INTERNATIONAL JOURNAL OF DIGITAL LAW - IJDL
ano 02 · n. 03 · setembro/dezembro 2021 - Publicação quadrimestral
DOI: 10.47975/digital.law.vol.2.n.3

03

ISSN 2675-7087

IJDL

International Journal of DIGITAL LAW

NUPED
Núcleo de Pesquisas em Políticas Públicas e Desenvolvimento Humano da PUCPR

FORUM

DOI: 10.47975/IJDL.coimbra.v.2.n.3

Public foment for innovation in artificial intelligence: an assessment based on technological data from patents

Fomento público à inovação em inteligência artificial: uma avaliação a partir dos dados tecnológicos de patentes

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Recebido/Received: 19.10.2021/ October 19th, 2021
Aprovado/Approved: 03.12.2021/ December 3rd, 2021

Abstract: This paper aims to study the Brazilian public policy for fomenting innovation in Artificial Intelligence (AI), presenting the initial premise (hypothesis), to be inductively tested, that its greatest challenge is related to the endogenization or internalization of the processes of development and production of AI-related technologies in the country. To this end, we analyze data from the patenting of these technologies in Brazil, the most widely used indicator to measure national technological innovation, contrasting them with international data. Considering the diversity of formats that such

Como citar este artigo/*How to cite this article*: COIMBRA, Elisa; LÔBO, Flávio Luiz de Aguiar. Public foment for innovation in artificial intelligence: an assessment based on technological data from patents. *International Journal of Digital Law*, Belo Horizonte, ano 2, n. 3, p. 11-26, set./dez. 2021. DOI: 10.47975/IJDL.coimbra.v.2.n.3.

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public policies can take, this work reveals its importance, since it provides an accurate diagnosis of the reality in the AI segment in Brazil, a fundamental subsidy for the formulation of efficient planning.

Keywords: Foment. Public policy. Planning. Innovation. Artificial intelligence. Technological data. Patents.

Resumo: Este trabalho objetiva estudar a política pública brasileira de fomento à inovação em Inteligência Artificial (IA), apresentando a premissa inicial (hipótese), a ser testada indutivamente, de que seu maior desafio está relacionado à endogenização ou interiorização dos processos de desenvolvimento e produção de tecnologias relacionadas à IA no país. Para tanto, analisam-se dados de registro de patentes dessas tecnologias no Brasil, indicador mais utilizado para medir a inovação tecnológica nacional, contrastando-os com dados internacionais. Considerando a diversidade de formatos que tais políticas públicas podem assumir, o presente trabalho revela sua importância, pois fornece um diagnóstico apurado da realidade no segmento de IA no Brasil, subsídio fundamental para a formulação de um planejamento eficiente.

Palavras-chave: Fomento. Política pública. Planejamento. Inovação. Inteligência artificial. Dados tecnológicos. Patentes.

1 Introduction

Health, safety, education, telecommunications, agriculture, livestock, mobility, commerce, and hospitality are just some of the industries already deeply affected by the use of Artificial Intelligence (AI).[1] The list of segments under transformation is extensive and tends to grow, also reaching public services, the Public Administration and other activities developed by all branches of power (Executive, Legislative and Judiciary),[2] which is why this paper focuses on the study of State planning and foment policies for the development of this technology in Brazil.

Its importance stems, among other things, from the fact that AI is a key enabling technology, that is, a mechanism that shows utility for different areas of knowledge, because it can interact with many others and have different applications.[3]

Furthermore, there are many studies that relate innovation and economic development.[4] Therefore, if the National Innovation Policy – Decree No. 10,534/2020

1 CORVALÁN, Juan G. Inteligencia Artificial GPT-3, PretorIA y oráculos algorítmicos en el Derecho. *International Journal of Digital Law*, Belo Horizonte, year 1, n. 1, p. 11-52, jan./apr. 2020.

2 FIGUEIREDO, Carla Regina Bortolaz de; CABRAL, Flávio Garcia. Inteligência artificial: machine learning na Administração Pública. *International Journal of Digital Law*, Belo Horizonte, year 1, n. 1, p. 79-95, jan./apr. 2020.

3 OECD. Start-up Latin America. *National Intellectual Property Systems, Innovation and Economic Development* – With perspectives on Colombia and Indonesia. 2014.

4 See contributions by: DAHLSTRAND, Asa Lindholm; STEVENSON, Lois. Innovative entrepreneurship policy: linking innovation and entrepreneurship in a European context. *Annals of Innovation & Entrepreneurship*, v. 1, n. 1, p. 5602, 2010; PASCAL, Andre. *Science, technology and industry outlook*. OECD, 2001; ROSENBERG, Nathan (Ed.). *Studies on Science and the Innovation Process: Selected Works by Nathan Rosenberg*. World Scientific, 2009; KLINE, Stephen J.; ROSENBERG, Nathan. An overview of innovation. *Studies on Science*

– disregarded the reality of AI, probably in a few years the national economy would accumulate a huge sum of losses related to unrealized economic transactions.

Along these lines, in view of the principles, axes, goals, and guidelines established by the National Innovation Policy, the current Ministry of Science, Technology, and Innovations (MCTI) has listed AI as an enabling technology, in terms of MCTIC Administrative Rule No. 1,122/2021, suggesting priority to the promotion of its development in the national territory by the Executive Power.

In this context, the Brazilian government released a policy to foment, or foster, innovation in AI, materialized in the Brazilian Strategy for Artificial Intelligence (EBIA) – MCTI Ordinance No. 4,617/2021 (amended by MCTI Ordinance No. 4,979/2021) – which included among its objectives: (a) the promotion of sustained investments in AI research and development; (b) the removal of barriers to innovation in AI; (iii) the training and education of professionals for the AI ecosystem; (iv) the stimulation of innovation and the development of Brazilian AI in an international environment, and; (v) the promotion of an environment of cooperation between public and private entities, industries and research centers for the development of AI in Brazil.

Taking such elements into consideration, by inductive reasoning, this paper presents the initial premise (hypothesis) that there is a great challenge for artificial intelligence incentive policy, related to the endogenization or internalization of the productive process related to artificial intelligence, despite the efforts made so far. In other words, there is a challenge in transforming an innovative idea into a product, in such a way that its effective development and technological production occurs within the national territory, solving genuinely national problems and/or maximizing wealth for the country and employing more qualified and better paid professionals.

According to the Handbook of Patent Statistics,[5] patents are one of the few output indicators related to technology and economic performance, and probably the most widely used. Also, still according to the Handbook, patents can be used as mechanisms to map certain aspects of the dynamics of the innovation process, such as those related to research cooperation and the level of technological diffusion between industries and countries.

Thus, throughout the paper, technological data from patents will be analyzed and, at the end, a theoretical construction resulting from the inferences drawn from these analyzed data will be presented as a conclusion. After all, data related to patents is very representative, since it is the most widely used technological indicator

and the innovation process: Selected Works of Nathan Rosenberg. 2010. p. 173-203; HUDSON, John; MINEA, Alexandru. Innovation, intellectual property rights, and economic development: a unified empirical investigation. *World Development*, v. 46, p. 66-78, 2013.

[5] OECD. *Patent Statistics Manual*. 2. ed. Paris: OECD Publishing, 2009.

to measure national innovation.[6] Furthermore, data from specialized literature on the subject will be used to complement the analysis, thus allowing a more robust theoretical construction.

From the outset, it is recognized that this type of methodology finds support in the *Grounded Theory*, theorized by Kathy Charmaz,[7] which teaches how to build a reflection from empirical data, whose approach can be complemented by the inference rules of Lee Epstein and Gary King,[8] defined by the authors as learning facts we don't know by using known facts.

According to Lee Epstein and Gary King,[9] the recommendation to collect the largest amount of data is not incompatible with the possibility of using easier methods to do this, since the most specialized task of an empirical researcher is making inferences.

For this, in the case of data related to patents, the information available in the patent scope platform, supported by the World Intellectual Property Organization (WIPO), will be adopted. The choice is justified because its historical series is more robust and internationally comprehensive if compared to others, due to WIPO's efforts in organizing this platform.

The importance of this work arises from providing subsidies for the formulation of more efficient Brazilian public policies, given that, among the infinite possibilities at Government's disposal to carry out foment activities, some will achieve results closer to those initially projected. Thus, the more variables of reality are known, the better. In this aspect, this work contributes by presenting technological data and related technical inferences to contribute to a more structured IA development, since the *State foment* can be defined as:

> every interventionist activity from the Administration, positive or negative, that aims, in a non-coercive way, to induce, instigate, provoke, promote, protect, propel, encourage, shelter, direct, propel, or foster directly, immediately and concretely, the private sector and even other administrative entities or agencies, to the decision-making in specific sectors, with the objective to satisfy certain public interests, by means of activities rendered in favor of the entire collectivity, unburdening the structure of the one that performs it, and aiming at economic or social

6 See: OECD/Eurostat. *Oslo Manual: Guidelines for Collecting, Reporting and Using Data on Innovation.* 4. ed. Paris/Eurostat, Luxembourg: OECD Publishing, 2018; OECD. *Manual de Oslo: Diretrizes para coleta e interpretação de dados sobre inovação.* 3. ed. Trad. Rio de Janeiro: Finep, 2005.

7 CHARMAZ, Kathy. *A construção da teoria fundamentada*: guia prático para análise qualitativa. Porto Alegre: Bookman Editora, 2009.

8 EPSTEIN, L.; KING, G. 2013. *Pesquisa empírica em direito*: as regras de inferência. Various Translators. São Paulo: GV Law.

9 EPSTEIN, L.; KING, G. 2013. *Pesquisa empírica em direito*: as regras de inferência. Various Translators. São Paulo: GV Law.

> development or progress, supplying eventual deficiencies in a temporary and transitory manner, as a way to achieve objectives foreseen in the Constitution and to put fundamental rights into effect.[10]

In short, there are several possibilities for a stimulative State activity. However, the efficiency of each measure will depend a lot on elements of reality, which is why they need to be studied based on empirical data, the object of this research.

2 The complexity of innovation, especially when associated with artificial intelligence and the legal mark

Jan Fagerberg, when discussing the phenomenon of innovation, does not consider it a recent phenomenon, associating it with the human nature of thinking about problems and implementing solutions. However, innovation attracts the attention of academics for a relatively recent period, so that the first studies on innovation as a separate field of research appear in the 1960s,[11] although strangers to the most prestigious disciplines and universities.[12]

It happens that innovation is a complex phenomenon, because it involves two sets of forces that interact with each other in an unpredictable and sudden way: the *market* and the *scientific-technological progress*.[13] Both are associated and interact to produce new products/processes/others[14] with low cost and high market acceptance, so that the consequence of the whole process is economic growth, thus breaking with earlier economic cycles related to previous innovations. According to Kline and Rosenberg,[15] the innovation process is an exercise of managing and reducing uncertainties, not only related to technical performance, but also to the response of the market and businesses in absorbing and effectively using the "new".[16] The

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10 Free translation from André Saddy's definition in: SADDY, André; SOUSA, Horácio Augusto Mendes; RODOR, Fernanda Medeiros e Ribeiro. *Direito Público das Startups*: uma nova governança público-privada nas parcerias administrativas entre o Estado e as entidades de tecnologias e inovação. 2. ed. Rio de Janeiro: CEEJ, 2021, p. 69 and 70.

11 Before that, for example, Karl Marx (2010) studied technical progress, although tangentially to the main theme of labor exploitation, associating it with the increase in productivity and the increase in surplus value. Such concepts were later taken up in Schumpeterian theory.

12 FAGERBERG, Jan. Innovation: a guide to the literature. *In*: Fagerberg J., Mowery DC, Nelson RR (Org.). *Oxford handbook of innovation*. New York: Oxford University Press, 2004. p. 1-26.

13 KLINE, Stephen J.; ROSENBERG, Nathan. An overview of innovation. *Studies on Science and the Innovation Process: Selected Works of Nathan Rosenberg*. 2010. p. 173-203.

14 This constant resistance in the text to categorically indicate the content of innovation reflects a broadening trend of the concept that used to encompass only product and process, but now encompasses other categories such as non-technological innovations (organizational and *marketing*), reproduced in the evolution of the Oslo Manual editions (OECD, 2006 and OECD/Eurostat, 2018).

15 KLINE, Stephen J.; ROSENBERG, Nathan. An overview of innovation. *Studies on Science and the Innovation Process: Selected Works of Nathan Rosenberg*. 2010. p. 173-203.

16 To better understand the phenomenon of disruption, see SADDY, André; CHAUVET, Rodrigo da Fonseca; SILVA, Priscila Menezes da (Coord). *Aspectos Jurídicos das Novas Tecnologias (Inovações) Disruptivas*. Rio de Janeiro: Lumen Juris, 2019.

fact is that this correlation between market, technology and innovation varies from case to case, depending on each of these variables.

Besides describing the nodes in the innovation process, Kline and Rosenberg[17] indicate some critical factors for the innovation process to occur, so that overcoming each one of them has relevance in its leverage. Among them are the difficulty of dealing with (a) the development costs of innovation, which imply a threat to the ability of the entrepreneurial society to reorganize itself around innovation; (b) the resistance to radical innovations, especially those working with the dominant technologies of the moment; (c) the financial risks of recovering the investment and; (d) the development of something "new" that is superior from the point of view of performance and, at the same time, desirable by consumers, who do not know the product yet, working with future expectations that do not exist yet.[18]

In this context, it is necessary to recognize the importance of foment within the national innovation system,[19] aiming precisely to overcome the innovation knots – some indicated above by Kline and Rosenberg[20] – which, in developing countries, are amplified. For this reason, foment activities[21] have normative foresight in the text of the Brazilian Constitution,[22] especially in art. 174.

It should also be noted that, after the above-mentioned provision, a legal mark for innovation was created,[23] associated with the promulgation of Law No. 10,973/2004, the first to systematize the instruments of the innovation policy with the regulation of their respective legal regimes, as well as the attribution of institutional roles to different public and private actors involved in the innovation process.[24] Thus, the State, committed not only to the promotion and encouragement

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17 KLINE, Stephen J.; ROSENBERG, Nathan. An overview of innovation. *Studies on Science and the Innovation Process: Selected Works of Nathan Rosenberg.* 2010. p. 173-203.

18 KLINE, Stephen J.; ROSENBERG, Nathan. An overview of innovation. *Studies on Science and the Innovation Process: Selected Works of Nathan Rosenberg*. 2010. p. 173-203.

19 On national innovation systems see: FREEMAN, Christopher. Technological infrastructure and international competitiveness. *Industrial and Corporate Change*, v. 13, n. 3, p. 541-569, 2004; LUNDVALL, Bengt-Ake. *The Learning Economy and Economics of Hope*. London: Anthem Press, 2016. As a further development of the theories on national innovation systems, the theses on regional innovation systems in the 1990s and the concepts of technological system and sectoral innovation system are cited.

20 KLINE, Stephen J.; ROSENBERG, Nathan. An overview of innovation. *Studies on Science and the Innovation Process: Selected Works of Nathan Rosenberg*. 2010. p. 173-203.

21 The foment activity exercised by the State can occur in several ways, see André Saddy's definition in: SADDY, André; SOUSA, Horácio Agunsto Mendes; RODOR, Fernanda Medeiros e Ribeiro. *Direito Público das Startups: uma nova governança público-privada nas parcerias administrativas entre o Estado e as entidades de tecnologias e inovação*. 2. ed. Rio de Janeiro: CEEJ, 2021, p. 69 and 70.

22 BRAZIL. *Constituição da República Federativa do Brasil*, October 5, 1988. Available at: http://www.planalto.gov.br/ccivil_03/constituicao/constituicao.htm. Accessed on: 19 July 2021.

23 Such innovation mark could be referred to as the legal mark for fostering innovation, since it predominantly deals with foment.

24 It should be added that it was only subsequent to Law No. 10,973/2004 that Constitutional Amendment No. 85/2015 was enacted, which amended and added provisions to the 1988 Federal Constitution in order to update the treatment of the various science, technology and innovation activities, thus making explicit the strategic function of the innovation policy, as seen in the amendment to the wording of Article 2016 and inclusion of its sixth paragraph.

of scientific development, research, scientific and technological training, but also to the promotion and encouragement of innovation, began to stimulate the articulation between public and private entities, in various spheres of government.

In addition, the current model for fostering innovation is not compatible with the adoption of protectionist measures,[25] as has been established in other historical moments. In this context arises the recent Economic Freedom Law (Law No. 13,874/2019),[26] which, illustratively, in its article 4 establishes, among other measures, the prohibition of creating market reserves, and the prohibition of clauses that prevent the entry of new competitors.[27]

Therefore, considering the diversity of the legal institutes to foster innovation[28] brought by the legal mark for innovation, the limitations inherent to Public Administration's actions (such as those brought by the Economic Freedom Law), and the peculiarities of the AI's field of knowledge, it was necessary to draw specific guidelines that contemplated these main aspects.

MCTIC Ordinance No. 1,122/2021, when defining the priorities for research and development of technologies and innovation projects for the period 2020 to 2023 in Brazil, indicated AI as one of the areas to be contemplated. After numerous criticisms carried out by the scientific community,[29] this regulation was altered by MCTIC Ordinance No. 1,329/2020, so that, among other aspects, it would adopt a merely indicative character.

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[25] MAZZZOLENI, Roberto *et al*. *Accumulation of technological capabilities and economic development: did Brazil's regime of intellectual property rights matter?* Course of Economics of the Federal University of Goiás – FACE, 2009.

[26] In the opinion of Justice Luís Felipe Salomão, of the Superior Court of Justice, the "Economic Freedom Law" has the potential to reduce the number of litigations, change the role of regulatory agencies and be one of the factors to promote the growth of Brazil, thanks to the requirement of regulatory impact studies, preventing that new rules bureaucratize and impede the flow of economic and financial activity in the country (REVISTA CONSULTOR JURÍDICO. *Lei da liberdade econômica traz segurança e redução de litígios, avalia Salomão*. Oct. 7, 2009. Available at: https://www.conjur.com.br/2019-out-07/lei-liberdade-economica-reduzira-litigios-avalia-salomao. Accessed on: 07 September 2021).

[27] In this line, see art. 5 of Law 13.874/2019.

[28] Remembering also that the development activity can be further divided into social and economic development, which can be exemplified by the following possibilities: tax benefits, offering of guarantees, subsidy or grant, expropriation, development of securities market, development of industrial, commercial centers, export processing zones, venture capital companies, among others (SADDY, André. *Formas de Atuação e Intervenção do Estado na Economia*. 2. ed. Rio de Janeiro: Lumen Juris, 2016).

[29] See joint letters 043 and 079 from the Brazilian Society for the Progress of Science – SBPC (Brazilian Academy of Sciences), subscribed by more than seventy scientific societies from different areas of knowledge. SOCIEDADE BRASILEIRA PARA O PROGRESSO DA CIÊNCIA; ACADEMIA BRASILEIRA DE CIÊNCIAS. [Public manifestation letter sent to the MCTIC: MCTIC Ordinance No. 1,122, of March 19, 2020]. Addressee: BRAZIL. Ministry of Science, Technology, Innovations and Communications. São Paulo and Rio de Janeiro, 27 March 2020. 1 joint letter. Available at: http://hdl.handle.net/20.500.11832/5324. Accessed on: 7 September 2021; SOCIEDADE BRASILEIRA PARA O PROGRESSO DA CIÊNCIA; ACADEMIA BRASILEIRA DE CIÊNCIAS. [Public manifestation letter sent to MCTIC: Ordinances No. 1.122, March 19, 2020 and No. 1.329, March 27, 2020]. Addressee: BRAZIL. Ministry of Science, Technology, Innovations and Communications. São Paulo and Rio de Janeiro, April 29, 2020. 1 joint letter. Available at: http://hdl.handle.net/20.500.11832/5337. Accessed on: 7 September 2021.

Thus, among the objectives of the MCTIC Ordinance No. 1,122/2021 were the definition of the following priorities:[30] (a) contribute to leverage sectors with greater potential to accelerate the economic and social development of the country; (b) promote the institutional alignment of all organs in the organizational structure of MCTIC, in order to obtain synergy among them, to improve the allocation of budgetary, financial and human resources, logistics and infrastructure, and; (c) rationalize the use of budgetary and financial resources, according to the initial programming of the PPA 2020-2023.

Article 2, of MCTIC Ordinance No. 1,122/2021, in turn, established as a priority the research, development and innovation projects focused on the areas of Enabling Technologies, which includes Artificial Intelligence, whose goal is to contribute to the innovation basis in intensive products in scientific and technological knowledge.[31]

Also, in the context of fomenting innovation in AI, subsidized by the hiring of a specialized consulting firm, by national and international *benchmarking,* and by a public consultation held between December 2019 and March 2020, the Brazilian Strategy for Artificial Intelligence – EBIA emerged, implemented by means of MCTI Ordinance No. 4,617/2021 and amended by MCTI Ordinance No. 4,979/2021. EBIA included among its objectives: (a) the promotion of sustained investments in AI research and development; (b) the removal of barriers to innovation in AI; (c) the training and formation of professionals for the AI ecosystem; (d) the stimulation of innovation and the development of the Brazilian AI in an international environment, and; (e) the promotion of a cooperation environment between public and private entities, industry and research centers, for the development of Artificial Intelligence.

As an effort to align with the principles outlined by the Organization for Economic Co-operation and Development (OECD), the EBIA was developed with the goal of promoting: (a) inclusive growth, sustainable development and well-being; (b) human-centered values and equity; (c) transparency and explainability; (d) robustness, safety and security; and (e) accountability – liability and account rendering.

These are, therefore, State planning instruments for fomenting in the area of AI, which ultimately aim to promote continuous innovation of this technology in Brazil.

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[30] It is duty of the Financier of Studies and Projects (FINEP) and the National Council for Scientific and Technological Development (CNPq) to promote the necessary adjustments and adaptations in their respective financing and development lines, to incorporate in their programs and actions the priorities established by the ordinance (art. 8, §1).

[31] The MCTI bodies were instructed to (a) internalize the priorities established in the Ordinance, where appropriate, through adjustments in regulations, plans, programs and projects; (b) detail the actions to meet these priorities and define the forms of implementation, including them in the instruments and terms of partnership signed with actors internal and external to the ministry; (c) to promote the interlocution with actors of other public policies that present an interface with the actions of science, technology and innovation in the sectors of the areas defined as priorities, in order to align priorities, strategies and actions, aiming at the strengthening of public governance.

Despite the legislative introductions to support the development of AI, it is necessary to contextualize the technological development of AI in Brazil. In this case, from patent indicators. This is to propitiate an improvement in the application of the already normatized and planned long-term fomenting instruments, providing, perhaps, even metrics to verify whether the initially planned objectives are being achieved. In the next section, based on technological data from patents, it will be possible to understand the Brazilian reality a little better, in the sense of where we are and where we are heading to, when it comes to the domain of AI technology.

3 Presentation of patent technology data

As previously mentioned, considering patents as one of the few output indicators related to technology and economic performance, data regarding requirements for patent applications in AI were chosen for this work. According to Denis Barbosa,[32] in the case of immaterial goods, a good placed on the market is susceptible to immediate dispersion, but the downside would be that there would be no return on the economic activity of research, constituting a market failure. In this context, through a legal mechanism – property entitlement – a second market failure would lead to the restriction of rights, in most cases, restricting access to what could be easily dispersed.[33]

Thus, it is necessary to point out that the origin of legal institutes protecting the results of an intellectual work goes back to the end of the 19th century, associated with two main concerns: (a) to reward individuals for the investments made and risks taken in developing new products; and, (b) given the temporary nature of the exclusivity right, to allow consumers to experience the benefits provided by long-term competition.[34] Douglass North,[35] for example, points to the embryonic English organization of a patent system in the Modern Age as one of the main factors that allowed England to lead the Industrial Revolution.

Therefore, the choice of patent technology data is not random.

Specifically, regarding the technological data related to the patent applications in AI used in this work, it is verified that all were collected on the same day (05/11/2021,) in the WIPO Platform (patent scope). By collecting all the data on the same day, we avoided disproportions with eventual new registrations without considering them in the fields already searched. There was also a previous search on the main terms associated with AI, to choose relevant keywords that would bring

[32] BARBOSA, Denis Borges. *Tratado da Propriedade Intelectual*. Rio de Janeiro: Lumen Juris, 2020.
[33] BARBOSA, Denis Borges. *Tratado da Propriedade Intelectual*. Rio de Janeiro: Lumen Juris, 2020.
[34] MALAVOTA, Leandro Miranda. *A construção do sistema de patentes no Brasil*: um olhar histórico. Rio de Janeiro: Lumen Juris, 2011.
[35] NORTH, Douglass C. The rise of the western world. *In*: *Political competition, innovation and growth*. Springer, Berlin, Heidelberg, 1998.

data closer to the AI context. Thus, "*artificial intelligence*", "*machine learning*", "*deep learning*", "*chatbot*", and "*neural network*" were inserted in the filter, to be considered in any search field.

It was chosen to search for terms in English, because it is the official language in international politics. Thus, if the keywords were in Portuguese, the results would be biased towards bringing more results for patents originating from countries with this official language, which would affect the comparative analysis.[36]

Thus, all patent applications involving artificial intelligence and its related concepts were found, although some may be disapproved in the future, as this is a filter for applications and not definitive grants.

Thus, the total results (3,103 applications) observed the following trend:

Table 1 – Patent applications by country

Countries	Patent Applications
China	2,721
United States of America	87
PCT	73
Brazil	71
Portugal	69
Republic of Korea	27
European Patent Office (EPO)	15
India	9
Australia	6
Canada	6

Source: WIPO

Given the discrepancy in the number of patent applications from China compared to the other countries, it was found that most of the Applicants and Inventors are Chinese.

Another data that can be extracted from the platform is related to the area of knowledge of the patent. In fact, the platform indicates the field of knowledge according to the International Patent Classification (IPC). The IPC was established by the 1971 Strasbourg Agreement, providing a hierarchical system of patents and utility models, according to the different areas of technology to which they belong.[37]

In this segment, it is noteworthy that more than half of the 10 most frequent ICP categories that appear in patent applications concern class G, which corresponds to the physics area.

[36] This assumption was tested and it was indeed confirmed that the results in Portuguese were predominantly from countries with this official language: Brazil, Portugal, China (probably due to Macau).

[37] As a rule, a new version of the CPI goes into effect every January 1st.

Of the 3,103 applications, 71 of them are patent applications originating from Brazil. Although this seems like a small number comparatively, Brazil ranks 4th among the countries that have filed the most patent applications. However, when we look at the categories of the applicants, we see that most of them are multinational companies:

Table 2 – Most representative Brazilian applicants according to the number of patent applications

Applicants	*Patent Applications*
NOVARTIS AG	6
ASTRAZENECA AB	3
BECTON DICKINSON AND COMPANY	2
COSMO ARTIFICIAL INTELLIGENCE AI LIMITED	2
MEDIMMUNE LIMITED	2
MENTIS CURA EHF	2
SAMSUNG ELECTRONICS CO LTD	2
UNIVERSITY OF SÃO PAULO USP	2
ABB INC	1
AGC APARTMENT GLASS NORTH AMERICA INC	1

Source: WIPO

In contrast, in the United States, of the 87 patent applications, there is a concentration of domestic companies among the applicants:

Table 3 – Most representative US applicants according to the number of patent applications

Applicants	*Patent Applications*
APEX ARTIFICIAL INTELLIGENCE INDUSTRIES INC	11
ALLEGRO ARTIFICIAL INTELLIGENCE LTD	10
INCEPTION INSTITUTE OF ARTIFICIAL INTELLIGENCE LTD	10
ARTIFICIAL INTELLIGENCE FOUNDATION INC	7
SHANGHAI TUSEN WEILAI ARTIFICIAL INTELLIGENCE TECH CO LTD	7
MOSHE GUTTMANN	6
COSMO ARTIFICIAL INTELLIGENCE AI LIMITED	3
DEEP LEARNING ROBOTICS LTD	3
MACHINE LEARNING WORKS LLC	3
THE ALLEN INSTITUTE FOR ARTIFICIAL INTELLIGENCE	3

Source: WIPO

It should be added that, in relation to the IPC classification of Brazilian patent applications, in spite of the predominance of class G (Physics) among the 10 most frequent categories, these do not occupy the first positions. The highlighted areas are class A (Human Needs) and C (Chemistry and Metallurgy), both associated with the medical and pharmaceutical areas, related to the core objectives of the main patent applicants in Brazil.

In the United States, the seven most frequent IPC categories in patent applications are related to class G (Physics).

4 Discussions of results

Among the results related to patent data, a difference in trend can be observed when comparing the overall results for the United States and Brazil. In Brazil, one notices a high concentration of Brazilian patent applications filed by multinationals belonging to foreign economic groups, and there is not even one national economic group in this segment.

When a genuinely Brazilian institution appears in this segment, it is a university. In other words, no Brazilian-based company appears among the main patent applicants.

It is explained.

Brazil is recognized for occupying a good position in international *rankings of* academic production, both in number of both production and citation of academic production. For example, in the *Scimago Journal*,[38] Brazil ranks 15th, considering publications produced between 1996-2019. However, Brazil does not have an equivalent position in the Global Innovation Index (GII) ranking, which also includes the phase of commercialization of products with some degree of technological increment, occupying the 62nd position in 2019.[39]

In short, Brazil has a relevant academic capacity, but does not have a productive environment interested in/capable of absorbing domestically developed high-technology projects. This problem is also reported by Mazzoleni,[40] who even brings other examples, such as the COBRA company (Computadores Brasileiros S.A.), whose project was frustrated. And it also seems to be a problem evidenced by the patent indicators pointed above.

[38] SCIMAGOJR. *Country Rankings*. Available at: https://www.scimagojr.com/countryrank.php. Accessed on: 15 August 2021.

[39] GUADAGNO, Francesca; WUNSCH-VINCENT, Sacha. Introduction to the GII 2020. Who will finance innovation? *The Global Innovation Index 2020*, p. 67-73, 2020.

[40] MAZZZOLENI, Roberto *et al*. *Accumulation of technological capabilities and economic development: did Brazil's regime of intellectual property rights matter?* Course of Economics of the Federal University of Goiás – FACE, 2009.

Although there are several AI laboratories in Universities (USP, Unicamp, Coppe, UEL, etc.) as well as initiatives for the creation of others,[41] which will certainly continue to support the academic production, so far, it is not known *if* or *when* these technological advances will reach the national industry, given that, according to the data above, they have not yet arrived. At most, it is the multinationals that have enjoyed the innovation in AI, even though, without bringing their development centers to the country.

The fact is that the difficulty in endogenizing innovation without adopting protectionist policies that, in the end, reduce the competitiveness of national industries, is not a recent problem. Although the economic context and economic policies have been completely transformed since the 1960s, the difficulty of articulating national and foreign capital to produce innovation, without creating national economic dependency, has always been an issue.

In the mid-1990s, with the liberalization of the economy, the model of attracting transnational companies and the consequent denationalization of the production structure reached effects like those of the 1960s with the exhaustion of the imports-substitution model. This is because the main technological activities of transnational companies are restricted to small adaptations of technology projects massively developed in foreign research centers, usually located in the territory of the parent company, and as these companies work with high rates of imported inputs, the increased internationalization of the production structure led to a hindrance of local technological development and innovation.[42] In short, a regression that brings us closer to the context of the 1960s, considering the low capacity of industrial production.

Thus, the problem of endogenizing innovation remains until today, despite being pointed out decades ago by Celso Furtado.[43]

Therefore, if this decades-long problem is not solved, it is natural that the patent data in AI will remain in the hands of foreign or multinational companies.

In any case, what draws attention in the State planning instruments is the lack of signaling on this issue, which, in our view, is central to the promotion of the country's economic and social development, which is the objective of both MCTIC Ordinance No. 1,122/2021 and EBIA. In other words, to achieve the country's economic and social development, it is necessary to propose specific measures

41 PEDUZZI, Pedro. Ministro anuncia criação de 8 laboratórios de inteligência artificial. *Agência Brasil*, Brasilia, 04 Nov. 2019. Available at: https://agenciabrasil.ebc.com.br/geral/noticia/2019-11/ministro-anuncia-criacao-de-8-laboratorios-de-inteligencia-artificial. Accessed on: 15 August 2021.

42 CASSIOLATO, José E.; LASTRES, Helena M. M. Celso Furtado e os dilemas da indústria e inovação no Brasil. *Cadernos do Desenvolvimento*, v. 10, n. 17, p. 188-213, 2018.

43 CASSIOLATO, José E.; LASTRES, Helena M. M. Celso Furtado e os dilemas da indústria e inovação no Brasil. *Cadernos do Desenvolvimento*, v. 10, n. 17, p. 188-213, 2018.

for overcoming this Brazilian innovation knot, both in more traditional sectors and in the AI sector - observed in the indicators projected above.

Another fact that draws attention when analyzing the technological data of the previous section is the importance of physics as the predominant area of knowledge in international patent applications, which allows, in theory, the inference that the technology involved has potential applications in other areas of knowledge, given that physics is a basic science that touches several economic segments. Therefore, the greater the number of AI patents in physics, the more we observe the AI phenomenon as an effective enabling technology for that economy.

5 Conclusions

Considering the patent technology data investigated, it was noted that the main applicants of Brazilian patents are multinational companies. Besides the fact that the holders of AI technology are predominantly foreigners, there are no representatives of the domestic industry, which points to a technological dependency in AI.

Moreover, given that the largest concentration of Brazilian patent applications is not related to physics knowledge, it fails to signal potential application in various areas of knowledge, going against the international trends.

These findings, associated with other data from specialized literature, lead us to infer a Brazilian deficiency in endogenizing AI technology, despite the State planning and development initiatives underway.

A first initiative to improve the already existing instruments would be expressly recognize this issue, peculiar to the Brazilian reality, which is probably the reason why it was not found in the international benchmarking carried on when formulating EBIA, for example.

Thus, this is, perhaps, the biggest challenge for the innovation policy regarding AI: to activate genuinely national industrial poles capable of innovating in this area, taking advantage of the potentialities of Brazilian research centers already available, to solve genuinely national problems – such as social development – as well as maximizing wealth for the country and employing more qualified and better paid professionals – leading to the country's economic development.

In this context, Brazil needs to adopt Governmental actions that recognize these problems and seek specific solutions to avoid the country's technological dependence in this area, as well as the importation of foreign solutions, to resolve the low competitiveness of the national industry in this segment.

For all said above, we hope to contribute to the formulation of more efficient Brazilian public policies, given that, considering the many possibilities of carrying out foment activities by the State, it seems more adequate to achieve its projected objectives, if concrete data is analyzed and well interpreted - the objective of this research.

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Informação bibliográfica deste texto, conforme a NBR 6023:2018 da Associação Brasileira de Normas Técnicas (ABNT):

COIMBRA, Elisa; LÔBO, Flávio Luiz de Aguiar. Public foment for innovation in artificial intelligence: an assessment based on technological data from patents. *International Journal of Digital Law*, Belo Horizonte, ano 2, n. 3, p. 11-26, set./dez. 2021. DOI: 10.47975/IJDL.coimbra.v.2.n.3.

IJDL – INTERNATIONAL JOURNAL OF DIGITAL LAW

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Impressa no Brasil / Printed in Brazil / Distribuída em todo o Território Nacional

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IN61 International Journal of Digital Law – IJDL. – ano 1, n. 1 (abr. 2020) –.– Belo Horizonte: Fórum, 2020-.

Quadrimestral; Publicação eletrônica
ISSN: 2675-7087

1. Direito. 2. Direito Digital. 3.Teoria do Direito. I. Fórum.

CDD: 340.0285
CDU: 34.004

Coordenação editorial: Leonardo Eustáquio Siqueira Araújo
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