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POLÍTICAS PÚBLICAS E FORMAÇÃO DE RECURSOS HUMANOS PARA A INDÚSTRIA 4.0

PUBLIC POLICIES AND HUMAN RESOURCES TRAINING FOR INDUSTRY 4.0

POLÍTICAS PÚBLICAS Y FORMACIÓN DE RECURSOS HUMANOS PARA LA INDUSTRIA 4.0

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Resumo: O termo indústria 4.0 (I4.0) foi cunhado na Alemanha em 2011 e pode ser visto como o movimento para digitalizar e automatizar processos no campo da manufatura, e sua implementação necessita de uma força trabalhadora com novas qualificações. Nesse artigo, através de uma revisão da literatura, foram analisadas as políticas públicas para a implantação da I4.0 na Alemanha, China, Reino Unido (GB), Suécia, Japão e Brasil catalogando-as em três temas, Empregados - questões relacionadas aos recursos humanos; Produção – referente aos recursos físicos utilizados no processo produtivo; Social – relativo à criação e compartilhamento de conhecimento entre os trabalhadores e os efeitos na sociedade em geral. A pesquisa revelou que Alemanha, China, GB e Japão possuem maiores similaridades em sua forma de adotar a I4.0, especialmente quanto ao grande foco em pesquisa, adaptação de seus recursos humanos e constante profissionalização da força de trabalho, mas a China diferencia-se especialmente na maneira de distribui-la, focando em empresas grandes e centralizadas, enquanto esses os outros focam numa distribuição mais democrática, abrangendo mais regiões e pequenas e médias empresas. Por fim quanto ao Brasil, apesar de possuir algumas iniciativas direção certa, são poucas e falham em resolver a falta de entendimento dos benefícios da I4.0, a falta de infraestrutura tecnológica e as restrições financeiras.

Palavras-chave: Indústria 4.0. 4ª Revolução industrial. Políticas públicas. Digitalização. Recursos humanos.

Abstract: The term industry 4.0 (I4.0) was coined in Germany in 2011 and can be seen as the movement to digitize and automate processes in the field of manufacturing, its implementation requires a workforce with new qualifications. In this article, through a literature review, public policies for the implementation of I4.0 were analyzed in Germany, China, the United Kingdom (GB), Sweden, Japan, and Brazil, cataloging them into three themes, Employees - issues related to human Resources; Production – referring to the physical resources used in the production process; Social – relating to the creation and sharing of knowledge among workers and the effects on society in general. The research revealed that Germany, China, GB, and Japan have greater similarities in their way of adopting I4.0, especially in the great focus on research, an adaptation of their human resources, and constant professionalization of the workforce, however, China differs especially in the way of distributing it, focusing on large and centralized companies, while the others focus on a more democratic distribution, covering more regions and small and medium-sized companies. Finally, as for Brazil, despite having some initiatives in the right direction, they are few and fail to resolve the lack of understanding of the benefits of I4.0, the lack of technological infrastructure, and financial restrictions.

Keywords: Industry 4.0. 4th industrial revolution. Public policies. Digitalization. Human resources.

Resumen: El término industria 4.0 (I4.0) fue acuñado en Alemania en 2011 y puede verse como el movimiento para digitalizar y automatizar procesos en el ámbito de la fabricación, y su implementación requiere de una fuerza laboral con nuevas habilidades. recursos humanos; Producción – refiriéndose a los recursos físicos utilizados en el proceso de producción; Social: relacionado con la creación y el intercambio de conocimientos entre los trabajadores y los efectos en la sociedad en general. La investigación reveló que Alemania, China,

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Gran Bretaña y Japón tienen mayores similitudes en su forma de adoptar I4.0, especialmente en términos de gran apuesta por la investigación, adaptación de sus recursos humanos y profesionalización constante de la fuerza laboral, pero China se diferencia especialmente en la forma de distribuirlo, centrándose en empresas grandes y centralizadas, mientras que los demás se centran en una distribución más democrática, abarcando más regiones y pequeñas y medianas empresas. Finalmente, en cuanto a Brasil, a pesar de tener algunas iniciativas en la dirección correcta, son pocas y no logran resolver la falta de comprensión de los beneficios de la I4.0, la falta de infraestructura tecnológica y las restricciones financieras.

Palabras llave: Industria 4.0. 4ta Revolución Industrial. Políticas públicas. Digitalización. Recursos humanos.

1. INTRODUCTION

The term “Industry 4.0” was created in Germany in 2011 and despite its importance, the term does not have only one definition, it can be seen as the movement to digitize and automate the process in the manufacturing field, connecting platforms through this digitalization (RIBEIRO et al., 2022). Industry 4.0 (I4.0) has its base in technologies that seek to improve the value chains and value-added networks in the industry (DURÃO *et al.*, 2017; MUNIZ Jr. et al., 2023).

The adoption of the I4.0 requires the support of the government to create policies for the creation an economic environment favorable to the rise of new digital business, in Brazil this approach still superficial with the industrial sector risking getting to far behind in its competitiveness (SITORI *et al.* 2021, MUNIZ Jr. & VALENTIM, chapter), this lack of development towards the adoption of the I4.0 can be seen in the other emerging nations aside from China and India, thus being important to them to understand how to create and sustain an environment of competitive advantage with its implementation, while also dealing with financial, technological and strategic limitations (CEZARINO *et al.*, 2019), those limitations can be due to the lack of maturity of the industry, investments in equipment and software limited to automatize routines and to update dated equipment, due to lower income of the population, difficult to innovate with a competitive differential, less integrated supply chain, political and economic instability, and worse quality of education and research institutions (DELENOGARE, 2018). Brazil in particular has three major barriers to its adoption of I4.0, the lack of understanding about the benefits of I4.0, technological infrastructure, and financial restrictions (REIS & FERNANDES, 2023). Within this field of strategic difficulties, there is the adaptation of employees to the I4.0, which is a necessary development in their training (PIO e*t al.*, 2021).

To have a successful digitalization, the workers must be capable and willing to use the adopted technology, factors such as employee morale and good working conditions should not be ignored as they can lead to the failure of the adoption of the I4.0. Hence the process of innovation depends on the combination of the human dimension and the technological

one (BORGES & TAN, 2017).

The implementation of I4.0 leads to greater automation, integration, and efficiency of the processes, which in turn requires its employees to have intellectual and cognitive skills, as well as multidisciplinary and teamwork skills (SILTORI *et al.*, 2021). Oliveira & Santos (2020) and Melo et al., 2022 identify skills expected of a production engineer in Industry 4.0, which concluded that not only technical skills (ex. Internet of Things and Systems Information within I4.0) but also human skills (ex. communication, reading and writing, and knowledge of foreign languages) also have been more sought after.

For the qualification of the worker the I4.0, the HR sector must act to adapt new workers and those to be hired (PIO *et al.* 2021; MELO et al., 2022), in this sense, undergraduate courses play a relevant role in qualifying students to work in I4.0 (RAMPASSO *et al.*, 2019). Few companies have a human resources (HR) department to (1) Map the skills that employees need to have; (2) Establish systems that recognize talent among employees that can be trained; (3) Study new techniques and training to use in the context of I4.0; (4) Estimate needs related to financial resources and employee training time; (5) Study the performance metrics to be used in I4.0; (6) Study the level of autonomy that will be adopted in I4.0 (PIO *et al.* 2021).

The identification of the importance of human aspects in the implementation of I4.0, indicates the research question: How are Germany, China, the United Kingdom (UK), Sweden, Japan, and Brazil treating the training of human resources?

This paper aims to discuss the training of human resources for I4.0 and existing public policies, focusing on the themes Employees– issues related to human resources; Production – referring to the physical resources used in the production process; Social– related to the creation and sharing of knowledge among workers as well effects in the society as a whole. This study will also compare public policies in Germany, China, the United Kingdom (UK), Sweden, Japan, and Brazil.

This paper follows the following structure: Section 2 presents the research method, displaying how the literature review was conducted. Section 3 presents the Theoretical Background, where the relevance of the research theme is displayed. Section 4 presents the Countries comparison, where the findings of the research of each country are displayed. Section 5 presents the results and discussion, where the findings are compared, tabulated and patterns are explicit. Section 6 presents the conclusion, where the conclusions were drawn and the limitations are presented.

2. RESEARCH METHOD

The theoretical review of this research is based on the guidelines presented by

PRISMA (Key Items for Reporting Systematic Reviews and Meta-analysis), especially on the information flowchart of a systematic review (MOHER et al., 2009). Thus, the theoretical review followed the following steps: identification, selection, and eligibility.

In the identification stage, based on the research theme, 3 groups of topics were selected to start the search, namely keywords related to I4.0: "industr* 4.0" OR "manufactur* of the future" or "future manufactur*" OR "advanced manufactur* technolog*" OR "smart* factor*" OR "digitalizat*" OR "smart* manufactur*" AND Human* OR Competenc* OR Skill OR Social* OR Qualific* OR Job* OR Employ* OR Work* AND Brazil.

After searching the databases of the topics above, the selection stage was started based on four selection criteria: the first related to the type of document, considering only articles and reviews, the second considering categories related to engineering, business, management, multidisciplinary humanities, and social sciences, the third and selecting only articles in English and Portuguese and the fourth and last criteria was eligibility, selecting articles based on title and abstract. As the research database, two platforms were used to access the documents: the Web of Science and Scopus.

Table 1 - Theoretical Review Research

Database	**Scopus**	**Web of Science**
Researched Topics (Identification)	"industr* 4.0" OR "manufactur* of the future" or "future manufactur*" OR "advanced manufactur* technolog*" OR "smart* factor*" OR "digitalizat*" OR "smart* manufactur*"AND Human* OR Competenc* OR Skill OR Social* OR Qualific* OR Job* OR Employ* OR Work* AND Brazil	
Results	82	48
Document Type (1st exclusion criteria)	Article AND Review Article	Article AND Review Article
Results	51	42
Categories (2nd exclusion criteria)	all	Management OR Business OR Operations Research Management Science OR Social Sciences Interdisciplinarity OR Education Educational Research OR Engineering Manufacturing OR Education Scientific Disciplines OR Engineering Industrial OR Humanities Multidisciplinary OR Sociology
Results	51	25
Language (3rd exclusion criteria)	English or Portuguese	English or Portuguese
Results	49	24
Eligibility (4th exclusion criteria): titles and abstracts	14	6 (6 in common)
Total nº of articles		14

Source: author (2023)

In Table 1, it is possible to visualize the step-by-step of the theoretical review of the

research.

The critical analysis of the literature related to I4.0 was guided by Nakano and Muniz Jr. (2018) and comprised the review of 14 articles whose records supported the theoretical framework (Section 3).

For the research of the articles of the countries the process was repeated to each one of them, selecting 3 groups of topics: "industr* 4.0" OR "manufactur* of the future" OR "future manufactur*" OR "advanced manufactur* technolog*" OR "smart* factor*" OR "digitalizat*" OR "smart* manufactur*" OR “fourth industrial revolution" AND “policies” OR “Policy” AND the country/nationality as in “China” OR “chinese”

In this step was added the time criteria, excluding articles from before 2018. Furthermore, as in WoS not always had articles in all the selected fields, in the table was put aloof the field selected during the research. As for the UK, although few articles were found in the direct research, several of the articles of the other countries' research included info about the UK.

Table 2 - Country research

Database	**Scopus**	**Web of Science**
Researched Topics (Identification)	"industr* 4.0" OR "manufactur* of the future" OR "future manufactur*" OR "advanced manufactur* technolog*" OR "smart* factor*" OR "digitalizat*" OR "smart* manufactur*" OR “fourth industrial revolution" AND “policies” OR “Policy” AND the country/nationality as in “China” OR “chinese”	
Results	181 Germany 184 China 106 UK 79 Sweden 67 Japan 56 Brazil	185 Germany 305 China 65 UK 47 Sweden 34 Japan 148 Brazil
Time (1st exclusion criteria	Published from 2018	Published from 2018
Results	156 Germany 166 China 83 UK 72 Sweden 55 Japan 51 Brazil	168 Germany 279 China 60 UK 45 Sweden 32 Japan 140 Brazil
Document Type (2nd exclusion criteria)	Article AND Review Article	
Results	118 Germany 122 China 57 UK 48 Sweden 31 Japan 31 Brazil	157 Germany 258 China 45 UK 35 Sweden 29 Japan 121 Brazil
Categories (3rd	Business, Management	Business OR Management OR Business

exclusion criteria)	and Accounting OR Social Sciences OR Economics, Econometrics and Finance OR Engineering OR Decision Sciences OR Psychology	Economics OR Engineering OR Engineering Industrial OR Engineering Manufacturing OR Government Law OR Law OR Multidisciplinary Sciences OR Political Science OR Science Technology Other Topics OR Public Administration OR Social Sciences Interdisciplinary OR Business Finance OR Social Issues OR Psychology OR Multidisciplinary OR Automation Control Systems OR Operation Research Management Science OR Development Studies
Results	92 Germany 106 China 47 UK 47 Sweden 25 Japan 27 Brazil	124 Germany 102 China 19 UK 13 Sweden 14 Japan 42 Brazil
Language (4th exclusion criteria)	English or Portuguese	English or Portuguese
Results	74 Germany 91 China 44 UK 46 Sweden 18 Japan 26 Brazil	77 Germany 102 China 19 UK 13 Sweden 13 Japan 42 Brazil
Eligibility (5th exclusion criteria): titles and abstracts	7 Germany 9 China 1 UK 1 Sweden 5 Japan 5 Brazil	6 Germany 5 China 0 UK 1 Sweden 6 Japan 7 Brazil
Total documents from theoretical review		12 Germany 10 China 1 UK 1 Sweden 7 Japan 10 Brazil

Source: author (2023)

In the direct research, several of the articles of the other countries' research included info about the UK. In Table 2, it is possible to visualize the step-by-step of the country's research.

3. THEORETICAL BACKGROUND

I4.0 represents the integration of a production system through digitalization and

automation of manufacturing mechanisms and processes (RAMPASSO et al., 2019; CEZARINO et al., 2019; PIO et al., 2021; QUELHAS & SOUZA, 2020; MUMMOLO et al., 2019), and the use of technologies that seek to improve the economic performance of a company (QUELHAS et al., 2020; DURÃO et al., 2017). SILTORI et al. (2021) characterize six principles: interoperability, virtualization, decentralization, real-time capacity, service orientation, and modularity.

Of the 14 articles, 7 theoretical reviews were identified (RAMPASSO et al., 2019; PIO et al., 2021; SILTORI et al. 2021; HU, 2021; NICOLETA-CLAUDIA et al., 2021; OLIVEIRA & SANTOS, 2020) and 7 empirical studies, in which DURÃO et al. (2017), focused on organizational and business processes in the distributed production environment, CEZARINO et al. (2019) used the structuralist method to capture the dimensions of the main analysis combining scientific rigor for a long and complex problem, BORGES and TAN (2017) developed an approach that incorporates human aspects in the adoption of Automated and advanced manufacturing technologies (AAMT), PIRES hey al. (2021) carried out a survey of 119,266 employees from 284 companies headquartered in Brazil, QUELHAS & SOUZA (2020) classifies their research as exploratory, bibliographical and qualitative, aided by a bibliographical research, OLIVEIRA, MACHADO & PEREIRA (2021) carried out a survey in 5 medium and small companies in the information technology segment in Brazil. QUELHAS et al. (2020) state that their research used the inductive method, using IT professionals from Brazilian companies, MUMMOLO et al. (2019) carried out a conceptual approach to assess the degree of preparation of a manufacturing company to adopt I4.0, characterizing their research as a conceptual paper.

The articles indicate that the objective of this research is in line with research opportunities related to the skills of new engineers required by Industry 4.0 (QUELHAS & SOUZA, 2020 and OLIVEIRA & SANTOS, 2020), such as "people management, service orientation, negotiations, and cognitive flexibility" (RAMPASSO et al., 2019). There is a need for discussions on organizational guidelines (BORGES and TAN, 2017; CEZARINO et al., 2019; SILTORI et al. 2021; HU, 2021; NICOLETA-CLAUDIA et al., 2021; PIRES et al., 2021; OLIVEIRA, MACHADO & PEREIRA, 2021; QUELHAS et al., 2020; MUMMOLO et al., 2019). DURÃO et al. (2017) deepen the study of a specific organizational structure "central factory and distributed site". In the research carried out, no articles were found that addressed the interaction between the HRs and the adaptation of students and employees to work in I4.0.

4. COUNTRIES COMPARISONS:

As the adoption of the I4.0 requires the country's government to actively promote it through public policies (SITORI et al. 2021), In this section the relevant info about each

country's public policies towards the I4.0 found in the research was extracted and is displayed.

Germany:

Germany, being the birthplace of I4.0, used a wide variety of public policies for its consolidation (DAUDT & WILLCOX, 2018; KUO, SHYU & DING, 2019). In this section, their effects will be analyzed.

National Academy of Science and Engineering (acatech): founded in 2002, politicians can seek external advice in technical, scientific, and technology policy matters, funding was ensured with institutional support from the federation and the 16 federal states (SCHROEDER, 2016). Generally, it emphasizes cyber-physical systems and facilities capable of autonomously exchanging information and triggering other actions (DAUDT & WILLCOX, 2018).

Future of the Manufacturing Industry Alliance: such an alliance was established in Berlin, in 2015. The coordinating body for the alliance is the Ministry of Economics. The alliance aims to improve the conditions that can influence Germany's industrial competitiveness the following sub-targets for the alliance were set out in a declaration "For a contemporary and sustainable manufacturing industry policy in Germany": increase industry acceptance, secure competitiveness through investment and innovation, free trade and free competition, understand digitalization as an opportunity, strengthen industrial policy also in the EU, win specialists also through immigration (SCHROEDER, 2016).

Digital Workplace: has a tripartisan configuration, understanding itself as part of the federal government's “Digital Agenda”. The platform deals with flexible work, in terms of location and time, employment and further education, as well as social protection standards (SCHROEDER, 2016).

High-Tech Strategy 2020: The police began in 2014, to switch from centralized to decentralized networks which connect devices and equipment that communicate with each other and can respond accordingly to gain information for revolutionizing the manufacturing industry (TAY et al., 2018).

The initiative is coordinated by the government and has the participation of important companies (DAUDT & WILLCOX, 2018). It aims to solve challenges posed by globalization, as Germany cannot compete on cost, by making Germany’s production and economy more competitive, efficient, flexible, and digitized. Is designed to explore opportunities posed by specific segments and cross-technologies (POSZYTEC, 2021; DAUDT & WILLCOX, 2018). The project grants billions of Euros each year to develop the latest technologies in the manufacturing industry (TAY et al., 2018). The initiative is coordinated by the government and has the participation of important companies mainly German-owned (KUO, SHYU & DING, 2019). The High-Tech Strategy emphasizes the need to secure new

markets through a mix of mission-oriented projects and export promotion initiatives (DAUDT & WILLCOX, 2018).

Intensive cooperation and consultation with stakeholders are also critical factors in the success of the High-Tech Strategy (KUO, SHYU & DING, 2019).

The strategy succeeded in improving the country's global competitiveness, increasing and consolidating the investments in research, development, and innovation (LABRUNIE, PENNA & KUPFER, 2020).

High-Tech Strategy 2025: This new version was created based on reports from the Industry Science Research Alliance, it began in 2014, with the main task being to amplify the scope of its previous version (LABRUNIE, PENNA & KUPFER, 2020).

It defined 10 projects for the future (ARBIX et al., 2018): Cities with energetic efficacy and neutral balance on CO2 emissions; Biomass as an alternative to oil; Intelligent conversion of energetic sources; Medical treatment personalized; Preventive health and nutrition; Aging and independent living; Sustainable mobility; Internet for the economy; Industrie 4.0; Secure identification.

Brings together all previous solutions in a broader and more interdepartmental innovation policy. As such, new topics and innovation funding tools were included, as well as an expansion of the concept of innovation to include not only technological innovations but also social innovations, which has society as a central participant. The main objective of Germany's industrial strategy is to create an environment where new ideas are rapidly transformed into innovative products and services, thus advancing the country's position as the European and global leader in innovation, while generating prosperity and providing a higher quality of life for its population. Achieving these goals entails finding creative answers to the urgent challenges of our time, such as sustainable urban development, sustainable energy, individualized medicine, and the challenges of digital society (LABRUNIE, PENNA & KUPFER, 2020).

Fraunhofer Institute of Labour Economics: This is a post-war network of institutes, that is one of the major pillars of German industrial policies (DAUDT & WILLCOX, 2018), with the aim of initiating research for small and medium-sized enterprises (LEE, LEE & SUNG, 2018), The institute seeks, above all, to facilitate the access to technological progress for SMEs (LEE, LEE & SUNG, 2018). The Fraunhofer Institute is also responsible for policies such as the Industrial Community Research (IGF), which fills the gap between basic research and economic application, new technologies are processed here for entire economic sectors or often across sectors, Companies accompany the research work that is geared to their needs and interests, the IGF results are open to all interested parties being they, the precursor for company-specific developments, for example, in Germany, companies are not only involved in a work-sharing based system but also a cooperation system (LEE, LEE & SUNG, 2018).

Industrie 4.0 platform: One of Europe's largest technical-scientific associations and

e-published the first German standardization roadmap (KUO, SHYU & DING, 2019). The goal of the platform is to advance the fourth industrial revolution in Germany, developing intensive applications of digital technologies of communication and industrial information (ARBIX et al., 2018). Gathers representatives from government, business, trade unions, and research institutes tasked with collectively achieving a shared understanding and common technical standards around the transformations in the technological domain, the organizational realm, and the effects on human beings (PRODI et al., 2022).

Three major aspects of the platform are drawing the attention of many governments, companies, and researchers: (1) it focuses on the development of advanced manufacturing technologies; (2) the medium and long-term spectrum; (3) The aggregating nature and the institutional amplitude (ARBIX et al., 2018).

The goals are to accelerate the digitalization of traditional industries and to develop smart services. The Industrie 4.0 programme includes several projects designed to foster technological development in Germany to help to maintain its leadership in innovation. Industrie 4.0 projects are related to the fields of cyber-physical systems, Information and Communication Technologies (ICT), autonomics, and resource efficiency (CORROCHER, MAVILLIA & GIORGIO, 2018).

Mittelstand 4.0: digital production and work processes: Established in 2013, this initiative targets the creation of competence centers (CCs) across the country. A CC is a network of innovation intermediaries located within the boundaries of a federal state, tasked with supporting both local innovation ecosystem participants and more digitally backward small-to-medium enterprises (SMEs) in terms of their adoption of Industry 4.0 solutions and, more broadly, engaging with manufacturing digitalization. A CC is a network made up of a limited number of intermediary organizations and non-market actors (ranging from 4 to 10) experienced in technology development and knowledge transfer activities. Each CC leverages the competencies embedded in the two categories of partners that the CC itself is made up of (1) research institutions and research and technologies organizations (such as universities and Fraunhofer institutes), where most Industry 4.0 applications and technologies are developed and tested and (2) nonmarket partners (such as chambers of commerce or industry organizations) familiar with SME needs. This arrangement ensures an appropriate mix of frontier research, technology transfer experience, and expertise in tackling the challenges that SMEs face in expanding their business. CCs are tasked with advising SMEs on the economic benefits of and issues related to the use of Industry 4.0 applications and supporting them in developing tailored solutions for business optimization. CCs exclusively target SMEs located in their respective federal states. The CC also promotes training for managers, employees, and trade union members (PRODI et al., 2022).

In a nutshell, Mittelstand 4.0 seeks to increase the competitiveness of small and medium enterprises by establishing research centers and model factories for the

transference of practical knowledge and capability building, highlighting the Research Centre for Artificial Intelligence (LABRUNIE, PENNA & KUPFER, 2020).

China:

China's efforts to adopt the I4.0 are focused on securing an exporting structure and improving its manufacturing production, the Chinese focus is majorly under the Made in China 2025 policy, but it also possesses other auxiliary policies (AGARWALA & CHAUDHARY, 2021). In this section, the effects of those policies will be analyzed.

Made in China 2025: The police began in 2015. It's the first 10-year national plan for transforming manufacturing (KUO, SHYU & DING, 2019), aiming to boost the manufacturing industry by giving efficiency and quality to domestic products. It is inspired by the German policy "Industry 4.0" (PAUTASSO, 2019, AGARWALA & CHAUDHARY, 2021; CORROCHER, MAVILLIA & GIORGIO, 2018). It seeks to improve the multi-level personnel training system (ZHANG et al., 2018) and possesses a focus on self-reliance on some key components, such as semiconductors and innovation, seeking to achieve high-income status (AGARWALA & CHAUDHARY, 2021; LABRUNIE, PENNA & KUPFER, 2020). To a certain extent, it also includes preoccupations about sustainability, such as pollution and resource efficiency (LABRUNIE, PENNA & KUPFER, 2020).

It includes five main projects related to the construction of manufacturing innovation centers, smart manufacturing projects, manufacturing base strengthening projects, green manufacturing projects, and high-end equipment innovation projects (CORROCHER, MAVILLIA & GIORGIO, 2018), the plan expects to increase the funds in research and development (R&D) of large manufacturing business from 0.95% in 2015 to 1,68% in 2025 (LABRUNIE, PENNA & KUPFER, 2020; CORROCHER, MAVILLIA & GIORGIO, 2018).

In order to achieve its goals, five directives are defined: Promote innovation; improve quality of products and services available in the market; make the economy more sustainable; optimize the industrial structure; and encourage the qualification of human resources and talent retention (ARBIX et al., 2018).

The policy has 10 priority sectors: new advanced information technology; automated machine tools and robotics; aerospace and aeronautical equipment; maritime equipment and high technology transportation; modern railway equipment; new energy vehicles and equipment; power equipment; agricultural equipment; new materials; and biopharmaceuticals and advanced medical products (PAUTASSO, 2019; ARBIX et al., 2018; WANG, WU & CHEN, 2020; LABRUNIE, PENNA & KUPFER, 2020). To advance these priorities, the central government, together with big companies, defined and concentrated resources on strategy areas, making intensive public purchases and making possible mergers and acquisitions of foreign companies to access their technologies (ARBIX et al., 2018).

The entire objective is to increase the national content of national components and

materials first to 40% by 2020 and then to 70% by 2025 (PAUTASSO, 2019), while also significantly increasing the overall quality of the manufacturing sector, enhancing the innovation capacity and significantly improving the full labor productivity, achieving a new level of integration of industrialization and informatization (KUO, SHYU & DING, 2019).

It aims to achieve its goal through several financial instruments such as large-scale technology funds, non-financial instruments, such as the creation of National Manufacturing Innovation Centres, and investments in digital infrastructure, and other types of instruments, such as the Pilot Cities and National Demonstration Zones (LABRUNIE, PENNA & KUPFER, 2020).

There are 12 indicators targeted by the policy, 4 related to Ecology, 2 to Innovation, 3 to Quality and Cost, and 3 related to Industrialization & Informalization (WANG, WU & CHEN, 2020).

Finally, the most important aspect of the policy is the promotion and dissemination of smart manufacturing (AL-SAYED & YANG, 2018).

Guiding opinions of the State Council on promoting "Internet plus" action: The police began in 2015. It strengthens intellectual building, as it seeks to strengthen the training of the application of capacity, accelerates the training of compound talents, and encourages joint training as well as the use of global intellectual resources (ZHANG et al., 2018).

"Internet plus" artificial intelligence 3-year action plan: The police began in 2016. It is an action plan with a variety of objectives in four different areas: Economic: through internet applications in all economic sectors and E-commerce; Social: through services platforms addressing health, education, and transportation sectors; Infrastructure: building next-generation broadband as well as promoting AI, IoT and cloud computing; Environment: raising awareness and issuing regulations and standards (AL-SAYED & YANG, 2018).

It encourages relevant research institutions, institutions of universities, and experts to carry out the basic knowledge and application training of artificial intelligence (ZHANG et al., 2018).

The main goal is to drive economic growth through the integration of Internet technologies with manufacturing business (AL-SAYED & YANG, 2018).

13th Five-Year National Science and Technology Innovation Plan: The police began in 2016. Prioritizes the development of talents, bringing them to the highest priority of scientific and technological innovation (ZHANG et al., 2018). It promotes the digitalization of Chinese universities (XIAO, 2019).

New generation artificial intelligence development plan: The police began in 2016. It accelerates the training and gathering of artificial intelligence high-end talents, vigorously strengthens the training of the artificial intelligence labor, establishes a lifelong learning of employment training system to meet the needs of smart economy and smart society,

supports the training of artificial intelligence skills in colleges and universities, vocational schools and socialized training institutions (ZHANG et al., 2018).

UK:

The UK has a long-term action plan for its manufacturing industries called "Future of Manufacturing", created in 2013, which reoriented and rebalanced policies to support manufacturing resilience through 2050 (RODRIGUES et al., 2020; TAY et al., 2018), in 2017 however a detailed document named "Industrial strategy: building a Britain fit for future" was published, proposing a high amount of resources destined to various areas such as research, infrastructure, education and training, specific sectors, and regions. This strategy is commanded by the British government, and assisted by several public-private agencies. The policy objectives include supporting the research system, enhancing workforce skills, investing in infrastructure, improving the business environment, and promoting specific locations. Financial instruments like public funding for R&D, SMEs, start-ups, less developed regions, skill development and training, and infrastructure; creation of research centers, testbeds, training centers, networks, regulation reform, and programs for international collaboration in research. The policy also seeks to make the UK a global leader in the design of the future of mobility, maximization of the advantages of clean growth, using innovation to find solutions for an aging society and development of artificial intelligence. (LABRUNIE, PENNA & KUPFER, 2020).

In the Walles, the government has the Digital Wales strategic plan, with the goal to improve digital information and services and save money, as well as the Superfast Broadband Business Exploitation (SFBE) funded partly by the European Regional Development Funds and managed by the Welsh government, which seeks to support SMEs on the adoption of I4.0 technologies. By providing specialist information and grant funds to enable them to purchase new IT (HENDERSON, 2020).

Sweden:

There was no article about the public policies about I4.0 in Sweden specific with the research filters, but the one selected is still useful for the analysis, however, there is the existence of the Produktion2030, which if searched for on Scopus and WoS results on results on conference papers, with are outside this paper research spectrum.

The article selected was about e-governance in the EU (MISKIEWICZ, 2022), with the author defining it as "the provision of public services via the Internet and IT in all processes carried out by public sector organizations", highlighting Sweden as one of the most advanced on this aspect, on the same article, Germany was deemed needing to improve.

Japan:

The main policy of the Japanese regarding the I4.0 is the Society 5.0 (SANTOS et al., 2021; RIMINUCCI, 2018).

In Japan, intellectual properties are well protected and there's a lot of scientific cooperation with other nations (NAFCHI & MOHELSKA, 2018). The Japanese government seeks to encourage and create favorable conditions for vocational education and training systems in companies and enterprises, as well as preferential policies for skilled and expert workers. There are policies of pay rises and seniority bonuses. The government aims to promote the creativity and initiatives of workers, creating favorable conditions for workers' quick adaptation to changes in working conditions, such as the introduction of new technologies (PHAM & DUNG, 2022). Also, a case study made by AZHAR, MOHAMAD & PITCHAY (2022) showed that Japanese companies have been pressuring their subsidiaries to adopt I4.0 practices.

The Cabinet of Japan published the Future Investment Strategy (FIS) in June 2017, suggesting "Society 5.0" as a way to integrate society and industry into the innovations of the I4.0. Starting with policies aimed at expanding investments in human resources and its development, seeking to improve individual working skills needed by the I4.0, cooperation between industry, government, and academia, and focus on the development and expansion of IT skills. When it comes to improvements in productivity, the plans include diversification and flexibilization of work, such as limiting working hours, reducing unfair treatment between workers, increase of wages, promotion of diversity, and inclusiveness of people with disabilities. Finally, an online platform would be developed in order to collect occupational information and increase its visibility, promoting labor mobility of older workers by enhancing their career education and a system for the fair settling of labor disputes. (RIMINUCCI, 2018).

The Japanese policies aim at strengthening Japanese innovation and expanding the partnerships between industry, academia, and government with financial instruments such as public funding and tax incentives for R&D, SMEs, start-ups, and less developed regions. Also proposes the creation of a "service platform" integrating several productive systems and the creation of "Designated National R&D Institutes '. Among their objectives are sustainable growth and regional development, guaranteeing security, high quality and prosperous way of life for its citizens, sustainable creation of intellectual assets, increase in the number of full-time university workers, development of sensors and AI technologies, and increase of robots in manufacturing plants and quotidian scenarios (LABRUNIE, PENNA & KUPFER, 2020).

Brazil:

In 2017, the São Paulo Industries Federation (FIESP) made a survey that showed that

in a sample of 227 companies, 73 didn't know the term “Fourth Industrial Revolution” or its variants, to make things worse, due to the recent COVID-19 pandemic, many Brazilian manufacturing companies postponed most of their initiatives associated to I4.0 in order to survive (CAZERI, EULALIA & RAMPASSO, 2020).

Brazil has three major barriers to its adoption of the I4.0, the lack of understanding about the benefits of I4.0, technological infrastructure, and financial restrictions (REIS & FERNANDES, 2023)

DAUDT & WILLCOX (2018), recalls that although not oriented directed to adopt the I4.0, some initiatives happened to modernize Brazilian industries, such as the Inova Empresa (2013-2015), which involved public calls for supporting priority sectors and technologies, and the PNPC, which sought to create knowledge platforms in selected areas strengthening research institutions, CEZARINO et al. (2019), also brings the Brazilian National Innovation System (SNI), which seeks to provide technological autonomy, providing investment and incentives to scientific and technological development. There is also the Strategic alliance to promote technological innovation, composed of the Abipti, Anpei, and Anprotec, all Brazilian research associations, it’s an institutional articulation and permanent exchange of info between the entities (DA SILVA, PUFFAL & FLORES, 2020).

One issue with the investments in software acquisition is that they brought no market benefits or internal improvement of the manufacturing process, possibly due to acquiring them to only automate their operational routines instead of advanced ICT tools (RODRIGUES et al., 2020).

BAIERLE et al. (2022) analyzed the state of the Brazilian industries toward the I4.0, finding that despite none of the Brazilian industries being I4.0, electrical, electronic, vehicle, machinery, coke, and refined petroleum, other manufacturing, mining of metal ores and food industry are aligned towards the I4.0, but still requires more investment to bring economic and technological development.

FERRAZ et al. (2019) state that up to 2027, around 60% of the firms at a basic digitalization level in 2017 are expected to move forward, however, many are not taking actions to further digitalize.

5. RESULTS AND DISCUSSION

In order to compare the policies towards their adoption of the I4.0 and its effects on the Social, Production, and Employee aspects, Figure 1 was made.

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Figure 1 - Policies comparison

Social	Countries	Production	Countries	Employees	Countries
Makes easier the policymaking process for technical, scientific, and technological policies.	Germany	Helps in the improvement of automation.	Germany China UK Japan	Social protection standards.	Germany Japan
Investment in research.	Germany China UK Japan Brazil	Better adaptability for future conditions/manufacturing resilience.	Germany UK	The effects of I4.0 on human beings is studied.	Germany
International collaboration in research about I4.0.	Germany UK Japan	Lower entry obstacles for medium-sized and smaller enterprises.	Germany UK Japan	Helps maintaining the popular health and prosperity to its citizens.	Germany Japan
Helps the spread of I4.0 throughout the country in a more democratic way.	Germany UK Japan	Helps the industrial competitiveness.	Germany China	makes it easier for workers to pursue further education.	Germany
Digitalization of the economy, services, and information.	Germany UK Sweden	Helps the process of digitization/automatization of the industry.	Germany China UK	Eases flexible work.	Germany
Seeks to reinforce the country's global position.	Germany China UK	Actively seeks foreign specialists.	Germany	Constant training of the workforce.	Germany China UK Japan
Preoccupations about sustainability.	Germany China UK Japan	SMEs gets support for the development of business optimization solutions.	Germany UK Japan	Efforts on talent retention.	China
Focus on AI development.	Germany China UK Japan	Increases the efficiency and quality to domestic products.	China	Improvement of the business environment.	Germany UK Japan
Creation knowledge platforms.	Germany Brazil	Seeks self-reliance on some key components, such as semiconductors.	China	Seeks to increase per capita income.	China Japan
Research for solutions to aging society.	UK	Seeks the development of large manufacturing business.	China	Increase payments and bonuses to older workers as well their labor mobility.	Japan
Effort to provide technological autonomy.	Brazil	Acquirement of foreign manufacturing technologies.	China	Promotes equality, diversity, and inclusiveness on the work environment.	Japan
		Focus on priority sectors and technology.	China Brazil	Creation of a system for the fair settling of labor disputes.	Japan
		Support for Start-ups.	UK Japan		
		Increase of robots in manufacturing plants and quotidian scenarios.	Japan		

Source: author (2023)

Comparing the results on the Society aspect, we can highlight that China, Germany, and the UK seek to reinforce their global position with the adoption of the I4.0 (DAUDT & WILLCOX, 2018; LABRUNIE, PENNA & KUPFER, 2020; KUO, SHYU & DING, 2019), they and Japan are making great investment on research on the area (ARBIX et al., 2018; KUO, SHYU & DING, 2019; TAY et al., 2018; LABRUNIE, PENNA & KUPFER, 2020), (NAFCHI & MOHELSKA, 2018; NAFCHI & MOHELSKA, 2018), China and Germany also incentivize the immigration of foreigners intellectuals (SCHROEDER, 2016; ZHANG et al., 2018), China, Germany, the UK and Japan show some sustainability preoccupations (ARBIX et al., 2018; LABRUNIE, PENNA & KUPFER, 2020; ARBIX et al., 2018). Germany, China, the UK, and Japan have a focus on the research of artificial intelligence technologies (PRODI et al., 2022; LABRUNIE, PENNA & KUPFER, 2020; ARBIX et al., 2018). UK and Sweden showed some efforts to digitize their public services (HENDERSON, 2020; MISKIEWICZ, 2022).

Now comparing the results on the Production aspect, China, Germany, the UK, and Japan wants the automation of their industries, but while Germany, the UK, and Japan seek to contemplate medium and smaller-sized enterprises as well as increasing the efficiency of the decentralized network, while China focuses on the large and centralized manufacturing business (PRODI et al., 2022; LABRUNIE, PENNA & KUPFER, 2020, LABRUNIE, PENNA & KUPFER, 2020; CORROCHER, MAVILLIA & GIORGIO, 2018), the four put efforts to achieve greater cooperation between different sectors of the economy (DAUDT & WILLCOX, 2018, KUO, SHYU & DING, 2019; RIMINUCCI, 2018; LABRUNIE, PENNA & KUPFER, 2020). China, to get its production technologies on par with the foreign ones, actively acquires foreign manufacturing technologies (ARBIX et al. 2018). Finally, China seeks to achieve self-reliance on some key components, such as semiconductors (AGARWALA & CHAUDHARY, 2021; LABRUNIE, PENNA & KUPFER, 2020), by 2022 it achieved success in the assembly step but not yet on the design and fabrication (GARCÍA-HERRERO & WEIL, 2022). China goes for a more focused investment on the I4.0, while Germany, the UK, and Japan seek to spread it more democratically (PRODI et al., 2022; LABRUNIE, PENNA & KUPFER, 2020; ARBIX et al., 2018). Japan has a bigger focus on the use and development of robots (LABRUNIE, PENNA & KUPFER, 2020).

Lastly, comparing the results on the Employees aspect, China, Germany, the UK, and Japan actively seek to further professionalize their employees and to keep them (ARBIX et al., 2018; SCHROEDER, 2016; ZHANG et al., 2018, LABRUNIE, PENNA & KUPFER, 2020; RIMINUCCI, 2018). Germany, the UK, and Japan also focus on maintaining the health of their citizens in good condition (ARBIX et al., 2018; LABRUNIE, PENNA & KUPFER, 2020; RIMINUCCI, 2018; PHAM & DUNG, 2022), Germany also encourages the study of the effects of the I4.0 on human beings (PRODI et al., 2022), eases flexible work practices, and seeks to establish social protection standards. Japan created a system of fair settlement of labor

disputes and has a focus on the well-being of older workers (PHAM & DUNG, 2022; RIMINUCCI, 2018).

Brazil has made efforts to strengthen its research (CEZARINO et al., 2019; DA SILVA, PUFFAL & FLORES, 2020) in the Society aspect and support priority sector and technologies (CEZARINO et al., 2019) in the Production aspect, however, there was no mention to any Employees aspect in this research.

6. CONCLUSION

While China, Germany, the UK, and Japan have major similarities in their way of adopting the I4.0 in all three aspects, when it comes to how it's implemented and the improvement of the employer's life standards, there is a major diversion in their policies. Germany, the UK, and Japan seek to spread to contemplate medium and small-sized enterprises besides the big-sized ones, while China focuses on the large and centralized manufacturing business (PRODI et al., 2022; LABRUNIE, PENNA & KUPFER, 2020; LABRUNIE, PENNA & KUPFER, 2020; CORROCHER, MAVILLIA & GIORGIO, 2018). Germany, the UK, and Japan also show an active effort in their policies to improve the quality of life of their workforce besides increasing the income per capita (ARBIX et al., 2018; LABRUNIE, PENNA & KUPFER, 2020; SCHROEDER, 2016; PHAM & DUNG, 2022; RIMINUCCI, 2018).

Finally, despite those differences, the backbone of China, Germany, the UK, and Japan in their efforts towards the I4.0, is a greater focus on research and the adaptation of its human resources to the I4.0 by investing in the formation and constant professionalization of its workforce (ARBIX et al., 2018; SCHROEDER, 2016; ZHANG et al., 2018; LABRUNIE, PENNA & KUPFER, 2020; PHAM & DUNG, 2022; RIMINUCCI, 2018).

Brazil although not having I4.0 possesses some initiatives that mimic successful ones in the countries studied in this article, like the creation of a knowledge platform and the prioritization of strategic sectors and technologies (CEZARINO et al., 2019), as seen in this paper, the research of new technologies is essential to any policy aimed to the adoption of the I4.0, however, Brazil lacked initiatives to solve the lack of understanding about the benefits of the I4.0, although the Inova Empresa do help to finance innovative projects, it only lasted from 2013-2015, finally, Brazil has some investment in its technological infrastructure but most processes and products are mimicry of what was produced and production models of other countries, as well having a historical deficit in its physical infrastructure (FIGUEIREDO & GRAGLIA, 2021).

Brazil has some initiatives in the right direction, but they are few and fail to solve any of the three major barriers, not only that but also neglect the human aspect. With the info reunited in this article, is possible to identify with kind of public policies nations that already

adopted the I4.0 have, however Brazil has issues of a development nation, that are absent in the other countries analyzed, and thus, before trying to replicate, would be wise to research how to adapt those policies to the Brazilian reality.

This paper was based on articles available in the Web of Science and Scopus databases where many more articles about Germany and China were found than the other nations, Sweden in particular, so they might require further understanding of their public policies.

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