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BRAZILIAN NATIONAL INNOVATION SYSTEM: CHALLENGES TO THE CATCHING UP PROCESS

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INTRODUCTION

The wide use of the concept of national innovation systems has helped to direct theattention of the circles in charge of formulating public policies for research, innovation and development industrial in one perspective linear for athought interactive gives innovation (LUDVALL, 2007).

Initially, it is necessary to make a brief approach to the concepts of innovation and in system of innovation.

Law Number 10.973/2004 - Innovation Law, as amended by Law Number 13.243/2016, defines innovation, for your legal effects, in article 2, incised IV:

> Art. 2 For the purposes of this Law, it is considered:(...)
>
> IV- Innovation: introduction in News or improvementat the environment productive and social what result in new products, services or Law Suit or what understand the aggregation in new functionalities or characteristics to an existing product, service or process that may result in improvements and ineffective gain in quality or performance;

The Oslo Manual (OECD, 2018, p. 20) brings a broader concept and contemporary ininnovation:

> An innovation is a new or improved product or process (or a combination of both) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or put to use by the unit (process). (Free translation).

(2005, page 4), the leave gives notion in innovation as result in interactive process of learning and knowledge generation, involving different actors (companies, institutions in teaching and research andState), conceptualize system in innovation:

> The "innovation system" is conceptualized as a set of distinct institutions that contribute to the development of the innovation and learning capacity of a country, region, sector or locality - and also affect it. They consist of elements and relationships that interact in the production, dissemination and use of knowledge. The basic idea of the innovation systems concept is that innovative performance depends not only on the performance of companies and education and research organizations, but also on how they interact with each other and with various other actors, and how institutions - including policies - affect the development of systems. It is understood, therefore, that the processes of innovation that occur within the scope of the company are, in general, generated and sustained by its relationships with other companies and organizations, that is, innovation consists of a systemic and interactive phenomenon, characterized by different types of cooperation.
>
> The National Innovation System can be conceptualized as a network of direct and indirect, formal and informal relationships between companies, scientific and technological institutions, universities and other educational institutions, government, researchers and inventors, whose degree of interaction between the actors and configuration of the system results from historical, economic, social and political factors.

The objective of this article is to identify some of the main reasons for the permanent immature stage of development of the Brazilian national innovation system (SNI), from the analysis of the structural and operational problems identified by the Federal Court of Auditors (TCU); the historical roots of the formation of the national innovation system, which determine the low interaction between universities/research institutions and companies; of income concentration, which imprisons the system in a vicious cycle of underdevelopment and international experiences of successful catching up processes.

METHODOLOGY

The methodology consisted of a critical analysis of the problems pointed out by the Court of Auditors of the Union in the Brazilian national innovation system and respective recommendations for measures, embodied in Judgment Number 1,237/2019 – TCU – Plenary.

The operational audit carried out by the TCU in 2018, which resulted in the recommendations contained in Judgment Number 1,237/2019 - TCU - Plenary, did not have as its object the performance of one or some specific federal institutions, but rather the identification of state and parastatal bodies and entities that act in the national innovation system, and analysis of governance aspects of policies to promote innovation in the productive sector.

The TCU identified and classified the actors of the national innovation system at three levels, namely: at the first level, political actors; at a second level, the promotion entities and, at a third level, entities and bodies that operationalize innovation. Each class of actors is described in 1 of the results of this work.

The governance problems of innovation policies in the product sector (absence of coordination, failures in the strategy, in the monitoring, follow-up and evaluation of results) and the respective recommendations for action forwarded by the Court of Auditors (structural changes in the national innovation system and changes in the governance of public policies) were the object of critical analysis, based on bibliographic research on the challenges to be faced for a successful up-innovation process, the most successful catching up of the national system. low interaction between universities/ research institutions and companies; the need for a combined construction of a national innovation system and a welfare state; and analysis of international lessons from successful catching up processes.

RESULTS AND DISCUSSION

JUDGMENT NUMBER. 1.237/2019 - TCU-PLENARY

The operational audit carried out by the Federal Audit Court (TCU) on the national innovation system in 2018 aimed to identify actors, policies, initiatives and institutional arrangements, as well as the factors that may be contributing to Brazil's persistent low positioning in the international innovation rankings, in particular the Index

Global Innovation Index (GII)[1], proposing mitigating actions.

In item 1.5 of the report, the scope of the audit was delimited to the analysis of aspects associated with the governance of the innovation initiatives presented by the audited government and parastatal actors, more precisely aspects of institutionalization, coordination and political articulation, as well as the evaluation of issues related to the long-term vision for the topic and mechanisms of monitoring and evaluation of initiatives regarding the results of government action.

One of the results of the audit was the identification of the actors that make up the national innovation system in Brazil, which were classified into three levels, as provided for by the National Strategy for Science, Technology and Innovation (Encti 2016-

1. The Global Innovation Index – Global Innovation Index provides detailed metrics on the innovation performance of around 120 countries (more precisely 126 countries in 2018 and 129 countries in 2019), representing around 90.8% of the world's population and 96.3% of global GDP. It comprises 80 indicators that explore a broad view of innovation, including the political environment, education, infrastructure, business sophistication, investments in research and development, patent applications and international trademarks. Brazil occupied the 64th position in 2018 and the 66th position in 2019. (Source: sítio do Observatório Internacional SEBRAE. Disponívelemhttp://ois.sebrae.com.br/publicacoes/indice-de-inovacao-global-2018.

2022), namely: political actors, development agencies and organizations that operationalize innovation.

At the first level of action, the political actors define the guidelines that will guide the system's strategies. The political actors are the federal and state Executive and Legislative Powers and sectoral representation entities (businessmen, workers and researchers).

At the second level of action are the funding agencies, responsible for allocating public resources, through various instruments to support research, development and innovation activities: a) National Council for Scientific and Technological Development (CNPq); b) Coordination for the Improvement of Higher Education Personnel (Capes); c) Financier of Studies and Projects (Finep); d) National Economic and Social Development Bank (BNDES); e) Brazilian Industrial Research and Innovation Company (Embrapii); f) Research Support Foundations (Faps).

Finally, at the third level, there are organizations that operationalize innovation, namely: a) innovative companies; b) federal and state universities; c) federal and state institutes of Science, Technology and Innovation (ST&I); d) scientific, technological and innovation institutions (ICT); e) foundations to support higher education and scientific-technological research institutions; f) centers of technological innovation (NIT); g) technological parks, h) research institutes of the Ministry of Science, Technology and Innovation (MCTI), i) national science and technology institutes (INCT); and j) business incubators and accelerators.

The audit team's findings were classified into three groups, namely: a) absence of an active structure for coordinating federal policies to foster innovation from an integrated government perspective; b) failures in the National Strategy for Science, Technology and Innovation (Encti); c) failures in the monitoring and evaluation of public policies to foster innovation.

The theme of innovation in the productive sector is transversal and there is no active structure in the coordination of federal policies, programs and initiatives to foster innovation, in order to guarantee cooperation, prevention and conflict resolution between the Ministry of Science, Technology and Innovations and others. interested parts. In addition, it was also found by the TCU that the federal regulations do not define how the coordination of national policy with the sectoral innovation policies proposed by the ministries acting on the subject must occur, with regard to the roles and responsibilities of each of the actors.

It is important to emphasize that there is no coordination structure that is active, since the National Council of Science and Technology (CCT), created by Law Number 9,257, of January 9, 1996, regulated by Decree Number 10,057, of October 14, 2019, was constituted to be a "superior advisory body to the President of the Republic, for the formulation and implementation of the national policy for scientific and technological development", in the exact terms provided for in article 1, caput, of the founding law, and article 2, caput, of the current regulatory decree.

When analyzing Law Number 9,257/1996, Decree Number 8,898/2016 (which was in force at the time of the audit) and Decree Number 10,057/2019, we inferred that there is an advisory unit directly linked to the President of the Republic, with legal competence to establish political articulation and coordinate the alignment of policies, programs and initiatives, whose composition observes the transversality of the referred to national science and innovative policy unit. eTechnology (CCT).

However, the CCT has not acted in accordance with its constitutive act, according to the TCU's finding recorded in the report of Judgment Number 1.237/2019 - TCU - Plenary, which cites the Minutes of the Meeting of the Thematic Commission on Technology and Innovation of the CCT of 03/7/2018, which was mentioned by the Commission's Coordinator in the sense that the CCT would be an advisory body to hold that meeting.

In the report of Judgment Number 1,237/2019 – TCU – Plenary, examples of countries well classified in the GII 2018 ranking are mentioned, such as the United States, the United Kingdom, Israel and Australia, in which the success of policies and innovation programs is directly related to the central bodies of government – the Office of the Presidency or the Prime Minister – that are responsible for the strategy of C, community, business, and civil society.

The second group of findings from the audit carried out by the TCU concerns the shortcomings in the National Strategy for Science, Technology and Innovation (Encti2016-2022), which consist of the absence of a long-term strategy, absence of strategic planning for the entire government, excess of prioritized topics, lack of unfolding in medium-term plans and action plans, absence of follow-up forecast, absence the participation of relevant actors in its elaboration process, lack of alignment of initiatives of development institutions with the Encti 2016-2022.

According to the report of Judgment Number 1.237/2019 – TCU – Plenary, there was recognition by the MCTI of the inexistence of a long-term national vision (between 10 and 20 years) for innovation and that the ST&I strategies in Brazil always have a short-term horizon, varying between 4 and 6 years. with other policies that already do so, such as the National Energy Plan 2030 and the National Mineral Plan 2030.

Currently, in addition to not having a long-term strategy, there is no strategic plan for the whole government, as Encti has no binding effect on other ministries, that define their own strategic planning and innovation, in addition to not having the strategy folded into medium-term plans and action plans, nor forecasting the monitoring of indicators, as a consequence of the absence of intermediate goals for the period from 2016 to 2022.

The excess of prioritized topics, namely: renewable energies, biofuels, oil & gas, nanotechnology, photonics, advanced manufacturing, advanced materials, defense, nuclear-aerospace energy, demonstrates that there is in fact no prioritization. Brazil must prioritize strategic sectors in which it has the ability to lead internationally.

As a result of the lack of participation of relevant actors in the process of elaboration of Encti, several initiatives to promote innovation do not result from the strategy defined at Encti.

As an example of countries that treat ST&I as a State Policy, the report of Judgment nº 1.237/2019 – TCU – Plenary mentions Germany and China, which will have their catching up processes analyzed on the 3rd of this article.

The failures pointed out in the monitoring and evaluation of public policies to promote innovation were the following: a) inexistence of an evaluation history for part of the policies, programs and public initiatives to promote innovation; b) different stages of maturity of the monitoring and evaluation processes; c) inexistence of result and impact indicators for part of policies, programs and public initiatives to foster innovation; and d) lack of information to support monitoring and evaluations.

In view of the failures found in the National Innovation System, the Ministers of the Court of Auditors of the Union agreed on the recommendations and measures that we transcribe:

> 9.1 recommend to the Civil House of the Presidency of the Republic that, based on the attributions conferred on it by art. 1 of Annex IdoDecree 9.678/2019:
>
> 9.1.1. establish inter-ministerial coordination mechanisms to promote the alignment and consistency of public policies related to fostering innovation in the productive sector;
>
> 9.1.2. establish cooperation mechanisms with the states, Federal District and municipalities with a view to promoting the alignment of federal initiatives and policies to promote innovation with those formulated and implemented by subnational entities (vertical coordination);
>
> 9.1.3. Evaluate the convenience and opportunity of defining an inter-ministerial instance to act on the national system of science, technology and innovation, enabling the production of economic and strategically significant innovation, as well as articulating and harmonizing the system.
>
> 9.2. recommend to the Civil House of the Presidency of the Republic, based on Decree 9.678/2019, Annex I, article 1, item I, item "a", and to the Ministry of Science, Technology and Innovation that, together with the other ministries involved with policies, programs and initiatives to promote innovation in the productive sector, and After hearing the other relevant actors, such as representatives of society, the National Congress and other public and private entities active in the subject, coordinate the preparation of a national strategy for science, technology and long-term innovation, whose design contains, at least:
>
> 9.2.1. definition of State priorities, based on objective criteria;
>
> 9.2.2. measurable objectives, accompanied by indicators, targets and the respective responsible areas;
>
> 9.2.3. breakdown into action plans;
>
> 9.2.4. provision of periodic monitoring during their execution; and
>
> 9.2.5. monitoring and evaluation methodology of results.

INTERACTION BETWEEN UNIVERSITIES/RESEARCH INSTITUTIONS AND COMPANIES IN HISTORICAL PERSPECTIVE

According to the triple helix postulate, the interaction between universities, companies and government is the key to improving the conditions for innovation in a knowledge-based society (ETZKOWITZ, 2004).

Throughout history, the organizational characteristics of the relationships between universities, companies and government have evolved according to the type of knowledge implicit in each Industrial Revolution (VIALE and ETZKOWITZ, 2005).

In the First Industrial Revolution, which began in England in the 18th century and lasted until the mid-19th century, knowledge was less formalized and had its origin in practical experience in a trial-and-error method. The predominance of tacit knowledge made collaboration and dialogue between inventors difficult. There was little collaboration within the university and almost none between university and industry. This is the model of interaction that Etzkowitz (2005) calls the single helix.

In the second industrial revolution (mid-nineteenth to mid-twentieth century), the problem of tacit knowledge was no longer so present, but there were still methodological and epistemological differences that made interaction between the two worlds difficult (university and industry). Industry, without the ability to solve many technical problems, is forced to interact with the university. A successful case in this interaction occurred in the German chemical industry, which we will discuss later, when we deal with international experiments. In this period, there was still weak interaction with the government, except in military matters. It is the double helix model.

In the third industrial revolution (from the mid-twentieth century), a new form of interdisciplinary and integrated knowledge emerges, challenging the traditional boundaries of disciplines in universities. There is integration between different branches of knowledge, such as nanobiotechnology, biophysics, etc. Interaction between different branches of knowledge becomes indispensable to seek solutions to scientific and technological problems. Therefore, the role of universities in the development of new technological paradigms becomes more evident. In this new model of knowledge production, the more the government promotes and finances the interaction between university and industry, the greater the productivity of the national innovation system. This is the triple helix model.

Albuquerque (2009) identifies three regimes of interaction between the scientific and technological dimensions in the current world. In the regime1, the scientific infrastructure is still very small and unable to support minimal technological production. In regime 2, scientific production grows and can determine some technological production, but not to the point of enabling a feedback effect on scientific production. In regime 3, connections are fully established and the main determinant of economic growth is scientific and technological training. Brazil is in regime 2 of development of the national innovation system, alongside countries such as India, South Africa and Mexico. Access to regime 3 is the objective of the catching up process.

The development stage of the Brazilian national innovation system is characterized by the existence of research and teaching institutions that have been built, but that are still unable to mobilize contingents of researchers, scientists and engineers in proportions similar to those of more developed countries, and by companies that still have a limited involvement in innovative activities (Suzigan and Albuquerque, 2008).

Suzigane Albuquerque (2008) emphasize that the still precarious stage of development of the national innovation system stems from the low interaction between universities/research institutions and companies, with a few "interaction points", which constitute successful cases of the relationship between science and technology, namely: in health sciences, the production of serosevaccines (Oswaldo Cruz Institute, Butantan Institute) ;in agricultural sciences: cotton, forests for pulp, grains, meats (IAC – Instituto Agronômico de Campinas, Embrapa); in mining, materials engineering and metallurgy, production of ores, steel and special metal alloys (UFMG); in aeronautical engineering, aircraft production by Embraer (CTAeITA); in geosciences, oil and gas extraction by Petrobras (COPPE-UFRJ, Unicamp).

The historical roots of the low interaction between universities/research institutions and companies in Brazil are linked to the late nature of the creation of research institutions and universities in the country, the late Brazilian industrialization, as well as the late beginning of monetary and financial institutions.

Until 1808, when the Portuguese court was transferred to Rio de Janeiro, there were no higher education institutions or monetary institutions, and manufactures were prohibited.

During the colonial period, until 1808, there was no concern with the creation of higher education institutions in Brazil and any initiative in this direction was seen as a threat by the colonizer. Due to this context, Brazil was one of the last Latin American countries to create higher education institutions, which only occurs, with the exception of theological seminars, after the arrival of the royal family in 1808 (Coelho and Vasconcelos, 2009).

The construction of the institutions of the national innovation system in Brazil, in addition to belatedly, took place in adverse conditions caused by slavery and the social and economic consequences, which put down roots of inequality, delayed the formation of a wage labor market, in addition to generating historical deficiencies in education and technical qualifications. Nearly four centuries of slavery in 520 years of history have a weight that still resonates strongly today, and it was the adverse conditions that gave rise to the historical process of industrialization, whose demands on the country's scientific infrastructure were limited and little challenging.

Suzigane Albuquerque (2008) makes a periodization of the formation of educational and research institutions in Brazil, describing five "waves of institutional formation".

The first wave of institutions was created after 1808, when the first higher education institutions were created (in 1808, the anatomy and surgery courses in Rio de Janeiro and Salvador, and the Military Academy in 1810), the Botanical Garden and the National Library.

It must be noted that, through the Charter of 1808, the ban on manufacturing in the colony was revoked. In 1812, the Chemical Laboratory of Rio de Janeiro was created, whose purpose would be the "manufacture of solid soap", and in 1818, the Royal Museum was created, later transformed into the Imperial Museum and, with the end of the Empire (1889), it became called the National Museum, which would house the first Physics and Chemistry Laboratory (1824).

Schwartzman (1979) also points out in that period the first attempts to implement a steel industry, with the Real Fábrica de Ferro do Morro de Gaspar Soares, in Minas Gerais.

Although the ban on manufactures was abolished through the 1808 Permit, historically, the first experience of industrialization driven by the State in Brazil took place in the 1950s. Before the 1950s, the role of the State in promoting industrial development was insignificant (SUZIGAN, 1988).

The second wave of institutional creation mentioned by Suzigane Albuquerque (2008) took place around 1870 to 1900: Archaeological and Ethnographic Museum of Pará (1866); Escola de Minas de Ouro Preto (1875); Instituto Agronômico de Campinas (1887);Vaccinogenic, Bacteriological and Butantã Institutes (between 1892 and 1899); Manguinhos Institute (1900); Luiz de Queiroz Higher School of Agriculture (1901); Office of Material Resistance of the Polytechnic School of São Paulo (1899 – predecessor of the Instituto de Pesquisas Tecnologias –IPT, officially created in 1934) (SUZIGANe ALBUQUERQUE, 2008).

The science that was institutionalized in Brazil at the end of the 19th century and the beginning of the 20th century was characterized by its location outside the higher education system.

The fourth wave of institution creation took place in the post-World War II period, with the creation of the Brazilian Center for Physical Research (1950), the Instituto Tecnológico da Aeronáutica – ITA (1950), the Centro Tecnológico da Aeronáutica – CTA (1951), the latter two dedicated to the training of aeronautical engineers and learning in aeronautical technologies, having preceded the creation of the Brazilian Company Aeronautics - Embraer in 1969, which became one of the world's largest aircraft manufacturers.

In the fourth wave of institutional formation, two important coordinating institutions of the national science and technology system were also created: the National Research Council (CNPq) and the Coordination for the Improvement of Higher Education Personnel (CAPES), both in 1951.

The fifth wave of institutions was created during the military regime, with the creation of research centers in state-owned companies (CENPE at Petrobras and CPqD at Telebrás), and the sinking of the Empresa Brasileira de Pesquisa Agropecuária – Embrapa (1973) (SUZIGAN and ALBUQUERQUE, 2008).

It was also created institutions and funding funds for science and technology: Fundo de Desenvolvimento Tecnológico – FUNTEC (1964), administered by the National Bank of Economic Development – BNDE (1952). From that fund was born the Financier of Studies and Projects – Finep (1965), with an important role in coordinating government actions in the area of funding for Science and Technology and in the implementation of postgraduate courses in universities.

In the period from 1972 to 1984, national plans for scientific and technological development were launched, but partially implemented and abandoned from the 1980s onwards, with the worsening of the economic crisis.

The end of the Military Regime was not, as the military elite defended, a "slow, gradual and secure" transition to the democratic regime, but a strategic retreat, in the face of the economic crisis generated by the external indebtedness, the increase in the price of oil, the high interest rates, the fall in international prices of basic export products (commodities), the reduction in the availability of international loans and the consequent loss of the political base of the military regime (Schwartzman, 2001).

It was only in 1985, after the end of the military regime, that Brazil became a Ministry of Science and Technology, which, however, did not constitute a sufficient factor to assure the Brazilian scientific community all the space, recognition and support that it expected to receive from the new regime. The new ministry was born weak and limited itself to bringing together existing entities, such as CNPq and Finep, to which the Special Secretariat for Information Technology was added.

Currently, the participation of universities in cooperative arrangements remains very low, despite having increased from 1.5% to 6.5% between 2003 and 2011, meaning that only 6.5% of the companies that implemented some innovation carried out in cooperation with universities, according to the 2003 to 2011 editions of the Technological Innovation Research – Pintec[2], carried out by the Brazilian Institute of Geography and Statistics. - IBGE (BastoseBritto, 2017).

The percentage of innovative companies that reported some type of government support for their innovative efforts also increased, from 18.7% in 2003 to 34.2% in 2011, but government support for innovative efforts is still very limited, having been stagnant in the period from 2003 to 2011, from 1.4% in 2003 to 1.3% in 2011, as well as the rate of innovation, which fluctuated in a range of 33% between 2003 and 2005, rising to 38.7% in Pintec 2008 and then returning to 35.7% in 2011.

The stagnation of the rate of innovation shown by Bastos and Britto (2017) and the

2. The Innovation Survey (PINTEC) is carried out by the Brazilian Institute of Geography and Statistics – IBGE every 3 years, covering the sectors of industry, services, electricity and gas. 2011, 2014 and 2017. (Source: https://www.ibge.gov.br/estatisticas/multidominio/ciencia-tecnologia-e-inovacao/9141-pesquisa-de-inovacao.html?edicao=17121&t=o-que-e.Accessed on 08/04/2020)

persistent low positioning of Brazil in the international innovation rankings reported in Decision, which determines the persistent low interaction between universities/institutions of research and companies, poverty and income concentration, which generate a constant inadequacy of technology, which will be the object of analysis in the next item.

CONCENTRATION OF INCOME AS AN OBSTACLE TO THE CATCHINGUP PROCESS

Albuquerque (2009) explains how the concentration of income contributes to maintaining the intermediate stage of development of the Brazilian national innovation system and the development process in relation to more developed nations.

The concentration of income generates a constant inadequacy of technology, preserving and transforming a surplus of labor. The economic elite (never more than 10% of the population) adopts consumption patterns similar to those of countries where technological revolutions take place. At an early stage, this high-income minority imports consumer goods from more developed countries. In the next stage, the import substitution process internalizes this production of consumer goods and protects domestic production. This protection of domestic production of consumer goods coexists with subsidies for the importation of capital goods, which temporarily blocks the development of a domestic capital goods industry. The combination of protection for the consumer goods industry and subsidies for the importation of capital goods generates productivity gains and a structural surplus of labor.

A "higher stage of underdevelopment is reached when the industrial nucleus is diversified, enabling it to produce part of the equipment required for development to take place" (FURTADO, 1986, p. 145). consumption, followed by a new phase of import substitution and imports of capital goods related to this new substitution (ALBUQUERQUE, 2009).

The end result is a process of modernization and marginalization that Albuquerque (2009) describes as:

> Modernization as the local industries are driven by the adoption and constant updating of consumption patterns spread by developed countries; this continuous effort, as technological revolutions take place in the centre, has at least allowed the Brazilian economy to preserve a relatively stable gap vis-à-vis developed countries. Marginalization as unemployment generated by the use of capital-intensive techniques is not absorbed by underdeveloped industries of local capital goods (which, when they develop, do so in a delayed and incomplete way), this unemployment affects the structural surplus of labor.

According to the author, the limitations of the domestic market, generated by the concentration of income, negatively affect the possibilities of technical progress, breaking the development impulse before what is necessary to establish a sustainable catching-up process, and, thus, despite having been expanding its scientific production since the 1980s, Brazil remains in the same position in the international scenario.

INTERNATIONAL LESSONS

Catching up processes cannot be reduced to mere copies of some previous successful model. There are differences in terms of dominant technological paradigms, different international contexts, different hegemonic countries, different starting points.

Therefore, institutional innovations must respond to different and specific challenges in each development process, although important lessons can be learned from successful catching up processes throughout history (ALBUQUERQUE, 2009).

In the German catching up process of the second half of the 19th century, the most important institutional innovations were the role of large banks in channeling resources to companies; the huge investment in education, especially secondary and higher; and the role of teaching and research institutions, which contributed to meet the demands presented by the industrial sector (ALBUQUERQUE, 2009).

According to Freeman (1995), R&D, as a business department, was introduced by Germany in 1870, in the paint industry, where it was first realized that it could be profitable to transform the research of new products and the development of new chemical processes on a regular, systematic and professional basis.

Also fundamental in the German process were the importation of machine tools from England for reverse engineering in the Technical Institutes of Training and diffusion in the industry, in addition to the acquisition of tacit knowledge, attracting English craftsmen. By the end of the 19th century, Germany was already able to design and produce steam locomotives, surpassing the British.

The United States was more successful than Germany in the process of overcoming England in the second half of the 19th century, having developed an educational system of greater scope than the German, strong not only in training for industry. The specificities of the US national innovation system in relation to Europe were the successive waves of immigration, the abundance and low cost of materials, energy and land, the smaller role of the State in the US (compared to Germany, for example) and the greater relevance of foreign investment in the US.

Kimura (2009) points out three vital lessons from the post-Second World War Japan catching-up process: macroeconomic stability, through the management of foreign currency and the balance of payments; the solution of bottlenecks to development, such as labor shortages, lack of infrastructure and other adverse social and economic conditions; and building a selective environment that would resolve the trade-off between external protection and competitive pressure on domestic firms, creating an incentive for the private sector to become more competitive.

Freeman (1995) explains Japan's extraordinary success in the 1980s, in contrast to the collapse of the socialist economies of Eastern Europe.

Initially, Japanese success in the 1950s and 1960s was attributed to simply copying, imitating, and importing technology. However, when Japan surpassed the US and Europe in technological performance of products and processes, this explanation became no longer adequate, although the importation of technology continued to be important (FREEMAN, 1995).

Japan's investments in civil R&D, as a proportion of industrial production in the 1970s, and as a proportion of GDP in the 1980s, exceeded US investments. The patent statistics of electronic companies in Japan have surpassed US and European companies in both domestic and US patenting.

The contract between Japan, on the one hand, and the former Soviet Union (USSR) and eastern European countries, on the other, is in qualitative aspects of the national innovation system, given that allocating increasing resources to R&D does not in itself ensure gains in innovation, diffusion and productivity. One of the main differences between the national systems of Japan and the USSR.

In the 1970s was the high commitment of USSR R&D resources to military and space spending. The arms race with the US made the then USSR invest three quarters of its resources for R&D in space defense and research.

Although Freeman (1995) has pointed to the concentration of USSR R&D resources on military and space spending as one of the reasons to explain the contrast between Japan's extraordinary success in the 1980s and the collapse of the USSR, there are authors who defend the potential of research in the defense area to generate innovation and technological diffusion in other areas of the economy (ALMEIDA, 2015).

Innovations in the defense area have the potential to generate new materials, products and services, creating new areas of economic activity and stimulating the development of related activities of suppliers and service providers, such as microelectronics, aeronautics, steel and special steel, among others, in addition to creating job vacancies with a high level of specialization (MONTEIRO, 2019).).

The Soviet system in the 1960s and 1970s was characterized by the separation of research institutes into basic research, applied research and technology import, without integration between the different R&D institutions with business R&D. While the integration between R&D, production and technology import at the enterprise level was the strongest feature of the Japanese innovation system, it was very weak in the former USSR, except in the aviation and defense sectors. Finally, there was a weak link between user and producer of technology in the Soviet system (FREEMAN, 1995).

The national systems of Japan and the former USSR had in common the high rates of economic growth in the 1950s and 1960s, good educational systems, long-term goals and prospects for the scientific-technological system, but while in Japan the long-term visions were generated by an iterative process, involving government, companies and universities, in the former USSR this process was more restricted to the military and space sectors.

East Asian countries started out with a lower level of industrialization than Latin American countries in the 1950s, but whereas in the 1960s and 1970s Latin American and East Asian countries were grouped together as rapidly growing newly industrialized countries from the 1980s onwards, A sharp contrast emerged: in East Asian countries, GDP grew at an average annual rate of 8%, in Latin American countries, this average was less than 2%, which in many cases meant a decreasing per capita income. Among the various explanations is the fact that East Asian countries implemented more radical social changes than in many Latin American countries, such as agrarian reform and universal education, which were social changes that enabled structural and technical transformations (FREEMAN, 1995).

In China, the innovation system began to develop along the lines of the Soviet model in the 1950s, in which scientific and technological innovation activities are separated from industrial activities. In 1978, it began a series of far-reaching reforms and began to open up to the world. In March 1985, the Central Committee of the Communist Party of China (CCCPC) proposed a strategic orientation according to which economic development must rely on science and technology, while the development of science and technology must be oriented to serve economic development. This orientation, which served as a roadmap for the reform of the national innovation system, had as its main foundations, namely: the reform of the science and technology financing system and its respective management; the implementation of a technology contractual system, in order to promote the development of a technology market and the commercialization of research results;

the introduction of market mechanisms and adjustments in the organizational structure of science and technology, in order to strengthen the companies' technological development capacity; granting greater autonomy and independence to research institutes; reform of the management of personnel dedicated to the science and technology system, implementing a merit-based reward system (GONÇALVES and CAVALHEIRO, 2015).

CONCLUSION

In the 21st century, the catching up process has, as distinctive elements of the previous processes, the emergence of new technological paradigms with an increasing scientific content, and the conjuncture of turmoil in the world economy, with the transition from the hegemony of a country (USA), without there still being a clear substitute for the hegemonic position (VIALE and ETZKOWITZ, 2005; ALBUQUERQUE, 2009).

The emergence of new technological paradigms with increasing scientific content requires a greater participation of teaching and research institutions in the development of knowledge absorption capacity by companies (ALBUQUERQUE, 2009).

According to Schumpeter, the capitalist system is characterized by the continuous and periodic emergence of innovations, which act as a factor of imbalance in the economic system, creating the conjuncture cycles, inherent to the system and in which there is a sequence of four interconnected phases: prosperity (expansion), recession, depression and recovery (SCHUMPETER, 1939 apud SZMRECSÁNYI, 2006)[3].

The transition from technical-economic paradigms associated with the conjuncture of international turmoil can generate catching up opportunities for less developed countries (ALBUQUERQUE, 2009).

In the Brazilian national innovation system, this opportunity may come through the new legal framework for science, technology and innovation, however, for governmental efforts to allocate more resources in ST&I to result in the promotion of economic and social development, in addition to the structural and governance changes proposed by the TCU in Decision /research institutions and the productive sector, as well as social reforms that reduce poverty and income concentration.

3. SCHUMPETER,J.A.Business cycles: a theoretical historical and statistical analysis of the capitalista process.New York:McGraw-Hill, 1939.

REFERENCES

ALBUQUERQUE, E. M. Catching up no século XXI: construção combinada de sistemas deinovação e de bem-estar social. In: Crescimento Econômico: Estratégias e Instituições. Rio deJaneiro:IPEA, 2009.

ALMEIDA, P. (2015) Defesa como vértice da retomada do desenvolvimento. Disponível emhttp://www.ezute.org.br/defesa-como-vertice-da-retomada-do-desenvolvimento-2/. Acesso em15/08/2020.

BASTOS, C. P.; BRITTO, J. Inovação e geração de conhecimento científico e tecnológico noBrasil: uma análise dos dados de cooperação da Pintec segundo porte e origem de capital.Campinas(SP): RevistaBrasileiradeInovação,16 (1), p. 35-62, janeiro/junho2017.

BRASIL, Congresso Nacional. Lei nº 10.973, de 2 de dezembro de 2004. Dispõe sobre osincentivos à inovação e à pesquisa científica e tecnológica no ambiente produtivo e dá outrasprovidências.

BRASIL, Congresso Nacional. Decreto nº 8.898, de 9 de novembro de 2016. Dispõe sobre oConselhoNacional deCiência eTecnologia.

BRASIL, Congresso Nacional. Decreto nº 10.057, de 14 de outubro de 2019. Dispõe sobre oConselhoNacional deCiência eTecnologia.

BRASIL,Ministério da Ciência, Tecnologia e Inovações. Estratégia Nacional de Ciência Tecnologia e Inovação–Encti 2016-2020. Disponível em: file:///C:/Users/furta/Downloads/PACTI_Sumario_executivo_Web.pdf.Acessoem 06/08/2020.

BRASIL, Tribunal de Contas da União. Acórdão nº1.237/2019–TCU–Plenário. Relatora Ministra Ana Arraes. Data da Sessão: 29/05/2019. Disponível em https://pesquisa.apps.tcu.gov.br/#/documento/acordao-completo/1722020181.PROC/%20/DTRELEVANCIA%20desc,%20NUMACORDAOINT%20desc/0/%20?uuid=966eb5e0-9859-11e9-95b8-2537453d60df.Acesso em 13/06/2021.

CASSIOLATO, J. E.; LASTRES, H. M. M. Sistema de inovação e desenvolvimento: asimplicações de política. São Paulo Perspec. vol.19 number1 São Paulo Jan./Mar. 2005. Disponível em: https://www.scielo.br/scielo.php?script=sci_arttext&pid=S0102-88392005000100003. Acesso em 16/08/2020.

ETZKOWITZ,Henry.The Evolution of the entrepre neurial university. In: International Journal of Technology and Globalisation, Vol. 1, nº 1, 2004, p. 64-77.

FREEMAN, C. The National System of Innovation in Historical Perspectives. CambridgeJournalof Economics, Vol. 19, nº 1. Cambridge, 1995.

FURTADO, C. Teoria e política do desenvolvimento econômico. 2ª ed. São Paulo: NovaCultural,1986.

GONÇALVES,A.,CAVALHEIRO,G.(2015)The Impact of Public Policies for Innovation in the Increasing Number of Patents–Brazil and China. IAMOT2015 Conference Proceedings.

Kimura,Fukunari.Japan's model of economic development: Relevant and non relevant elements for developing economies, WIDER Research Paper, Number 2009/22, ISBN 978-92-9230-191-0, The United Nations University WorldInstitute for Development Economics Research (UNU-WIDER), Helsinki. 2009. Disponível emhttps://www.wider.unu.edu/sites/default/files/RP2009-22.pdf.Acesso em16/08/2020.

KLEVORICK,A.;LEVIN,R.;NELSON,R.;WINTER,S.On the sources and significance of inter-industry diferences in technological opportunities. Research Policy, v. 24, p. 185-205.1995.

LUNDVALL, B. A. National innovation systems – analytical conceptand development tool.Industry and innovation, vol. 14, nº 1, págs. 95-119, 2007.

MONTEIRO,Marcelo. Apropriação do esforço de inovação tecnológica no exército brasileiro: o caso do rádio definido porsoftware. Dissertação apresentada como requisito parcial à obtenção do grau de Mestre em Propriedade Intelectual e Inovação, do curso de MestradoProfissional em Propriedade Intelectual e Inovação doInstituto Nacional da Propriedade Industrial.2019. Disponívelemhttps://www.gov.br/inpi/pt-br/atuacao-transversal/academia/arquivo/arquivos-biblioteca/monteiro-marcelo.pdf. Acessoem15/08/2020.

OCDE.*Oslo Manual. Guidelines for Collecting, Reporting and Using Data on Innovation, 4th Edition*, 2018.

SCHWARTZMAN, S. "Um espaço para a Ciência: a formação da comunidade científica no Brasil".Brasília, Ministério da Ciência, Tecnologia e Inovações, Centro de Estudos Estratégicos, 2001. Disponível via http://www.rep.org.br/issue.asp?vol=8&mes=4. Acesso em12/05/2020.

SUZIGAN, W., ALBUQUERQUE, E. M. A Interação entre Universidades e Empresas emPerspectivaHistóricanoBrasil.Belo horizonte: UFMG/Cedeplar,2008.

SUZIGAN, W. Estado e industrialização no Brasil. Revista de Economia Política, v. 8, n. 4,outubro-dezembro1988. Disponívelviahttp://www.rep.org.br/issue.asp?vol=8&mes=4.Acessoem 12/05/2020.

SZMRECSÁNYI, T. A herança schumpeteriana. In: PELAEZ, V. & SZMRECSÁNYI, T.(organizadores). Economiada InovaçãoTecnológica. SãoPaulo: HUCITEC,2006.

VIALE,Riccardo;ETZKOWITZ,Henry.(2005).Third academic revolution: poly valent knowledge; the "DNA" of the triple helix. Disponível em file:///C:Users/furta/Downloads/Third_academic_revolution_polyvalent_knowledge_the.pdf. Acessoem15/08/2020.