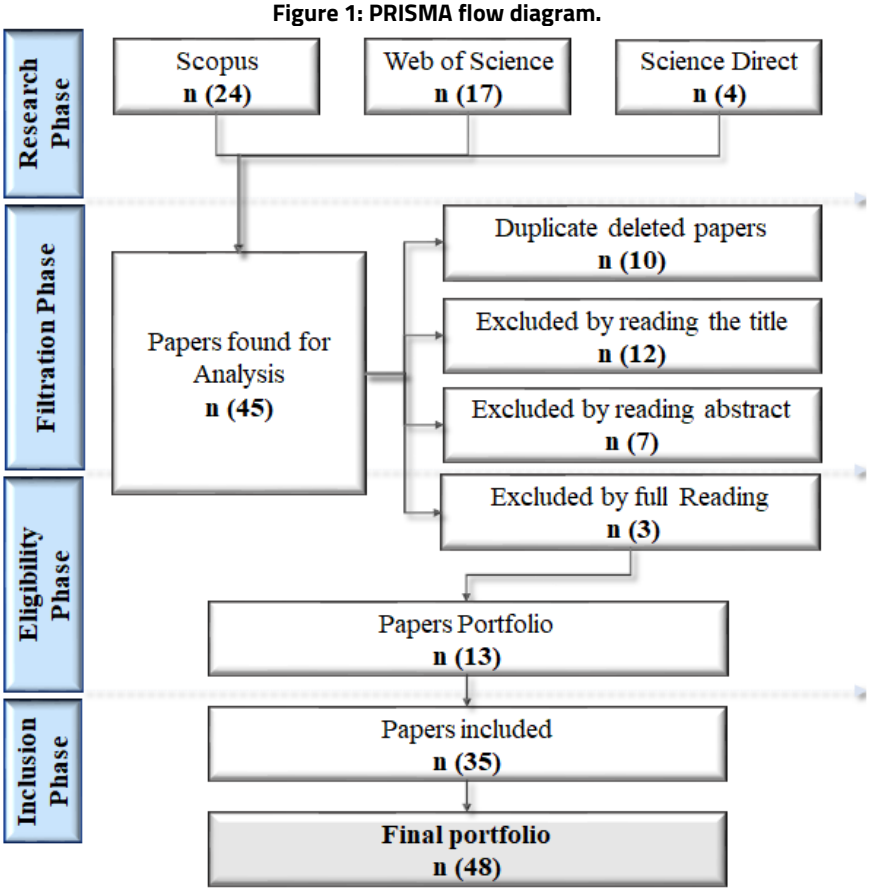
e-ISSN: 2446-6875
p-ISSN: 1807-5436

Figure 1: PRISMA flow diagram.



Source: Adapted from Moher et al. (2009).

For the research phase, the terms "Industry 4.0", "government initiative" and "industrial innovation polic" were used, as well as their possible variations. The databases used were: Scopus (SC); Web of Science (WoS) and Science Direct (SD), these were selected because they are considered as the main bases used internationally in similar studies, showing the most complete in terms of collection of scientific publications and provided a great combination of variables (ABATECOLA; MANDARELLI; POGGESI, 2013). The search was done in the databases, limiting the results to articles whose terms appear in the title, abstract or keywords in scientific literature articles, journal articles and conference articles, during the period 2009-2019, as Table 1 presents.

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e-ISSN: 2446-6875
p-ISSN: 1807-5436

Table 1: Search Results.

Keywords	SC	WoS	SD	Total
("government initiativ*" OR initiatives OR government OR politic* OR policy OR "industrial innovation policy") AND ("Industry 4.0" OR "Industrie 4.0" OR "Smart Factory" OR "Smart Industry" OR "4th industrial revolution" OR "Fourth industrial revolution")	24	17	4	**45**

Source: Authors (2020).

According to the PRISMA methodology, in the filtering stage the articles were excluded regarding duplication, reading titles and abstracts, providing a range of documents relevant to the second stage, the eligibility phase, where the articles were read in full. This phase allowed the exclusion of articles that did not fit the scope of the research. During the reading phase, references pertinent to the study were identified, which were added to the systematic literature review portfolio, completing the inclusion phase.

The methodology involved a systematic research, where the various initiatives and government programs focused on technology and innovation were analyzed, to provide an overview of existing research and contributions in the literature, the selected works are studied under the lens of content analysis, to compile the innovation policies of Industry 4.0. The results were based on the codification of the text, the frequency of the words and the relation of the words.

3 RESULTS

In view of the need for faster and more efficient manufacturing, investment in policies for the dissemination of the concept of Industry 4.0 by countries whose goal is innovation, development and competitiveness, becomes increasingly important (KUO et al., 2019). The following will explain how these policies are and the countries that invest the most in this issue. With this, it will be pointed out how much the countries invest in this new standard and their life of how their industries are ready for Industry 4.0.

The top three global manufacturing exporters are China, Germany and the USA. China ranks first, but its wages and energy costs are increasing substantially. Germany ranks second, even with a much higher manufacturing cost than other countries. The U.S. has the advantage of lower energy costs, productivity and only a small increase in labor pay. Therefore, overall manufacturing costs compared to China are almost the same and gradually threaten China's leading position (KUO et al., 2019).

This new industrial revolution offers scope for many basic ideas that have been widely implemented in many other countries. Internationally, many governments have noticed the trend and have taken steps

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e-ISSN: 2446-6875
p-ISSN: 1807-5436

to specifically react to the impact that Industry 4.0 would have on the manufacturing industry (TAY et al., 2018). Some of the government's plans are presented in the following topics.

3.1 GERMANY

In 2006, Germany launched an action plan known as "High-Tech Strategie", being the first national concept to bring together the main stakeholders in innovation and technology in a common goal of promoting new technologies. Approved in 2012, this project grants billions euros each year to develop the latest technologies in the manufacturing industry (LIAO et al., 2017).

In 2013, Germany promoted Industry 4.0 (Kagermann et al., 2013a), hoping to develop a new generation of integrated virtual reality manufacturing technology and maintain Germany's advantages in the global manufacturing sector (KUO et al., 2019).

Since 2013, the Industry 4.0 working group, composed of Siegfried Dais of Robert Roberts GmbH and Kagermann of the Academy of Sciences Leopoldina, advised the German federal government on the implementation of INDUSTRIE 4.0 (Kagermann et al., 2013a), formed under the influence of the German academy and industry.

Based on the manufacturing industry in Germany, the introduction of the Internet of Things and service-oriented thinking in the manufacturing industry, and the creation of CPS associated with resources, information, goods and people, triggered the fourth industrial revolution (KUO et al., 2019).

In 2013, Germany updated its INDUSTRIE 4.0 strategy for the "Industrie 4.0 Plattform" strategy and is supporting the construction of the "Cyber Physical System" (CPS) (YANG et al., 2019). Also in 2013, Kagermann et al., (2013a) published the main ideas of the fourth industrial revolution to build the basis of the Industry 4.0 manifes. The study was published by the German National Academy of Science and Engineering in 2013. The "Public-Private Partnership" (PPP) for "Factories of Future" (FoF) has implemented and initiated discussions on related topics of Industry 4.0 at the European level (TAY et al., 2018).

Directed by the German Academy of Engineering, Fraunhofer Association, Siemens and other Universities and Industries, the Federal Ministry of Education and Research and the Federal Ministry of Economics and Technology included INDUSTRIE 4.0 (Kagermann et al., 2013a) as one of the 10 prospective projects of education and research 2020. The INDUSTRIE 4.0 project received funding of up to EUR 200 million under the "2020 High Technology Strategy Action Plan" (KUO et al., 2019).

In November 2015, Germany released the second version of the RAMI4.0 standard, which not only became a German standard of the Institute for Standardization, but also reported to the International Electrotechnical Committee, actively promoting the establishment of digital product standards and emphasizing the importance of execution.

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e-ISSN: 2446-6875
p-ISSN: 1807-5436

Second, a German standardization script INDUSTRIE 4.0 version 2 was developed and, at the same time, the demonstration map of the implementation of INDUSTRIE 4.0 was released, which recorded a total of 202 demonstration projects oriented to INDUSTRIE 4.0 (KUO et al., 2019).

3.2 EUA

In 2011, to ensure that the United States of America (USA) was well prepared for the next generation of industrial revolution, U.S. President Barack Obama initiated a series of actions, discussions and recommendations at the national level, entitled "Advanced Manufacturing Partnerships" (AMP) (SWENSON, 2015). This initiative was undertaken to make more USA industries ready to invest heavily in advanced technology. In October 2014, the U.S. launched AMP2.0, hoping to continue promoting innovation, personnel training, and industrial environment modeling (KUO et al., 2019).

From the industrial plans, AT&T, Cisco, General Electric, IBM and Intel founded the Industrial Internet Consortium (IIC) in 2014 to catalyze and coordinate the priorities and enabling technologies of the Industrial Internet (EVANS; ANNUNZIATA, 2012). Meanwhile, other major industries such as Siemens, Hitachi, Bosch, Panasonic, Honeywell, Mitsubishi Electric, ABB, Schneider Electric and Emerson Electric have also invested heavily in projects related to IoT and CPS (LIAO et al., 2017).

In December 2014, Congress approved the Revitalize American Manufacturing and Innovation (RAMI), which instructed the Secretary of Commerce and management to establish the Manufacturing Innovation Network Program, often called the NNMI Program. NNMI is the program for coordinating public and private investments to improve the competitiveness and productivity of USA manufacturing by creating a robust network of manufacturing innovation institutes (KUO et al., 2019).

Due to the migration of American manufacturing industries to China, which has led to an increase in the unemployment rate in the USA, the US government is currently adopting an aggressive policy to support the new manufacturing development path and ensure the ability to innovate and invent in the USA, promoting the "Made in the USA" brand and offering high quality and well-paid work opportunities to the USA workforce (KUO et al., 2019).

3.3 CHINA

In 2015, the State Council of China released its first national 10-year plan to transform manufacturing, entitled "Made in China 2025". This initiative aims to increase manufacturing innovation and promote the deep integration of IT and industrialization. The plan presents advances in 10 important technological sectors, including new generation information technology, digitally controlled machine tools and robots,

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e-ISSN: 2446-6875
p-ISSN: 1807-5436

aviation and aerospace equipment and others. China has also announced the "Internet Plus" Initiative to boost its Internet-based economy (YANG et al., 2019).

"Made in China 2025" is to pursue the three-step strategy to achieve the manufacturing power goal. The first step is to move China from a large industrial country to a strong country by 2025. Mastery of several key areas of core technology will further increase competitive advantage in various fields and product quality will greatly improve. There will also be significant progress in digitizing the manufacturing industry, making it more networked and intelligent (YANG et al., 2019).

By 2025, the overall quality of the manufacturing sector is expected to be significantly increased, innovation capacity significantly increased, overall labour productivity significantly improved and the integration of industrialisation and computerisation will reach a new level. The next step is to empower China to compete with the manufacturing powers developed by 2035. Finally, China aims to become a leading manufacturing power by 2045 through the world's leading industrial systems and technology systems (KUO et al., 2019).

However, China's development depends on the full implementation of the integration of industrial processes and systems and a robust structure for the development of multi-layered talent. The measures taken in this regard will facilitate China's transformation from a manufacturing giant with a focus on quantity to one with a qualitative advantage (Kuo et al., 2019).

3.4 JAPAN

In 2013, Japan launched an industry revitalization plan, hoping to make Japan the most suitable environment for industries to carry out service activities. From the promotion of investments in equipment and research and development, it aims to revitalize the Japanese manufacturing industry (KUO et al., 2019).

In 2015, the Japanese government adopted the 5th Basic Science and Technology Plan, in which special attention was paid to the manufacturing sector for holding its "Super Smart Society" or Socity 5.0, a world leader (LIAO et al., 2017).

Japan has established a "Future Vision 2030" plan, which includes specific technology strategies for mobility, supply chain, healthcare and living technologies. "Future Vision 2030" includes seven strategies to establish new economic and social systems, more sophisticated rules, innovation ecosystems, economic rejuvenation systems, development systems, human resources use, social security systems, regional SME systems (small and medium-sized enterprises), and companies abroad (YANG et al., 2019).

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p-ISSN: 1807-5436

3.5 FRANCE

In 2013, the French government launched *'La Nouvelle France Industrielle'*. This programme prioritized 34 sectoral forms in France's industrial policy. French startup 2B1st Consulting introduced a collaborative digital tool in Hannover Messe designed to help industries implement Industry 4.0 solutions (TAY et al., 2018).

3.6 UNITED KINGDOM

The United Kingdom (UK) has been promoting high-value manufacturing strategies since 2012, arguing that high-value manufacturing is the leading technology used in the creation of products, manufacturing processes and social services (KUO et al., 2019). In 2013, a long-term action plan for the manufacturing industry in the UK called "Future of Manufacturing" was implemented. This program reoriented and rebalanced policies to support manufacturing resilience through 2050 (FORESIGHT, 2013). In 2018, Rolls-Royce partners with the Alan Turing Institute to explore how Artificial Intelligence (AI) and analysis can be applied at scale to supply chains and predictive maintenance regimes (TAY et al., 2018).

3.7 EUROPEAN UNION

In 2010, the European Union started the development of the Digital Agenda for Europe programme. In 2016, the Eurasian Economic Commission presented a programme for the development of the digital industry "Digital Single Market - Digitizing European Industry: Questions and Answers", to disseminate technological knowledge (ASATUROVA, 2019).

In 2014, the European Commission adopted a new contractual publication for PPP and FoF. A total of almost €80 billion of funding for the 7 consecutive years from 2014 to 2020 will be provided for the Horizon 2020 programme. In 2018, the European Commission announced a new series of measures to put artificial intelligence (AI) at the service of citizens and increase Europe's competitiveness in the field, with a budget of €20 billion by the end of 2020 (TAY et al., 2018).

3.8 KOREA

In 2014, the South Korean government announced "Innovation in Manufacturing 3.0", which emphasized four propulsion strategies and assignments for a new leap in Korean manufacturing (KANG et al., 2016; LIAO et al., 2017). As a result, Hyundai has developed a new autonomous car, the Hyundai Genesis, capable of tracking moving objects, avoiding collisions, driving on narrow roads and recognizing traffic lights and speed limit signs (TAY et al., 2018).

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p-ISSN: 1807-5436

The Korean government is considering the role it will play in the era of the Fourth Industrial Revolution, helping industries promote innovative activities. Technological innovation can induce sustainable growth and therefore tries to support the creation of new markets and jobs through technology-based innovations. It is important in Korea for the government to provide personalized support to companies facing difficulties in the transition from industrialization to technological development (Phaal et al., 2011). As part of these efforts, the Korean government developed the Flagship Project Support Program (FPSP), aimed at supporting small and medium-sized enterprises in promising technology fields (YANG et al., 2019).

3.9 INDIA

India is struggling with the revolution in terms of public policy and public-private partnerships and NGOs to elevate its development effort, particularly in agriculture and rural development. The success stories of individual Information and Communication Technology (ICT) interventions in agriculture are plentiful (LELE; GOSWAMI, 2017).

The Indian government and public-private partnerships are developing and disseminating a staggering number of innovative networked solutions, widely known as the Digital India Initiative, to increase the efficiency of safety nets and worker productivity and quality of life (LELE; GOSWAMI, 2017). The Government of India is connecting 2.5 million panchayat to high-speed Internet by 2018.

IT experts note that the Indian software industry must adjust to the fourth industrial revolution. There is enormous potential for the software industry to exploit India's large agricultural and non-agricultural sectors. While both sectors have more limited purchasing power than multinational customers, with improved management of the Corporate Social Responsibility Policy Act 2013–2014, IT can be a boon to India's rural poor. The law requires that 2% of corporate profits be dedicated to social causes (LELE; GOSWAMI, 2017).

3.10 MALAYSIA

In Malaysia, the government acted aggressively, making several efforts to help industry participants adopt Industry 4.0 by implementing automation and smart manufacturing. In the 2017 budget, the government highlighted several new incentive packages to accelerate the growth and adoption of the manufacturing industry and industry 4.0 in Malaysia. For example, Supermax Corporation Bhd, which was a glove manufacturing industry that under automation and Industry 4.0 in manufacturing, remains supported by the government from incentive programs to stimulate industry growth (TAY et. al., 2018).

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Former Malaysian Prime Minister Datuk Seri Najib Razak has initiated the government's plan to help develop Industry 4.0 in the future by increasing workforce resources. Under this program, the government allocated 50 million RM to improve the caliber and competitiveness of the workforce to help the nation's economic development. This budget is allocated from 30% of the funds of the Human Resources Development Fund (HRDF) specifically for the purposes of TVET (TAY et al., 2018).

3.11 SINGAPORE

In 2016, the Government of Singapore launched its RIE 2020 Plan (Research, Innovation and Business) with a budget of $19 billion. The field of advanced manufacturing and engineering identified eight important vertical sectors for the Plan. In 2018, Singaporean companies are developing machines that can help make small adjustments to fully automate hydroponic farms and maximize crop yields (TAY et al., 2018).

3.12 INDONESIA

In Indonesia, Pancasila-based citizen intelligence1 is critical to the nation's integration and progress. Adopting the development of a people-based economy, based on its four pillars of Pancasila, it seeks to regain the mentality that Indonesia is an agricultural country and promotes sustainable development from which it will reduce poverty and begin to build the next generation (ANGGUSTI, 2019). During the Industrial Revolution, the concern was with the inhuman effects of work. On the other hand, today's greatest fear may be the elimination of one's own work as a source of dehumanization, income insecurity, declining social agency and increased crime.

While digital startups are becoming more productive around the world, Indonesia still lacks an entrepreneurial workforce that can truly take advantage of new technologies and ways of doing business. Education related to the fourth industrial revolution is still evolving and is rarely seen in schools (ANGGUSTI, 2019).

3.13 TAIWAN

The Taiwanese government developed the Strategic Program and Productivity 4.0 policy in reference to Germany's INDUSTRIE 4.0 plan to help upgrade the manufacturing industry (KUO et al., 2019; WANG, 2015).

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3.14 RUSSIA

The Russian market for the introduction of the industrial Internet is at the early stage of its development (ASATUROVA, 2019). In 2015, its share was 64%, while the intersectoral segment was 20% and the state and consumer segment was about 8%. This indicates good prospects for the development of industrial Internet technologies in Russia. The total number of IoT devices will have increased to 79.5 million in 2021 and to 164.7 million in 2026. The widespread introduction of the industrial Internet will increase global GDP by $10 trillion to $15 trillion in 20 years (ASATUROVA, 2019; IDRISOV et al., 2018).

The creation of an industrial Internet development strategy in the Russian Federation currently involves public and state industries such as the Russian Ministry of Industry and Commerce. The development of a roadmap for the development of the Internet of Things with the participation of the "nternet Initiatives Development Fund", or Development of Internet Initiatives Fund (IIDF) (ASATUROVA, 2019).

3.15 SOUTH AFRICA

While the South African government has policies, programs and strategies developed by science and technology departments and NACI that lean toward innovation and advanced manufacturing, there is no specific focus and direction for the impending Industry 4.0 (MUKWAWAYA; EMWANU; MDAKANE, 2018).

In existing policies, technological advances are discussed predominantly in the traditional sense of Industry 3.0 without incorporating Industry 4.0 in any way. AMTS doesn't even come close to defining a manufacturing vision that has Industry 4.0 at its core (MUKWAWAYA et al., 2018).

According to the World Economic Forum report released in 2016, South Africa needs to invest more in improving productivity, creating technological readiness in the economy. Thus, the government needs to adequately plan the eventuality of Industry 4.0, increasing participation in technological advances (MUKWAWAYA et al., 2018).

3.16 BRAZIL

In Brazil, the program "Towards Industry 4.0" was created in 2017 by the Brazilian Agency for Industrial Development (ABDI), together with other initiatives of the Ministry of Industry, Foreign Trade and Services (MDIC - Ministry of Industry, Foreign Trade and Services) (ABDI, 2017).

In the Brazilian industry, investments in software acquisition have not led to good results in terms of market benefits or internal improvement of the manufacturing process. The authors suggest that companies are investing in software acquisition simply to automate their operational routines, rather than

Revista Gestão e Desenvolvimento

e-ISSN: 2446-6875
p-ISSN: 1807-5436

looking for advanced ICT tools that can give them a real competitive advantage in the development of innovation (FRANK et al., 2016; DALENOGARE et al., 2018).

However, despite the low level of digitization, Brazilian industries expect greater investments in digital technologies for the coming years, with a return on efficiency improvement, reduced operating costs and additional commercial revenue (COOPERS, 2016). Another important source of information is the industrial research conducted by the National Confederation of Industry of Brazil (CNI, 2016), where a set of technologies related to Industry 4.0 was considered and analyzed in the Brazilian industry.

The level of implementation is still low, but that there are already some industrial sectors investing in these technologies and that an important part of the industry is concerned about this problem and expects new benefits from these investments (DALENOGARE et al., 2018).

Other European countries, such as Austria, France, Italy, Switzerland and the United Kingdom, followed Germany's example and created platforms, as well as funding programmes that use exactly the same German label (REISCHAUER, 2018).

In summary, the government plans cited above show that developing countries are significantly focused on advancing technologies and the fact that industry 4.0 can bring many positive impacts to a nation's development. As the physical world, the biological world and the digital world continue to converge, advanced technologies and phases will provide opportunities for citizens to interact with their government and express their opinions and even circumvent the supervision of oppressive public authorities (TAY et al., 2018). Figure 2 summarizes industrial innovation policies around the world.

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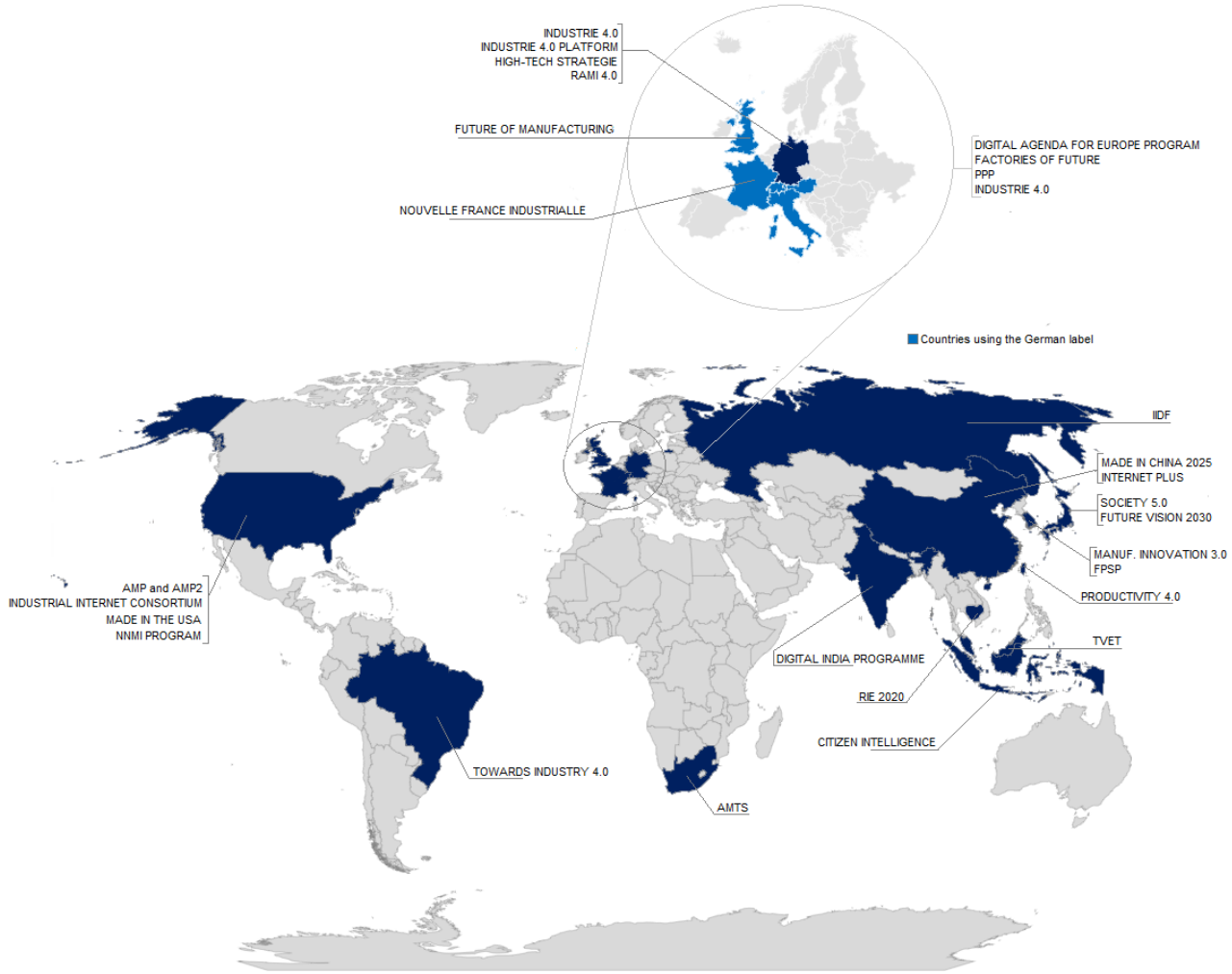
p-ISSN: 1807-5436

Figure 2: Global Government Initiatives for Industry 4.0.



Source: Authors (2020).

Based on the sub-topics mentioned above, the importance of government initiatives that support the technological development of their countries is evident. The investment, mainly in training the population and acquisition of technologies in the context of Industry 4.0 helps in the preparation of industries for this new paradigm, becomes a differential in relation to other countries with less investment in this sector (ARBIX et al., 2018; WOBETO et al., 2018).

With this it is necessary to present how initiatives of each government assists in the preparation of industry. To this end, Figure 3 presents a comparison between the countries presented above, taking into account investments, technologies and levels of industrialization.

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Figure 3: Comparison between countries considering Investment, Technologies and Industrialization Level.

Countries	Economic Development	Human Development	Industrial Development	Investment in Industry 4.0 (dollar)	Enabling Technologies cited in the analyzed papers	Industries at the level of industrial revolution
USA				$ 496.000.000.000,00	IoT, CPS, IoS, BD, Cloud, RA, MA, Robots, Simulation, AI, Cybersecurity, Machine Learning	1.0 2.0 3.0 4.0
China				$ 369.000.000.000,00	IoT, CPS, BD, Cloud, IA, Cybersecurity, Machine Learning, Robots	1.0 2.0 3.0 4.0
Japan				$ 194.880.000.000,00	IoT, IoS, CPS, BD, Cloud, IA, Security, Cyber Robots, Machine Learning	1.0 2.0 3.0 4.0
Germany				$ 36.042.467.500,00	IoT, CPS, IoS, BD, Cloud, RA, MA, Robots, Simulation, AI, Cybersecurity, Machine Learning	1.0 2.0 3.0 4.0
United Kingdom				$ 22.179.980.000,00	IoT, IoS, CPS, BD, Cloud, IA, Cybersecurity, Machine Learning, Robots, Simulation,	1.0 2.0 3.0 4.0
France				$ 18.000.000.000,00	IoT, CPS, BD, Cloud, IA, Cybersecurity, Machine Learning Robots, Simulation,	1.0 2.0 3.0 4.0
Brazil				$ 3.502.381.500,00	IoT, IoS, BD, Cloud, Cybersecurity, MA, Simulation	1.0 2.0 3.0 4.0
Singapore				$ 1.900.000.000,00	IoT, IoS, BD, Cloud, Cybersecurity	1.0 2.0 3.0 4.0
Russia				$ 79.500.000,00	IoT, CPS, BD, Cloud, IA, Cybersecurity, Machine Learning	1.0 2.0 3.0 4.0
Malaysia				$ 50.000.000,00	IoT, IoS, BD, Cloud, Cybersecurity	1.0 2.0 3.0 4.0
India				$ 32.000.000,00	IoT, IoS, BD, Cloud, Cybersecurity	1.0 2.0 3.0 4.0
Korea				$ 15.000.000,00	IoT, IoS, BD, Cloud, Cybersecurity	1.0 2.0 3.0 4.0
South Africa				-	IoT, IoS, BD, Cloud, Cybersecurity	1.0 2.0 3.0 4.0

((CNI), 2014; (US), 2014; ABDI, 2017; Adolph et al., 2016; ARBACHE, 2014; Arbix et al., 2018; Asaturova, 2019; Basseto, 2019; Both & Müller, 2018; Dalenogare et al., 2018; Kang et al., 2016; Kiel, Müller, Arnold, & Voigt, 2017; Kuo et al., 2019; Liao et al., 2017; Tay et al., 2018; WOBETO et al., 2018; Yang et al., 2019)

Subtitle
Very high
High
Medium
Low
Very low
Null

Source: Authors (2020).

It can be observed in Figure 3 that developed countries, with the exception of China, have a more advanced level in relation to digitization, this is due to the greater availability of investment in technologies. It can also be observed that the number of industries considered 4.0 is low, which indicates the need to prepare industries 3.0 to advance technologically.

It is also noticed that in emerging countries there are still a significant amount of industries equivalent to the first and second industrial revolution, because they are artisanal works and the absence of internet. To elucidate the disparity between these countries the following topic presents how emerging countries are treating Industry 4.0.

4 DISCUSSIONS

In the Fourth Industrial Revolution, emerging technologies and broad-based innovation are spreading much faster and more widely than in previous ones, which continue to develop in some parts of the world. The Second Industrial Revolution has not yet been fully experienced in different regions of the world, due to the fact that people still do not have access to electricity. This also applies to the Third

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Industrial Revolution, mainly to emerging countries, where millions of people still do not have access to the Internet (ANGGUSTI, 2019).

The experiences of advanced countries show that the most favorable conditions for industry innovation are a democratic society and well-developed national innovation systems (SHYU; CHIU, 2002). The objective of government intervention is to actively promote the dissemination of scientific and technological knowledge, maintaining the proper functioning of the market economy and innovation research. Governments can also adopt innovative policies to encourage regional economic cooperation, exchange and integration through cooperative competition mechanisms and decrees or establish regulations and institutions in accordance with general economic policy, trade policy, industrial development policy, educational policy, labor policy and industrial innovation policy, ensuring fair competition between companies (KUO et al., 2019).

Following this concept, Industry 4.0 was born in developed countries, where the previous industrial stages are already mature (KAGERMANN et al., 2013a) and can be seen as a matter of diffusion and adoption of technology. In this sense, emerging countries may face an important gap in the adoption of Industry 4.0 due to the low maturity of previous industrial stages (GUAN et al., 2006; KRAWCZYŃSKI; CZYŻEWSKI; BOCIAN, 2016; DALENOGARE et al., 2018). Therefore, different patterns of behavior can be seen when analyzing digital technologies in an emerging country compared to leading countries on this issue, such as Germany. Emerging countries may have a different perception of value from diffuse technologies (ALEKSEEV et al., 2018; LUTHRA; MANGLA, 2018), which may be based on different needs compared to developed countries (KAGERMANN; LUKAS, DIFIES; WAHLSTER, 2015; DALENOGARE et al., 2018).

As can be analyzed, despite being considered as an emerging country, China has been developing rapidly, with a full range of independent industrial systems, forming a strong impetus for the process of industrialization and modernization. However, compared to the world's advanced manufacturing levels, China's manufacturing industry is large but not yet strong, with significant gaps in independent innovation capacity, resource utilization efficiency, industrial structure and level, quality and efficiency of information (KUO et al., 2019). However, the social conditions of the population imply the commercialization of products, making price a more relevant factor in competitiveness than in innovation. Being can clearly influence investments in technology. Typically, companies in emerging countries are focused on investing in well-established technologies to increase productivity than on advanced technologies for product differentiation. Thus, the main pillars of Industry 4.0 still seem weak to advance towards the fourth industrial revolution in emerging countries (DALENOGARE et al., 2018).

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In addition, there are structural challenges that emerging economies can face and that can be a barrier to the establishment of Industry 4.0, such as: the growth of emerging economies; low-cost workforce; investments in automation (CASTELLACCI, 2008; RAMANI; THUTUPALLI; URIAS, 2017); less integrated supply chain (MARODIN et al., 2016; MARODIN et al., 2017); low investments in R&D (OLAVARRIETA; VILLENA, 2014); low quality of educational and research institutions (HALL; MAFFIOLI, 2008; CHRYSOSIS; LÓPEZ-ITURRIAGA; VALLELADO, 2011; FRANK et al., 2016; DALENOGARE et al., 2018).

Finally, based on this research, it is clear that the challenges for the adoption of Industry 4.0 technologies in emerging countries are different from developed countries (PHILLIPS; CALANTONE; LEE, 1994). As the concept of Industry 4.0 is relatively new, there is a high uncertainty and lack of knowledge about the real impact and contribution of technologies related to Industry 4.0 in the context of emerging countries in general (FRANK et al., 2016; DALENOGARE et al., 2018).

Scholars point out that science and technology policy can be used as a driving force to improve the innovation and development of a country, and from the structural mechanism and support system, to continue to support innovation activities (DODGSON et al., 2008). Innovation policy should be gradually taken seriously from the perspective of the national innovation system, although research indicates that national differences will affect innovation standards (DODGSON et al., 2011). Therefore, the government should formulate industry-related policies to help its smooth development (KUO et al., 2019).

To promote industry, the political tools adopted by the government may include the environmental side, the supply side and the demand side to comprehensively adjust the economic, political and regulatory environment or choose to change the international trade environment (KUO et al., 2019). Economists point out that successful innovation is a good combination of technology supply and market demand. In terms of research and development in science and technology, on the supply side, the process of developing new products depends on the following three factors at the appropriate level of investment: knowledge in science and technology and human resources; the necessary management of innovative market information techniques to ensure successful development, production and marketing; and third, financial resources. The Table 2 present examples for development for industrial innovation, while the Figure 4 shows how government policies affect industry innovation (KUO et al., 2019).

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Table 2: Government policy instruments for industrial innovation.

Layers	Political Tools	Examples
Supply layer	(1) Public company	Innovation by companies and state institutions, focusing on the development of new industries, pioneer in the use of new technologies, joint developments with private companies.
	(2) Scientific and technical development	Engagement in scientific and technical research, support to research institutes; development of the learning society; professional organisations; offering research grants in support of industrial innovation.
	(3) Education	Government support for education and training at all levels, including general education, higher education at university and graduate levels, vocational education, learning programs and continuing education.
	(4) Information service	Government support in developing business intelligence information networks for private companies, business centers, libraries, consulting and consulting services, cloud databases and connection services.
Environmental Layer	(5) Financial	Government support and subsidy to industrial innovation for specific projects, joint financial investments, equipment loans, third-party financing, loan guarantees and IPO assistance and export credits.
	(6) Taxation	Tax exemption and reductions for industrial innovation for specific projects, tax credits for P&D, capital gain tax exemption, personal tax deductions.
	(7) Regulation	Management of patents and intellectual property, regulatory agendas for environmental and health control, management of accreditation and certification, antitrust regulations and social justice supervision, awards and prices and development of protocol standards.
	(8) Politics	Strategic planning of national innovation programs, regional development policies and innovation awards, support for mergers and acquisitions and opinion consultancy and public consultancy for policy exploration, political and legal system for investments.
Demand Layer	(9) Shopping	Central or local government procurement and contracts, P&D contracts and technology transactions through government procurement.
	(10) Public services	Infrastructure and institutional developments in the development of science parks, facilitating market transactions, banking services, maintenance and management of diversity and applications of innovation, provision of services and health insurance, transportation and telecommunications, social transformation.
	(11) Commercial	Trade agreements, tariffs, exchange rate regulation, marketing, industrialization of innovation.
	(12) External Agent	Representation abroad for trade and international transactions, developing official organizations to support the internationalization of innovation.

Source: Adapted from Rothwell and Zegveld (1981).

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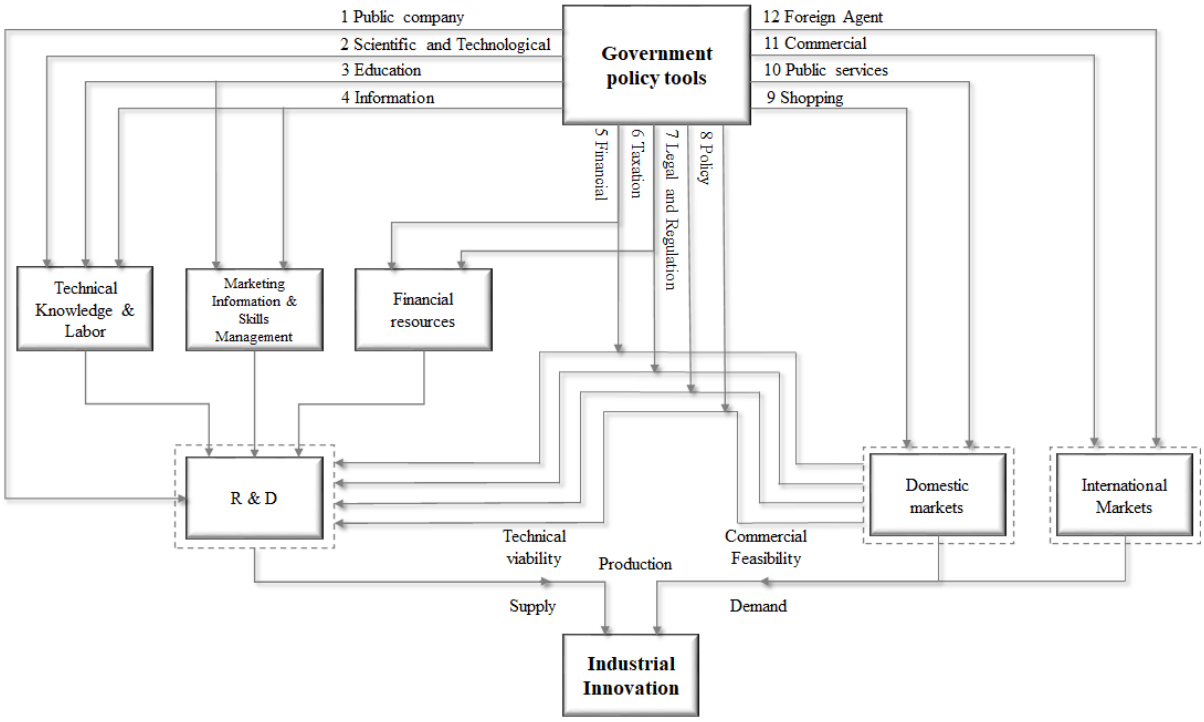
p-ISSN: 1807-5436

Figure 4: Political goals and tools to promote industrial innovation.



Source: Adapted from Rothwell e Zegveld (1981).

The new tools can generate extraordinary changes in the power of computing, connectivity, artificial intelligence (AI), biotechnology, robotics, the Internet of Things, autonomous vehicles, 3D printing, nanotechnology, materials science, energy storage, and quantum computing, which are changing the way it manufactures and lives. In addition, the fusion of different types of technologies is blurring the lines between the physical, digital and biological spheres. The fourth revolution has no borders; its high speed affects the way business is conducted by all companies, governments and individuals. The change also threatens to create more structural unemployment, particularly among unskilled workers in developed and developing countries. Through artificial intelligence and robotization, this revolution is expected to aggravate the situations that have already been left behind, potentially threatening the conventional liberal world economic order more than the forces of the anti-globalization movement, already manifested in Brexit and Trumpism (HAMMES, 2016; LELE; GOSWAMI, 2017).

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5 FINAL CONSIDERATIONS

Fundamental changes affecting the environment, economic, social and political systems are difficult to undo. The reality of rupture and the inevitability of impact drive political choices that seek to promote the changes that will make the Fourth Industrial Revolution an opportunity for all. Thus, the objective of this research was to review and analyze the progress of government initiatives on industrial innovation. presenting a comparative implementation of Industry 4.0 in developed and developing countries.

New technologies can be a tremendous driver of growth, equity and sustainability, but they do not replace human and institutional development. Its scope is vast, but its geographical application is still very limited. Access to technologies is unequal in emerging countries, some still do not have access to electricity (2nd Revolution) and internet (3rd Revolution). Insufficient connectivity and lack of basic computer and literacy knowledge hinder rapid regional development. Substantial investment in science and technology infrastructure is needed, as well as various measures, decrees and incentive standards that can encourage academia and the business community to conduct research and development, technology introduction and other activities.

The results show that national preferences for innovation policy differ in ways that are linked to the state of the manufacturing industry in these economies. The results suggest that political orientation tends to favor demand-side policies, public services, policies, education, training, scientific and technical development, and regulatory environmental policies. Based on this finding, Industry 4.0 policymakers can improve the implementation, results, and quality of their initiatives. Planning based on Industry 4.0 innovation policy should consider the temporal dynamics of such policies and try to mitigate disadvantages at each stage. By integrating this perspective into the revitalization of sector 4.0 policy planning, the necessary resources and possible outcomes can be optimized.

This study describes several innovation policies under development in Industry 4.0 initiatives and contributes to industry 4.0 policy research. In addition to contributing to a better understanding of innovation policies for the development of Industry 4.0, presenting to developing economies that it is essential to develop policies that guide the direction of revitalization of the development of industry, using demand-side policies. In addition to government agencies that can better prepare for challenges related to training and prior knowledge for the population in relation to Industry 4.0. The issue of inequalities between developed and developing countries in relation to technological development.

When considering the results of the present study, several limitations should be observed. First, the articles were collected in the largest database of abstracts and citations of the peer-reviewed literature (Scopus), along with only two other multidisciplinary databases (Science Direct and Web of Science)

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p-ISSN: 1807-5436

as supplements. From a completeness standpoint, this review could be more comprehensive if more databases.

As the concept of Industry 4.0 is relatively new, it is suggested for possible future work to conduct research to clarify the real impact and contribution of technologies related to Industry 4.0 in the context of emerging countries in general. Also carry out a technological development agenda comparing progress between the initiatives raised.

REFERENCES

ABATECOLA, G.; MANDARELLI, G.; POGGESI, S. The personality factor: how top management teams make decisions. A literature review. **Journal of Management & Governance**, v. 17, n. 4, p. 1073–1100, 2013.

ABDI, A. **Inovação, Manufatura avançada e o futuro da indústria: uma contibuição ao debate sobre as políticas de desenvolvimento produtivo**. 2017.

ADOLPH, L.; AMMON, E.; BAUSCH, U.; BECK, S.; BEDENBENDER, H.; BENTKUS, A.; WISCHMANN, S. **German standardization roadmap:** Industry 4.0. version 2. Berlin, Germany, 2016.

ALEKSEEV, A. N.; EVDOKIMOV, S. Y.; TARASOVA, A. Y.; KHACHATURYAN, K. S.; KHACHATURYAN, A. A. Financial strategy of development of industry 4.0 in the countries with developing economy. **Espacios**, v. 39, n. 12, 2018.

ANGGUSTI, M. Environmental policy in the wake of Indonesia's fourth industrial revolution. **Environmental Policy and Law**, v. 49, n. 2–3, p. 125–129, 2019.

ARBACHE, J. **Serviços e competitividade industrial no Brasil**. Brasília. 2014.

ARBIX, G.; MIRANDA, Z.; TOLEDO, D.; ZANCUL, E. Made in China 2025 e Industrie 4.0: a difícil transição chinesa do catching up à economia puxada pela inovação. **Tempo Social,** v. 30, n. 3, p. 143–170, 2018.

ASATUROVA, J. Peculiarities of development of industry 4.0 concept in Russia. IOP Conference Series: **Materials Science and Engineering**, v. 497, n. 1, p. 12039, 2019.

BASSETO, A. L. C. **Modelo de maturidade para a análise das indústrias no contexto da indústria 4.0.** Universidade Tecnológica Federal do Paraná, 2019.

e-ISSN: 2446-6875
p-ISSN: 1807-5436

BORRÁS, S.; EDQUIST, C. The choice of innovation policy instruments. **Technological Forecasting and Social Change**, v. 80, n. 8, p. 1513–1522, 2013.

BOTH, M.; MÜLLER, J. Building Information Modeling und Industrie 4.0. **Atp Magazin**, v. 60, n. 06–07, p. 100–107, 2018.

BRIEF, F. P. **The Need for Innovations in Business Models**. 2014.

C. N. D. A. I. **O custo tributário dos investimentos:** as desvantagens do Brasil e as ações para mudar. CNI Brasília. 2014.

CASTELLACCI, F. Technological paradigms, regimes and trajectories: Manufacturing and service industries in a new taxonomy of sectoral patterns of innovation. **Research Policy**, v. 37, n. 6–7, p. 978–994, 2008.

COOPERS, P. P. W. **Indústria 4.0:** Digitalização como vantagem competitiva no Brasil. Brasil: PWC, 2016.

CRISÓSTOMO, V. L.; LÓPEZ-ITURRIAGA, F. J.; VALLELADO, E. Financial constraints for innovation in Brazil. **Latin American Business Review**, v. 12, n.3, p. 165–185, 2011.

DALENOGARE, L. S.; BENITEZ, G. B.; AYALA, N. F.; FRANK, A. G. The expected contribution of Industry 4.0 technologies for industrial performance. **International Journal of Production Economics**, v. 204, p. 383–394, 2018.

DA SILVA, M. R. DOS SANTOS.; OLAVE, M. E. L. Contribuições das Tecnologias Digitais Associadas à Indústria 4.0 para a Formação Profissional. **Gestão e Desenvolvimento**, Novo Hamburgo, v. 17, n. 2, mai./ago. 2020.

DODGSON, M.; HUGHES, A.; FOSTER, J.; METCALFE, S. Systems thinking, market failure, and the development of innovation policy: The case of Australia. **Research Policy**, v. 40, n. 9, p. 1145–1156, 2011.

DODGSON, M.; MATHEWS, J.; KASTELLE, T.; HU, M. C. The evolving nature of Taiwan's national innovation system: The case of biotechnology innovation networks. **Research Policy**, v. 37, n. 3, p. 430–445, 2008.

DUTTA, S.; LANVIN, B.; WUNSCH-VINCENT, S. The global innovation index 2015. Effective Innovation Policies for Development, Geneva: **World Intellectual Property Organization**, 2015.

EVANS, P. C.; ANNUNZIATA, M. **Industrial internet:** Pushing the boundaries. General Electric Reports, 2012.

e-ISSN: 2446-6875
p-ISSN: 1807-5436

FORESIGHT, U. K. **The future of manufacturing:** a new era of opportunity and challenge for the UK. Summary Report, The Government Office for Science, London, 2013.

FRANK, A. G.; CORTIMIGLIA, M. N.; RIBEIRO, J. L. D.; OLIVEIRA, L. S. The effect of innovation activities on innovation outputs in the Brazilian industry: Market-orientation vs. technology-acquisition strategies. **Research Policy**, v. 45, n. 3, p. 577–592, 2016.

GUAN, J. C.; MOK, C. K.; YAM, R. C. M.; CHIN, K. S.; PUN, K. F. Technology transfer and innovation performance: Evidence from Chinese firms. **Technological Forecasting and Social Change**, v. 73, n. 6, p. 666–678, 2006.

HALL, B. H.; MAFFIOLI, A. Evaluating the impact of technology development funds in emerging economies: evidence from Latin America. **The European Journal of Development Research,** v. 20, n. 2, p. 172–198, 2008.

HAMMES, T. X. **Will Technological Convergence Reverse Globalization** (Strategic Forum, Number 297). National Defense University Washington United States, 2016.

IDRISOV, G. I.; KNYAGININ, V. N.; KUDRIN, A. L.; ROZHKOVA, E. S. New technological revolution: Challenges and opportunities for Russia. **Voprosy Ekonomiki**, v. 4, p. 5–25, 2018.

KAGERMANN, H.; LUKAS, W.; WAHLSTER, W. Abschotten ist keine Alternative. **VDI Nachrichten**, 16, 2015.

KAGERMANN, H.; WAHLSTER, W.; HELBIG, J. Recommendations for implementing the strategic initiative Industrie 4.0: Final report of the Industrie 4.0 Working Group. **Forschungsunion**, Berlin, Germany, 2013a.

KAGERMANN, H.; WAHLSTER, W.; HELBIG, J. Securing the future of German manufacturing industry. **Recommendations for Implementing the Strategic Initiativ Industrie**, v. 4, n. 199, p. 14, 2013b.

KANG, H. S.; LEE, J. Y.; CHOI, S.; KIM, H.; PARK, J. H.; SON, J. Y.; NOH, S. D. Smart manufacturing: Past research, present findings, and future directions. **International Journal of Precision Engineering and Manufacturing - Green Technology**, v. 3, n. 1, p. 111–128, 2016.

KHAITAN, S. K.; MCCALLEY, J. D. Design techniques and applications of cyberphysical systems: A survey. **IEEE Systems Journal**, v. 9, n. 2, p. 350–365, 2014.

KIEL, D.; MÜLLER, J. M.; ARNOLD, C.; VOIGT, K. I. Sustainable industrial value creation: Benefits and challenges of industry 4.0. **International Journal of Innovation Management**, v. 21, n. 8, 2017.

e-ISSN: 2446-6875
p-ISSN: 1807-5436

KRAWCZYŃSKI, M.; CZYŻEWSKI, P.; BOCIAN, K. Reindustrialization: A challenge to the economy in the first quarter of the twenty-first century. **Foundations of Management**, v. 8, n. 1, p. 107–122, 2016.

KUMAR, N.; SIDDHARTHAN, N. S. **Technology, market structure and internationalization: issues and policies for developing countries**. Routledge, 2013.

KUO, C. C.; SHYU, J. Z.; DING, K. Industrial Revitalization via Industry 4.0 – A comparative policy analysis among China, Germany and the USA. **Global Transitions**, 2019.

LEE, J.; BAGHERI, B.; KAO, H. A. A Cyber-Physical Systems architecture for Industry 4.0-based manufacturing systems. **Manufacturing Letters**, v. 3, p. 18–23, 2015.

LELE, U.; GOSWAMI, S. The fourth industrial revolution, agricultural and rural innovation, and implications for public policy and investments: a case of India. **Agricultural Economics (United Kingdom)**, v. 48, p. 87–100, 2017.

LIAO, Y.; DESCHAMPS, F.; LOURES, E. F. R.; RAMOS, L. F. P. Past, present and future of Industry 4.0 - a systematic literature review and research agenda proposal. **International Journal of Production Research**, v. 55, n. 12, p. 3609–3629, 2017.

LUTHRA, S.; MANGLA, S. K. Evaluating challenges to Industry 4.0 initiatives for supply chain sustainability in emerging economies. **Process Safety and Environmental Protection**, v. 117, p. 168–179, 2018.

MARODIN, G. A.; FRANK, A. G.; TORTORELLA, G. L.; SAURIN, T. A. Contextual factors and lean production implementation in the Brazilian automotive supply chain. **Supply Chain Management: An International Journal**, 2016.

MARODIN, G. A.; TORTORELLA, G. L.; FRANK, A. G.; GODINHO FILHO, M. The moderating effect of Lean supply chain management on the impact of Lean shop floor practices on quality and inventory. **Supply Chain Management: An International Journal**, v. 22, n. 6, p. 473–485, 2017.

MOHER, D.; LIBERATI, A.; TETZLAFF, J.; ALTMAN, D. G.; ALTMAN, D.; ANTES, G.; BERLIN, J. A. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement (Chinese edition). **Journal of Chinese Integrative Medicine**, v. 7, n. 9, p. 889–896, 2009.

MUKKAMALA, R. R.; SORENSEN, J. I.; HUSSAIN, A.; VATRAPU, R. Social Set Analysis of Corporate Social Media Crises on Facebook. *In* H. S.; M. W. (Eds.). **19th IEEE International Enterprise Distributed Object Computing Conference Workshps and Demonstrations, EDOCW,** 2015.

e-ISSN: 2446-6875
p-ISSN: 1807-5436

MUKWAWAYA, G. F.; EMWANU, B.; MDAKANE, S. Assessing the readiness of South Africa for Industry 4.0 - Analysis of government policy, skills and education. **Proceedings of the International Conference on Industrial Engineering and Operations Management Pretoria, IEOM,** 2018.

OLAVARRIETA, S.; VILLENA, M. G. Innovation and business research in Latin America: An overview. **Journal of Business Research,** v. 67, n. 4, p. 489–497, 2014.

PHAAL, R.; O'SULLIVAN, E.; ROUTLEY, M.; FORD, S.; PROBERT, D. A framework for mapping industrial emergence. **Technological Forecasting and Social Change**, v. 78, n. 2, p. 217–230, 2011.

PHILLIPS, L. A.; CALANTONE, R.; LEE, M. International technology adoption. **Journal of Business & Industrial Marketing**, 1994.

RAMANI, S. V.; THUTUPALLI, A.; URIAS, E. High-value hi-tech product introduction in emerging countries. **Qualitative Market Research: An International Journal,** 2017.

REISCHAUER, G.; LEITNER, K. H. Innovation 4.0: Wie das Innovationspotenzial von Industrie 4.0 analysiert werden kann. **Austrian Management Review**, v. 6, p. 76–83, 2016.

REISCHAUER, G. Industry 4.0 as policy-driven discourse to institutionalize innovation systems in manufacturing. **Technological Forecasting and Social Change**, v. 132, p. 26–33, 2018.

ROTHWELL, R.; ZEGVELD, W. **Industrial Innovation and Public Policy: Preparing for the 1980s and the 1990s**. Greenwood Pub Group, 1981.

SCHUMACHER, A.; EROL, S.; SIHN, W. A Maturity Model for Assessing Industry 4.0 Readiness and Maturity of Manufacturing Enterprises. **Procedia CIRP,** v. *52*, p. 161–166, 2016.

SCHWAB, K. **The fourth industrial revolution**. Currency, 2017.

SENDLER, U. Acatech Deutsche Akademie der Technikwissenschaften. **In Das PLM-Kompendium** (pp. 355–358). Springer, 2009.

SHYU, J. Z.; CHIU, Y. Innovation policy for developing Taiwan's competitive advantages. **R&D Management,** v. 32, n. 4, p. 369–374, 2002.

SOLTOVSKI, R.; RESENDE, L. M. M.; PONTES, J.; YOSHINO, R. T.; SILVA, L. B. P. Um Estudo Quantitativo sobre os Riscos da Indústria 4.0 no Contexto Industrial: Uma Revisão Sistemática da Literatura. **Gestão e Desenvolvimento**, Novo Hamburgo, v. 17, n. 3, set./dez. 2020.

Revista Gestão e Desenvolvimento

e-ISSN: 2446-6875
p-ISSN: 1807-5436

SWENSON, G. **President's Council of Advisors on Science and Technology,** 2015.

TAY, S. I.; LEE, T. C.; HAMID, N. Z. A.; AHMAD, A. N. A. An overview of industry 4.0: Definition, components, and government initiatives. **Journal of Advanced Research in Dynamical and Control Systems**, v. 10, n. 14, p. 1379–1387, 2018.

WANG, Y. H. The Challenge of Taiwan Productivity 4.0 from Industry 4.0. **Taiwan Economic Research Monthly**, v. 38, n. 8, p. 111–119, 2015.

WOBETO, R.; FREITAS, A. L. S. G.; REIS, A. V. A.; OLIVEIRA, M. N.; CINTRA, N. C.; SILVA, R. L. M.; QUEIROZ, A. L. Economia Mundial e a Quarta Revolução Industrial. **CIPEEX,** *2*, 2097–2104, 2018.

YANG, H.; KIM, S. Y.; YIM, S. A case study of the Korean government's preparation for the fourth industrial revolution: Public program to support business model innovation. **Journal of Open Innovation: Technology, Market, and Complexity**, v. 5, n. 2, 2019.