

The research, development and innovation policy in Brazil and the prospects for the development of Industry 4.0 in the Manaus Free Trade Zone

Luiz Frederico Oliveira de Aguiar¹ and Armando Araujo de Souza Junior²

¹ Master's Student of the Postgraduate Program in Production Engineering – PPGEF, Federal University of Amazonas – UFAM – luiz.aguiar@sufama.gov.br

² Ph.D. Professor of the Postgraduate Program in Production Engineering – PPGEF, Federal University of Amazonas-UFAM - armandoaraujo@ufam.edu.br

Abstract

The main objective of this article is to analyze the Brazilian public policy to promote research, development and innovation and the prospects for Industry 4.0 in the Industrial Pole of Manaus. For this, a documental and bibliographic survey was carried out with the objective of identifying public policies to encourage research, development and innovation in Brazil, as well as the initiatives of the Manaus Free Trade Zone for the development of Industry 4.0. Thus, the correlations between the public policies of the Brazilian government and its local perspectives in the Industrial Pole of Manaus were identified, highlighting that the main currently existing initiatives stem from the mandatory investment in RD&I contained in Brazilian legislation and how important is the participation of the National State for the development of Industry 4.0 initiatives in the Manaus Free Trade Zone.

Keywords: Research, Development and Innovation; Public Policies; Industry 4.0; Manaus Free Trade Zone.

1. Introduction

Since the beginnings of industrial production in the United Kingdom, many transformations have taken place in the production process, especially due to technological advances and innovations included in the production of manufactures. Such advances established new paradigms for industry and society, which divides these periods into four distinct moments: the so-called industrial revolutions, with the last one currently underway: the fourth Industrial Revolution. (Phuyal, Bista & Bista, 2020; Zhang & Yang, 2020).

The fourth industrial revolution, or Industry 4.0 – I4.0, was initially characterized as a technological evolution of automation initiated in the third industrial revolution. However, the Fourth Industrial Revolution is based on an “intelligent automation” where industrial workers, the production system, products and customers are interconnected. For this to occur, it was necessary to change the paradigm of the production process and the inclusion of new technologies, especially digital resources (Karre, 2017; Davies, Coole & Smith, 2017; Schwab & Davis, 2018).

Such a paradigm shift in the industrial production process made the most industrialized countries

begin the process of “adapting” to the new reality that was presented, in this sense, the German Government presented, in 2011, a “High Tech Strategy Action Plan for 2020” with the strategic objective of preparing their industry for the current productive paradigm shift. In this German Action Plan, the term Industry 4.0 – I4.0 was presented to the world for the first time (Davies, Coole & Smith, 2017; Schwab & Davis, 2018).

Although the new term I4.0 did not have a precise concept, at that time, it referred to the use of ideas and elements of the Internet of Things (IoT) in industrial production. In addition, the strong participation of the German Government in the process is highlighted, which also gave the term a political connotation, so much so that Germany created a Working Group on I4.0 that presented suggestions to the German Federal Government (Ribeiro, 2017; Beier et al., 2020).

In practice, I4.0 is based on the introduction of new technologies and innovations to the production process or the manufacturing environment, especially in the connection between the Internet of Things (IoT) and Cyber-Physical Systems (CPS) with machines in order to make smarter decisions. Such innovations and technological advances are based on nine pillars, namely: (1) analysis and big data, (2) autonomous robots, (3) 3D simulation, (4) horizontal and vertical integration of systems, (5) the internet of things in industry, (6) cybersecurity, (7) cloud computing, (8) additive manufacturing, and (9) augmented reality (Rubmann et al., 2015; Davies, Coole & Smith, 2017; Mogos & Eleftheriadis; Myklebust, 2019) ; Zhang & Yang, 2020).

Since the I4.0 represents a paradigm shift in industrial production, changes needed to occur for industrialized countries to adapt to this new imposed reality. In this sense, Germany stands out as the first to present a strategic public policy aimed at transforming the infrastructure of its industry through the application of new technologies. To this end, it made changes to its industrial policy with new principles, new protocols, new rules and new technologies through its strategic initiative called “High Tech Strategy Action Plan for 2020”. Consequently, Germany was followed by the United States of America and China (Kagermann, 2013; European Parliament, 2016; Santos et al., 2018; Elmi, Broekaert & Larsen, 2018; Kuo & Shyu; Ding, 2019; Moreira, Jr., 2020).

Therefore, the general objective of this article is to identify Brazil's national public policies for research, development and innovation - RD&I and their perspectives for the development of Industry 4.0 in the Manaus Free Trade Zone. In order to achieve this objective, a documental research was carried out, especially in the national regulations and legislation of research, development and innovation, highlighting the initiatives aimed at the development of Industry 4.0 in Brazil and, in particular, in the Manaus Free Trade Zone, where this located the Industrial Pole of Manaus.

2. State of Art

2.1 Public RD&I policies and Industry 4.0

It is true that the changes that have taken place in the production process and, therefore, in the industrialization of a country are the result of a decision by the State, established through an industrial policy that helps or provides the conditions for industrial development to occur or the necessary changes to modernization of local production. However, the implementation of a public policy focused on the industry requires overcoming institutional and political barriers (Andreoni & Chang, 2019).

The research, development and innovation policy in Brazil and the prospects for the development of Industry 4.0 in the Manaus Free Trade Zone

For this reason, since 2011, when Germany took the first step towards what the Germans themselves called Industry 4.0, other countries have also been restructuring their national industrial development policies in order to create the conditions for the creation of a new techno-productive paradigm, these are state efforts to implement I4.0 (Aiginger & Rodrik, 2020; Diegues & Roselino, 2021).

The development of an industrial policy that can serve as a basis for the process of implementing I4.0 requires States to drastically alter their current structures of manufacturing industries in order to provide the necessary directions for the establishment of advanced manufacturing (Elmi & Broekaert; Larsen, 2018).

In this sense, changes are promoted throughout the innovation and technological development chain with new methods, protocols, legislation, rules and plans, as was the case, for example, in Germany, the United States and China (Kuo & Shyu; Ding, 2019; Moreira, Jr., 2020).

Brazil, according to studies carried out by the Institute of Studies for Industrial Development and the Institute of Economics of Unicamp, needs to go through a process of productive transformation that requires cooperation between the State and private agents in directing the national development strategy of the I4 .0 in order to avoid losses of industrial structure as well as for public policy to be effective and specific, as well as to determine the use of adequate instruments to encourage the formation of production and innovation networks (Vermulm et al., 2018 ; Diegues & Roselino, 2019).

Previous studies indicate that industrial policies should be focused on some priority areas such as the standardization of operational reference architectures of factories, management of complex systems, provision of broadband infrastructure, cyber and information technology security, new organizations and work focused on the digital industry, continuous intellectual capital formation, regulation and standardization and resource efficiency. In this sense, Brazil needs greater public engagement to implement a new industrial policy aimed at developing I4.0 in the country (Menelau, 2020; Ottonicar & Valentim; Mosconi, 2019).

One of the public policies widely used by States for the industrial, technological and economic development of certain regions are the Free Zones or Special Development Zones. According to the definition used by the World Bank, the Free Zones - FZ's, are a type or form of Special Development Zones - SDZ's that also include Export Processing Zones - EPZ's, Free Economic Zones - FEZ's , Industrial Parks - IP's, Free Ports - FP's, Customs Logistic Parks - CLP's and Urban Company Zones - UCZ's (Amorim, 2021; Akinci & Crittle, 2008). Table.1 presents a summary of the definition of each of these public policies for economic development.

Table 1. Most common types of Special Economic Zones

Name	Definition
Free Zones - FZ's	Free Trade Zones – FZ`s (also known as Free Trade Areas) are fenced and tax-exempt areas, offering warehousing, storage and distribution facilities for trade, transshipment and re-export operations.
Export Processing Zones - EPZ`s	The EPZs are industrial parks aimed mainly at international trade. They offer companies free trade conditions and a simplified regulatory environment. There are, in general, two types of EPZs: one is a comprehensive type, open to all industrial segments; another is a specialized type, open only to certain specialized segments.

The research, development and innovation policy in Brazil and the prospects for the development of Industry 4.0 in the Manaus Free Trade Zone

Free Economic Zones - FEZ's	The FEZ's (also called "Multifunctional Economic Zones") are large areas that have different industrial, service and urban utilities operations. In some cases, these zones may encompass an entire city or jurisdiction, such as Shenzhen (city) and Hainan (province) in China.
Industrial Parks - IP's	Industrial Parks (also called "Industrial Zones") are largely manufacturing-based sites. Some are multifunctional and similar to "Free Economic Zones", but generally operate on a smaller scale. Parks typically offer a wide range of tax incentives and benefits.
Free Ports - FP's	Free ports means specific areas within a country geographically (in a port) but outside that country's established customs area, thus allowing components and goods to be imported, manufactured and exported without being subject to the host country's standard tariffs and to export/import procedures.
Customs Logistic Parks - CLP's	Bonded Parks or Customs Logistic Parks (also known as "Customs Warehouses") are specific buildings or other secure areas in which goods can be stored, handled or subjected to manufacturing operations without the payment of fees that would normally be imposed. To a certain extent, a "customs area" is similar to a "free trade area" or "free port". However, the main difference is that a "customs area" is subject to customs laws and regulations, while a "free trade area" or "free zone" is exempt from these provisions.
Urban Company Zones - UCZ's	An urban business zone is an area in which policies to encourage economic growth and development are implemented. Urban development zone policies often offer tax breaks, infrastructure incentives and reduced regulations to attract investment and private companies to the zones.
Specialized Zones – EZ's	Specialized Zones include science/technology parks, technology zones, logistics parks and airport zones.
Eco-Industrial Zones or Parks	Eco-industrial zones or parks focus on ecological improvements in terms of reducing waste and improving the environmental performance of companies. They often use a concept of "industrial symbiosis" and green technologies to achieve energy and resource efficiency. Given the serious environmental challenges, an increasing number of countries are adopting this new type of zone.

Source: Adapted from Zeng (2016).

In order to receive investments aimed at Industry 4.0 – I4.0, the Free Zones – FZ's installed in Latin America are also beginning to adapt. In this sense, in South America, the Bogotá Free Trade Zone - BFTZ was the first to modify its regulations to attract investments in the area of cloud services, automated customs control systems and recognition systems for the area of transport and goods. This BFTZ initiative motivated the Colombian Government to modify its legislation on the FZ's regime in order to promote and attract such

The research, development and innovation policy in Brazil and the prospects for the development of Industry 4.0 in the Manaus Free Trade Zone

investments. Following the Colombian example, the Oriental Republic of Uruguay also modified its FZ's framework in order to grant incentives to services related to Industry 4.0, as well as Brazil, which also defined regulatory frameworks aimed at attracting investments for I4.0 in the Manaus Free Trade Zone - MFTZ (Gutiérrez, 2020; Mincit, 2021; Itikawa & Santiago, 2021).

The so-called Manaus Industrial Pole - MIP is an industrial center created in the current molds by the Brazilian Decree-law 288 of 1967, which established the Manaus Free Trade Zone - MFTZ development project, which also created two other important centers, one commercial and the other agricultural. The MIP closed the year 2020 with around 450 industries installed and generating 93,317 direct jobs and more than 370,000 indirect jobs and the year 2021 with around 430 industries and generating 103,507 direct jobs and 400,000 indirect jobs. The revenue of the companies installed in the Manaus Industrial Pole reached R\$ 119.68 billion reais and in 2021, it reached 158.62 billion reais, the best result in history, with the electronics and computer goods segments ahead of the global revenue of the MIP, with shares that together reach 50% of global MIP revenue (Suframa, 2020; Suframa, 2022).

Faced with this challenge of implementing I4.0, countries sought to create their national industrial development plans with the objective of developing advanced manufacturing. Thus, it was intended to study the Brazilian public policy for the development of I4.0 in the Manaus Free Trade Zone - MFTZ in order to answer the guiding question of the research, which is: What are the drivers for the development of Industry 4.0 in the industries of the Manaus Industrial Pole - MIP?

3. Public Policies aimed at Industry 4.0 in the Manaus Industrial Pole - MIP

Public policies as the application of programs or plans whose objective is to develop, improve or mitigate societal problems based on scientific studies began in the first decades of the 20th century and were fundamental both for stimulating the science of public policies (policy studies) and investment in research applied to the main challenges of society. In Brazil, the first public policies began to be applied in the 1930s with the Government of President Getúlio Vargas and its objective of developing the country (Vaitsman, Ribeiro & Lobato, 2013; Farr et al., 2006).

One of the main challenges of modern societies is the development of science, technology and innovation - ST&I, for this, specific public policies are developed to help and encourage such activities in countries. They are relevant to the competitiveness and development, not only of certain regions, but also of companies in particular industries, since a good part of the use of scientific knowledge is applied to production processes, as occurred in all industrial revolutions (Viotti & Macedo, 2003; Ferreira, 2018).

The first initiatives of the Brazilian Government for the development of public ST&I policy in the country were in the 1950s with the institutionalization of public entities to promote Science, Technology and Innovation. Thus, Law No. 1,310 of January 15, 1951 creates the National Research Council, which in the first article provides that the purpose of the Council was to “promote and stimulate the development of scientific and technological research in any field of knowledge”, subsequently, on November 6, 1974, through Law No. 6,129, it became the National Council for Scientific and Technological Development – CNPq. Also in 1951, through Decree No. 29,741 of July 11, the President of the Republic instituted a Commission to

The research, development and innovation policy in Brazil and the prospects for the development of Industry 4.0 in the Manaus Free Trade Zone

promote the National Campaign for the Improvement of Higher Education Personnel - CAPES, constituting these initiatives the first in the history of the country aimed at to the promotion of science, technology and innovation (Ferreira, 2018; Oliveira, 2016).

On March 15, 1985, through Decree nº 91.146, President José Sarney created the Federal Government's central body for the management of the entire national policy aimed at ST&I, the Ministry of Science and Technology - MCT, which represented a landmark for the country's scientific and technological community and for the management of public policies in the area. Finally, on January 9, 1996, through Law No. 9,257, the Presidency of the Republic created the National Council of Science and Technology as a special advisory body directly linked to the President of the Republic of Brazil and responsible, among other things, for the proposition of the country's ST&I policy (Velho, 2011; Oliveira, 2016; Ferreira, 2018).

In order to organize the actions of the National Science, Technology and Innovation System - SNTCI, the Brazilian Federal Government established, in 2016, through the Ministry of Science, Technology, Innovations and Communications, a “National Strategy for Science, Technology and Innovation (Encti) - 2016/2022” where it recognizes that the country – until then – had not made a decisive inflection towards industrialization based on education, science and technology as a support for national development. The Encti 2016/2022 is, therefore, the strategic guideline for the implementation of public policies in the area of ST&I and was the result of public consultations debated with the actors of the sector (Muraro, 2021; Costa, Batista & Costa, 2020).

Although the Encti 2016/2022 does not directly mention the term Industry 4.0, its preparation involved the participation of public and private organizations linked to national industry, such as the National Confederation of Industry - CNI, the Brazilian Support Service for Micro and Small Enterprises – Sebrae and the Ministry of Industry, Foreign Trade and Services – MDIC, which included in the Strategy a priority area of new production processes focused on “Converging and Enabling Technologies” where there is a forecast for the elaboration of the “Action Plan in Science, Technology and Innovation for Converging and Enabling Technologies” and the “National Plan for Advanced Manufacturing”, a term synonymous with Industry 4.0 and which provides for the use of information and communication technologies and the Internet of Things for the production of goods in order to create the bases for the establishment of advanced manufacturing in the country, that is, it is the first document of the Brazilian Federal Government in which there is a forecast of the establishment of public policies aimed at the development of advanced manufacturing in Brazil, after which the Federal Government started some initiatives related to the development of industry 4.0 (Lucas & De Moraes Silva, 2017; Muraro, 2021; Costa, Batista & Costa, 2020). Table 2 presents a summary of the main initiatives of the Brazilian government for the development of I 4.0.

Table 2. Federal Government Initiatives and Industry 4.0

Initiative Name	Year	Body/Entity
National Strategy for Science, Technology and Innovation (Encti) - 2016/2022	2016	MCTI
ST&I Plan for Advanced Manufacturing in Brazil – Pró-Futuro	2017	MCTI
National Plan for the Internet of Things	2019	MCTI/BNDES
Brazil Chamber of Industry 4.0 Action Plan	2019	MCTI/ME/ABDI/CNI/FINEP/CNPq/BNDES/SEBRAE/EMBRAPII
ST&I Action Plan for Converging and Enabling Technologies (Volume IV – Advanced Manufacturing)	2020	MCTI
National Innovation Policy	2020	MCTI
National Innovation Strategy	2021	MCTI

Source: prepared by the author, 2022.

The National Strategy for Science, Technology and Innovation (Encti) – 2016/2022 is, therefore, the guiding document, published by the Brazilian Federal Government, in December 2016, that establishes the bases for the creation of public policies that promote Industry 4.0 or manufacturing advanced in Brazil. Based on this initiative, MCTI led a series of initiatives to promote Industry 4.0 in Brazil, some directly linked to the guidelines provided for in Encti 2026/2022, such as the “ST&I Plan for Advanced Manufacturing in Brazil – Pró-Futuro”, presented in 2017, the “National Plan for the Internet of Things” of 2019 and the “Plan of Action in Science, Technology and Innovation for Converging and Enabling Technologies”, launched in 2020 and whose 4th volume is dedicated to advanced manufacturing, these actions contributed for the establishment of the “Brazilian Chamber of Industry 4.0 Action Plan” in 2019, as well as other initiatives that help to promote I4.0 in the country, such as the “National Innovation Policy” and the “National Innovation Strategy” by 2020 and 2021, respectively (Arbix, 2017; Brasil, 2016; Brasil, 2017a; Brasil, 2017b; Brasil, 2020).

Some initiatives aimed at the development of Advanced Manufacturing or I4.0 had the support of the Ministry of Industry, Foreign Trade and Services – MDIC, the body responsible for managing Brazilian industrial policy, extinguished in January 2019 when it was incorporated into the Ministry of Economy – ME. In 2015, in partnership with MCTIC, the then MDIC created an Advanced Manufacturing Working Group whose first meeting took place on November 25, 2015 with the presence of representatives of the following bodies and entities: MCTI, MDIC, FINEP, SENAI, CNI, SEBRAE, ABDI, BNDES, ABIMAQ, ABIT,

The research, development and innovation policy in Brazil and the prospects for the development of Industry 4.0 in the Manaus Free Trade Zone

ANPEI, CERTI and CNPq, which culminated in the presentation, on November 29, 2016, of a study entitled “Perspectives of Brazilian specialists on opportunities and challenges for advanced manufacturing in the Brasil” result of seven workshops held in Brazilian capitals (Brasilia, Belo Horizonte, Florianópolis, São Paulo, Salvador, Recife and Rio de Janeiro). This document was essential for, on May 25, 2017, the MDIC established the Industry 4.0 Working Group – GTI 4.0 – Ordinance No. 728-SEI/2017 - which had more than 50 representative entities and whose objective was to establish a national policy for the I4.0, this is the first Working Group with the effective participation of the Superintendence of the Manaus Free Trade Zone – SUFRAMA – a federal entity of the Brazilian Government that manages the Manaus Free Trade Zone – which, in the end, presented in March from 2018 the “Brazilian Agenda for Industry 4.0” where it proposes 10 measures “From Industry to 4.0”, they are: (Brazil, 2016a; Brazil, 2018)

1. Dissemination of Industry 4.0 Concepts;
2. Self-Assessment Platform 4.0;
3. HUB 4.0;
4. More Productive Brazil 4.0;
5. Factories of the Future and Test Beds;
6. StartUp-Industry 4.0 connection;
7. Financing for an Industry 4.0;
8. Labor Market and Education 4.0;
9. Game Rules 4.0; and
10. International Trade 4.0.

The Superintendence of the Manaus Free Zone – SUFRAMA was invited to be part of the composition of the Working Group that produced the Brazilian Agenda for Industry 4.0 because, in addition to controlling the tax benefits established by the Brazilian Decree-Law n° 288/67, it is also responsible for the control of the Law on Information Technology in the Amazon established by the Brazilian Law 8,387 of December 30, 1991, which obliges all companies producing IT goods in the Manaus Free Trade Zone to invest, every year, at least 5% of their gross revenue in research activities and development to be carried out in the Amazon, based on a project presented to the Superintendence. Since then, SUFRAMA has become one of the public entities that foster research, development and innovation in Brazil, more specifically, in the Amazon (Brasil, 1967; Brasil, 1991).

SUFRAMA's participation in activities specifically related to Industry 4.0 begins with the publication of Ordinance No. 728-SEI/2017, which establishes the Industry 4.0 Working Group - GTI 4.0 and whose composition provides for a representative and an alternate of the Superintendence – Art 2, VIII – this is the first initiative linked to Industry 4.0 with the official representation of the Superintendence of the Manaus Free Trade Zone. This I4.0 Interministerial Working Group ended with the presentation, in March 2018, of the “Brazilian Agenda for Industry 4.0”, although the creation Ordinance n°728/17 itself established that a

The research, development and innovation policy in Brazil and the prospects for the development of Industry 4.0 in the Manaus Free Trade Zone

proposal for the “Strategy for Industry 4.0”. Even so, it is observed that all the regulations¹ of the Manaus Free Trade Zone linked to Industry 4.0 were only established after the entity's participation in this GTI 4.0 (Mdic, 2017).

The first initiative exclusively by SUFRAMA linked to the development of Industry 4.0 in the Manaus Free Trade Zone took place just two months after the presentation of the “Brazilian Agenda for Industry 4.0” with the publication, on May 10, 2018, of Resolution No. 40 of the Board of Directors of SUFRAMA – CAS that made it possible and disciplined the presentation of investment projects in RD&I for application in I4.0 to companies producing computer goods in the region. In this resolution, the definition of Industry 4.0 stands out as “a set of technologies that allow the fusion of the physical, digital and biological world in production processes, stages of the value chain, distribution, etc. that today are also associated with advanced manufacturing such as the internet of things, big data, 3D printing, cloud computing, among others (Suframa, 2018; Mdic, 2017).

In December 2018, SUFRAMA proposes to the MDIC and Ordinance No. 2.091-SEI of December 17, 2018 is approved, which establishes the methodology to be adopted in investments in research, development and innovation aimed at industry 4.0 in the Manaus Free Trade Zone, as well as creating the Seal of Industry 4.0. This Ordinance also establishes a definition of Industry 4.0 as the integration of production facilities, supply chains and service systems to allow the establishment of value-added networks, involving technologies such as: analysis of large volumes of data (big data) , autonomous (adaptive) robots, cyber-physical systems, simulation, horizontal and vertical integration, industrial internet, cloud computing, additive manufacturing and augmented reality, and comprising distributed systems such as sensor networks, cloud systems, autonomous robots and manufacturing additively connected to each other. In addition, the Ordinance determines that the initial and desired stages for the Industry 4.0 project are identified, having as reference the ALCATEH (German Academy of Science and Engineering) methodology of maturity in Industry 4.0 (Mdic, 2018).

Another measure taken, within the scope of SUFRAMA, aimed at the development of Industry 4.0 was the establishment of a Priority Program for Industry 4.0 and Industrial Modernization - PPI4.0 instituted through Resolution No. 9, of October 29, 2019 of the Activities Committee of Research and Development in the Amazon – CAPDA whose objective is to develop “an ecosystem focused on Industry 4.0 and the manufacturing of the future” encompassing cyber-physical systems; intelligent systems and manufacturing; industrial process automation; 3D printing; robotics; smart factories; artificial intelligence; cybersecurity; analysis and treatment of large volumes of data (big data); virtual reality; and new lean manufacturing and industrial digitalization techniques. The PPI4.0 has its actions aligned with the “Action Plan of the Chamber of Industry 4.0 of Brazil” established in 2019 and, after a public call made by CAPDA, the company CTIS

¹ Although without the use of the term “Industry 4.0 – I4.0”, RESOLUTION No. 12, OF JULY 14, 2016 of the Committee on Research and Development Activities in the Amazon – CAPDA, which establishes the Priority Programs for investments in research and development, created a Priority Program on DIGITAL ECONOMY that involved terms linked to I4.0 such as internet of things, cyber security, smart cities, big data and advanced manufacturing. However, this Resolution was revoked by others that culminated in RESOLUTION No. 9, OF OCTOBER 29, 2019, which is the first to expressly mention I4.0.

The research, development and innovation policy in Brazil and the prospects for the development of Industry 4.0 in the Manaus Free Trade Zone

Amazonas was defined with the Coordinator of the Priority Industry Program 4.0 and Industrial Modernization - PPI4.0 (Capda, 2019).

There are, therefore, initiatives within the scope of the Superintendence of the Manaus Free Trade Zone - SUFRAMA aimed at the development and promotion of Industry 4.0 in the Amazon and, since 2018, there is the possibility of investments in I4.0 through the obligations imposed imposed by the legislation for the region.

4. Final Considerations.

National public policies for development, research and innovation and the necessary transformations in the productive sector for Industry 4.0 to be implemented are challenges that all industrialized nations are facing in the last decade. Germany, the United States, China and Brazil, as highlighted in this article, strive for these transformations to occur.

When evaluating the Brazilian decisions aimed at the development of Industry 4.0 and the modernization of the production process in the country, perceives, initially, that Brazil took a long time to make decisions with national scope in this area, having created the first foundations only in 2016, with the National Strategy of Science, Technology and Innovation (Encti) – 2016/2022 which leaves it behind the other countries that started their plans years before.

In addition to the delay for the first initiatives to be taken, Brazil has difficulty in establishing a single leadership that can dictate initiatives and coordinate actions nationally, with several organizations and ministries published public policies that were not always being treated together, such as the initiatives now led by the MCTI, now led by the MDIC, currently ME.

This difficulty in defining a single body that would centralize the initiatives and public policies aimed at the development of Industry 4.0 made the Superintendence of the Manaus Free Trade Zone – SUFRAMA only participate in 2017 in the first meeting officially in which the topic was addressed, we refer to the Industry 4.0 Working Group – GTI4.0. Therefore, only in 2018 is the first initiative published in the Manaus Free Trade Zone aimed at Industry 4.0, Resolution No. 40 of the SUFRAMA Board of Directors. It is only from this action that the construction of a local infrastructure begins, aimed at the development of the innovation ecosystem aimed at the development of Industry 4.0 in the Manaus Industrial Pole.

Therefore, it is concluded, after analyzing the data collection, that the development of Industry 4.0 in the Manaus Industrial Pole faces three main challenges: 1) the delay that the country as a whole had for the creation of public policies aimed at development from I4.0; 2) the difficulty of establishing a central national coordinating body for Brazil's strategy for the establishment of an I4.0, and; 3) the construction of an infrastructure suitable for the development of an innovation ecosystem compatible with the requirements imposed on the development of advanced manufacturing.

5. References

Aiginger, K., & Rodrik, D. (2020). Rebirth of industrial policy and an agenda for the twenty-first century. *Journal of Industry, Competition and Trade*, 20(2), 189-207.

The research, development and innovation policy in Brazil and the prospects for the development of Industry 4.0 in the Manaus Free Trade Zone

- Akinci, G., & Crittle, J. (2008). Special economic zone: performance, lessons learned, and implication for zone development (No. 45869, pp. 1-83). The World Bank.
- Amorim, J. C., Monteiro, A. P., Cepêda, C. L. M., & Coelho, G. R. T. F. (2021). Análise comparativa do regime fiscal das Zonas Francas na Europa. *e3-Revista de Economia, Empresas e Empreendedores na CPLP*, 7(2), 031-055.
- Andreoni, A., & Chang, H. J. (2019). The political economy of industrial policy: Structural interdependencies, policy alignment and conflict management. *Structural change and economic dynamics*, 48, 136-150.
- Arbix, G., Salerno, M. S., Zancul, E., Amaral, G., & Lins, L. M. (2017). O Brasil e a nova onda de manufatura avançada: o que aprender com Alemanha, China e Estados Unidos. *Novos estudos CEBRAP*, 36, 29-49.
- Arbix, G., Miranda, Z., Toledo, D., & Zancul, E. (2018). Made in China 2025 e Indústria 4.0: a difícil transição chinesa do catching up à economia puxada pela inovação. *Tempo social*, 30, 143-170.
- Brazil. Decree-law No. 288, of February 28, 1967. Amends the provisions of Law No. 3,173, of June 6, 1957 and regulates the Manaus Free Trade Zone. *Official Diary of the Union*. section 1, Brasília, DF, February 28, 1967.
- Brazil. Law 8,387 of December 30, 1991. Gives new wording to § 1 of art. 3 to arts. 7 and 9 of Decree-Law No. 288, of February 28, 1967, to the caput of art. 37 of Decree-Law No. 1455, of April 7, 1976 and to art. 10 of Law No. 2,145, of December 29, 1953, and other provisions. *Official Diary of the Union*. section 1, Brasília, DF, December 30, 1991.
- Brazil. Ministry of Industry, Foreign Trade and Services (MDIC), Ministry of Science, Technology, Innovation and Communications (MCTIC). *Brazilian Expert Perspectives on Advanced Manufacturing in Brazil: An account of workshops held in seven Brazilian capitals in contrast to international experiences*. Brasília: MDIC, MCTIC, 2016A. Available at: <http://homologa.oic.nap.usp.br/wp-content/uploads/2016/11/mdicmctic-perspectivasdeespecialistassobreamanufaturaavanadanobrasil-2016-161129012506.pdf>. Accessed on: 03/26/2022.
- Brazil. Ministry of Science, Technology, Innovations and Communications (MCTIC). *National Science, Technology and Innovation Strategy: 2016-2022: Science, Technology and Innovation for Economic and Social Development*. Brasilia: MCTIC, 2016B. Available at: http://www.mctic.gov.br/mctic/export/sites/institucional/arquivos/ASCOM_PUBLICACOES/enci_2016-2022.pdf. Accessed on: 03/26/2022.
- Brazil. Ministry of Science, Technology, Innovations and Communications (MCTIC). *Science, Technology and Innovation Plan for Advanced Manufacturing in Brazil (ProFuturo - Production of the Future)*. Brasilia: MCTIC, 2017A. Available at: https://www.mctic.gov.br/mctic/export/sites/institucional/tecnologia/tecnologias_convergentes/arquivos/Cartilha-Plano-de-CTI_WEB.pdf. Accessed on: 03/26/2022.
- Brazil. Ministry of Science, Technology, Innovations and Communications (MCTIC). *National Plan for the Internet of Things*. Brasilia: MCTIC, 2017B. Available at: <https://www.bndes.gov.br/wps/portal/site/home/knowledge/pesquisaedados/estudos/estudo-internet-das-coisas-iot/estudo-internet--das-coisas-um-plan-of-action-for-brazil>. Accessed on: 03/26/2022.

The research, development and innovation policy in Brazil and the prospects for the development of Industry 4.0 in the Manaus Free Trade Zone

- Brazil. Ministry of Industry, Foreign Trade and Services (MDIC) Brazilian Agenda for Industry 4.0: Brazil prepared for the challenges of the future. Brasília: MDIC, 2018. Available at: https://www.gov.br/suframa/pt-br/assuntos/industria4-0_cits_ahk.pdf. Accessed on: 03/26/2022.
- Brazil. Ministry of Science, Technology, Innovations and Communications (MCTIC). National Science, Technology and Innovation Plan for converging and enabling technologies – v.4. Technologies for advanced manufacturing: MCTIC, 2020. Available at: <https://antigo.mctic.gov.br/mctic/export/sites/institucional/tecnologia/Categoriadestaque/Arquivo/Plano-de-Acao-em-CTI-Manufatura-Advanced-VF.pdf>. Accessed on: 03/26/2022
- Beier, G., Ullrich, A., Niehoff, S., Reißig, M., & Habich, M. (2020). Industry 4.0: How it is defined from a sociotechnical perspective and how much sustainability it includes—A literature review. *Journal of cleaner production*, 259, 120856.
- Capda. Committee on Research and Development Activities in the Amazon. Resolution No. 9 of October 29, 2019. Establishes the Priority Programs for Investments in Research and Development. Available at: <https://www.in.gov.br/web/dou/-/resolucao-n-9-de-29-de-outubro-de-2019-226220981> Accessed on: 03 Apr 2022.
- Costa, V. H. S., Batista, L. S., & Costa, R. A. T. (2020). POLÍTICAS PÚBLICAS PARA A CIÊNCIA E TECNOLOGIA: DESENVOLVIMENTO CIENTÍFICO E TECNOLÓGICO NO BRASIL. *Revista Portuguesa Interdisciplinar*, 1(01), 01-13.
- Davies, R., Coole, T., & Smith, A. (2017). Review of socio-technical considerations to ensure successful implementation of Industry 4.0. *Procedia Manufacturing*, 11, 1288-1295.
- Diegues, A. C., & Roselino, J. E. (2019). Indústria 4.0 e as redes globais de produção e inovação em serviços intensivos em tecnologia: uma tipologia e apontamentos de política industrial e tecnológica. Instituto de Economia, UNICAMP.
- Diegues, A. C., & Roselino, J. E. (2021). Política Industrial e Indústria 4.0: a retomada do debate em um cenário de transformações no paradigma tecnoprodutivo. *Revista Brasileira de Inovação*, 19.
- Elmi, N., Broekaert, K., & Larsen, A. M. E. (2018, January). Agile Governance: Reimagining Policy-Making in the Fourth Industrial Revolution. In White Paper. World Economic Forum, January.
- Etzkowitz, H. (2008). Strategic challenges for creating knowledge-based innovation in China: Transforming triple helix university-government-industry relations. *Journal of Technology management in China*.
- European Parliament. Industry 4.0. European Union, 2016. Available at: [https://www.europarl.europa.eu/RegData/etudes/STUD/2016/570007/IPOL_STU\(2016\)570007_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/STUD/2016/570007/IPOL_STU(2016)570007_EN.pdf).> Accessed on 05 May 2021.
- Farr, J., Hacker, J. S., & Kazee, N. (2006). The policy scientist of democracy: The discipline of Harold D. Lasswell. *American political science review*, 100(4), 579-587.
- Ferreira, V. B. (2018). E-science e políticas públicas para ciência, tecnologia e inovação no Brasil. EDUFBA.
- Gutiérrez, Mirna. Las Zona Francas avanzan rumbo a la era 4.0. **Forbes Centroamérica**, 27 de jul. de 2020. Available at: <https://forbescentroamerica.com/2020/07/27/zonas-francas-avanzan-cuarta-revolucion-industrial/>> Accessed on: 13 June 2021.

The research, development and innovation policy in Brazil and the prospects for the development of Industry 4.0 in the Manaus Free Trade Zone

- Holdren, J. P., Power, T., Tasse, G., Ratcliff, A., & Christodoulou, L. (2012). A National strategic plan for advanced manufacturing. US National Science and Technology Council, Washington, DC.
- Iedi (Instituto de Estudos para o Desenvolvimento Industrial). Indústria 4.0: A política industrial da Alemanha para o futuro. (2017). Carta IEDI, 1(807), 30.
- Iedi (Instituto de Estudos para o Desenvolvimento Industrial). Indústria 4.0: A iniciativa Made in China 2025. (2018) Carta IEDI, 1(827), 38.
- Itikawa, M., & Santiago, S. B. (2021). A Systematic Review on Industry 4.0 Maturity Metrics in the Manaus Free Trade Zone. *International journal of advanced engineering research and science*, 8, 1.
- Kagermann, H., Wahlster, W., & Helbig, J. (2013). Recommendations for implementing the strategic initiative INDUSTRIE 4.0. Final report of the Industrie, 4(0), 82.
- Karre, H., Hammer, M., Kleindienst, M., & Ramsauer, C. (2017). Transition towards an Industry 4.0 state of the LeanLab at Graz University of Technology. *Procedia manufacturing*, 9, 206-213.
- Kuo, C. C., Shyu, J. Z., & Ding, K. (2019). Industrial revitalization via industry 4.0—A comparative policy analysis among China, Germany and the USA. *Global transitions*, 1, 3-14.
- Labra, E. M. (2015). Vaitsman J, Ribeiro JM, Lobato L. Policy analysis in Brazil. Bristol: University of Bristol; 2013.
- Lucas, L. O., & de Moraes Silva, D. R. La difusión de innovaciones en la estrategia nacional de CT&I en Brasil. *Administración Pública y Sociedad (APyS)*, (4), 36-52.
- Menelau, S., Macedo, F. G. L., Carvalho, P. L. D., Nascimento, T. G., & Carvalho Júnior, A. D. D. (2020). Mapeamento da produção científica da Indústria 4.0 no contexto dos BRICS: reflexões e interfaces. *Cadernos EBAPE. BR*, 17, 1094-1114.
- Mdic, Minister's office. Ordinance No. 728-SEI, of May 25, 2017. Establishes a Working Group to prepare and propose a National Strategy for Industry 4.0 (GTI4.0) - 2017-2022. Available at: https://www.in.gov.br/materia/-/asset_publisher/Kujrw0TZC2Mb/content/id/20237684/UCEQITzKXPYVi6cWuD3q0ksQ Accessed on: 03 Apr 2022.
- Mdic. Minister's office. Ordinance No. 2091-SEI, of December 17, 2018. Approves the methodology to be adopted in research, development and innovation investments aimed at industry 4.0 in the Manaus Free Trade Zone and creates the Industry 4.0 Seal. Available at: https://www.in.gov.br/materia/-/asset_publisher/Kujrw0TZC2Mb/content/id/56127454/do1-2018-12-20-portaria-n-2-091-sei-de-17-de-december-de-2018-56127439 Accessed on: 03 Apr 2022.
- Mincit (Ministerio de Comercio, Industria y Turismo). **Se modifica el régimen de zonas francas.** Mincomercio, 15 de mar. De 2021. Available at: <https://www.mincit.gov.co/prensa/noticias/industria/se-modifica-el-regimen-de-zonas-francas> Accessed on: 13 June 2021.
- Mogos, M. F., Eleftheriadis, R. J., & Myklebust, O. (2019). Enablers and inhibitors of Industry 4.0: results from a survey of industrial companies in Norway. *Procedia Cirp*, 81, 624-629.

The research, development and innovation policy in Brazil and the prospects for the development of Industry 4.0 in the Manaus Free Trade Zone

- Moreira Jr, H. (2016). A política de inovação do Governo Obama como estratégia de recuperação econômica e manutenção da liderança internacional. *OIKOS* (Rio de Janeiro), 15(2).
- Moreira Jr, H. (2020). Indústria 4.0 e novas dimensões tecnológicas no centro da economia-mundo capitalista: perspectivas para o Brasil. *OIKOS* (Rio de Janeiro), 19(2).
- Muraro, L. G., & Castro-Lucas, C. (2021). Os Desafios da estratégia nacional de Ciência, Tecnologia e Inovação–ENCTI 2016/2022: Federalismo e Política Pública de CT&I no Brasil. *Revista de Empreendedorismo, Negócios e Inovação*, 6(1), 04-30.
- Oliveira, J. J. D. (2016). Ciência, tecnologia e inovação no Brasil: poder, política e burocracia na arena decisória. *Revista de Sociologia e Política*, 24, 129-147.
- Otonicar, S. L. C., Valentim, M. L. P., & Mosconi, E. (2019). Políticas públicas aplicadas à indústria 4.0: estudo comparativo entre o Brasil e o Canadá com foco na competência em informação. *Revista Ibero-Americana de Ciência da Informação*, 12(2), 558-584.
- Phuyal, S., Bista, D., & Bista, R. (2020). Challenges, opportunities and future directions of smart manufacturing: a state of art review. *Sustainable Futures*, 2, 100023.
- Ribeiro, J. M. (2017). O conceito da indústria 4.0 na confecção: análise e implementação (Doctoral dissertation).
- Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P., & Harnisch, M. (2015). Industry 4.0: The future of productivity and growth in manufacturing industries. Boston consulting group, 9(1), 54-89.
- Santos, B. P., Alberto, A., Lima, T. D. F. M., & Charrua-Santos, F. M. B. (2018). Indústria 4.0: desafios e oportunidades. *Revista Produção e Desenvolvimento*, 4(1), 111-124.
- Schwab, K., & Davis, N. (2019). *Aplicando a quarta revolução industrial*. Edipro.
- Suframa, Superintendence of the Manaus Free Zone. Study for the development of an integrated solution for the management of industrial waste in the industrial hub of Manaus. Retrieved from https://www.gov.br/suframa/pt-br/publicacoes/copy_of_newsletter_nr001_pt.pdf, v. 24, 2017.
- Suframa. Board of Directors of Suframa - CAS. Resolution No. 40/2018, of May 10, 2018. Disciplines the preparation of projects and the execution of the fulfillment of the investment obligation in research, development and innovation activities in the Western Amazon or in the state of Amapá for Industry 4.0, for the companies that produce computer goods benefited within the scope of the Manaus Free Trade Zone, as well as those that are applied in research, development and innovation through the waiver of a stage in the basic production process provided for in specific Interministerial Ordinances. Manaus: CAS, 2018. Available at: https://www.in.gov.br/materia/-/asset_publisher/Kujrw0TZC2Mb/content/id/15134973/do1-2018-05-21-resolucao-n-40-de-10-May-2018-15134969#:~:text=Discipline%20a%20designs%C3%A7%C3%A3o%20of%20projects,França%20of%20Manaus%2C%20well%20as. Accessed on: 3 Apr. 2022
- Suframa, Performance Indicators of the Industrial Pole of Manaus 2016 – 2021. Available at: <https://www.gov.br/suframa/pt->

The research, development and innovation policy in Brazil and the prospects for the development of Industry 4.0 in the Manaus Free Trade Zone

br/publicacoes/indicadores/caderno_indicadores_janeiro_marco_2021_gerado_27-05-2021_.pdf.

Accessed on: 20 jun. 2021.

Suframa, Performance Indicators of the Industrial Pole of Manaus 2016 – 2021. Available at:

[https://www.gov.br/suframa/pt-](https://www.gov.br/suframa/pt-br/publicacoes/indicadores/caderno_de_indicadores_janeiro_dezembro_2021__gerado_10-02-2022_.pdf)

[br/publicacoes/indicadores/caderno_de_indicadores_janeiro_dezembro_2021__gerado_10-02-](https://www.gov.br/suframa/pt-br/publicacoes/indicadores/caderno_de_indicadores_janeiro_dezembro_2021__gerado_10-02-2022_.pdf)

[2022_.pdf](https://www.gov.br/suframa/pt-br/publicacoes/indicadores/caderno_de_indicadores_janeiro_dezembro_2021__gerado_10-02-2022_.pdf). Access on: 05 Mar. 2022

Suframa, SUFRAMA Strategic Planning 2010. Available at: [https://www.gov.br/suframa/pt-](https://www.gov.br/suframa/pt-br/publicacoes/plano_estrategico_suframa_res43cas_07042010.pdf)

[br/publicacoes/plano_estrategico_suframa_res43cas_07042010.pdf](https://www.gov.br/suframa/pt-br/publicacoes/plano_estrategico_suframa_res43cas_07042010.pdf) Accessed on: 27 jun. 2021.

Schneegans, S., & Erocal, D. (2015). UNESCO science report: Towards 2030.

Vermulm, R. (2018). Políticas para o desenvolvimento da indústria 4.0 no Brasil.

Velho, L. (2011). Conceitos de ciência e a política científica, tecnológica e de inovação. *Sociologias*, 13, 128-153.

Viotti, E. B., & Macedo, M. D. M. (2003). Indicadores de ciência, tecnologia e inovação no Brasil. In *Indicadores de ciência, tecnologia e inovação no Brasil* (pp. 614-614).

Zhang, C., & Yang, J. (2020). *A history of mechanical engineering*. Springer.