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Comparison between Brazil and the 30 Most Innovative Countries in the World

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Abstract

Innovation can be defined as the implementation of a new or significantly improved product (good or service), or a process, a new marketing method, a new organizational method in business practices, workplace organization, or external relations. This innovation can be measured by several factors such as investments in research and development, the concentration of high-tech companies traded on the stock exchange, among others. The present study aims to perform a cluster analysis to investigate the behavior of the most innovative countries compared to Brazil. The study contemplates a historical series from the years 2012 to 2015 of the 30 most innovative countries in the world having been added to Brazil. In addition, a series of macroeconomic, political and social variables are considered.

Keywords: Innovation, Technologic Innovation, Innovative Countries, STEM, Education, Government, Cluster Analysis

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1. Introduction

Studies on innovation have emphasized that, knowledge developed in universities and research institutes can and must be incorporated by society to promote regional economic development. This new model centralized the role of science and altered the university's end-activity, introducing a third mission: regional economic development, along with the existing missions of human resource training and knowledge generation (Torkomian, 2011; Hayter, 2011). Therefore, innovation has come to be understood as a driving force for the generation of wealth of organizations and consequently of nations, an element of definition of competitiveness (Lawson and Samson, 2001).

The expression innovation has been widely used, sometimes recklessly. However, the technological innovation appears when the results from universities, research institutes, or companies are transformed into marketable products and/or services. Thus, invention and innovation are different. The invention is a new solution for a specific technical problem. For a solution to be considered as invention, it must be necessarily new, i.e., the idea could not be created, or disclosed, or even made available for the public; while the innovation is an introduction of new goods with inventive features or new technologies in the market. There is an obligation to sell goods, services, processes, among others (Macedo; Barbosa, 2000).

The Oslo Manual determines that, there are four types of innovations which can occur in companies: product innovation, process innovation, organisational innovation, and marketing innovation. The product innovation comprises significant improvements in goods and services, i.e., goods and services completely new or improved. The process innovations describe significant changes in the production and distribution methods. The organisational innovations are the new methods created by corporations resulting in changes in business, better work organisation, or interference in the external relations of the company. Finally, there are the marketing innovations that comprise the new methods of marketing, including changes in goods and packaging, product placing, promotion, or pricing (OECD, 1997).

Another important concept related to innovation is the degree of innovation. Thus, these innovations may present themselves in the form of radical or incremental innovation. Radical or disruptive innovation has a significant impact on the market and business activity, resulting in product obsolescence, technology change, and even the creation of new markets. The standards previously used by the company undergo a process of reorientation, however, involve risks and unpredictability. In an incremental innovation, small adaptations can occur. Most of the innovations developed are incremental, with small improvements in the goods or services already developed (OECD, 1997; Hitt et al., 2008).

For the innovation to happen, the Organisation for Economic Co-operation and Development (OECD) argues that it must be influenced by several factors; as the environment surrounding the institutions, the legal systems, the macroeconomic context, and other conditions independent of any considerations about innovation itself. Besides these factors, the interaction among these agents and institutions (private companies; science and technologic institutions, and government entities) create a favourable environment for the creation of a National Innovation System, allowing the innovations to happen and promote the national development. What is known is that, there are elements which can facilitate or hinder the emergence of innovation. The culture of innovation and technological development, national policies, taxes brakes, public spending on R&D, and the incentive for innovation may represent these factors (Esteves and Feldman, 2016).

On the other hand, to create a National Innovation System, some conditions must be met, as the formation of a science and technology base; structural conditions; transfer factors; and, finally, the innovation dynamo, as can be seen on figure 1**.**

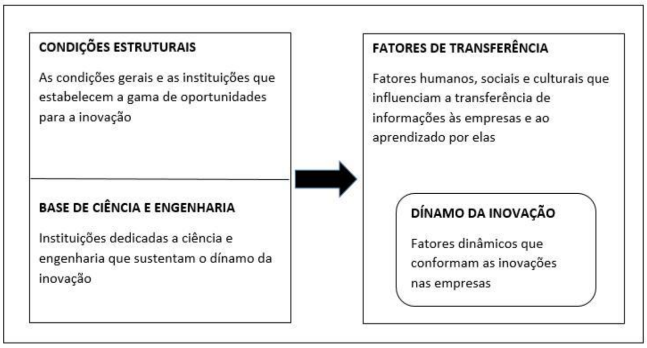

Figure 1. The field of Innovations Policies
Source: Adapted from Vasconcellos and Amato Neto 2012.

A National Innovation System is a social and dynamic system where the main activity is the interactive learning between the participants (Lundvall, 1992). The formation of a science and technology base guarantees the development of scientific and technological knowledge, which are, therefore, the basis for the further development of innovation, since science and technology institutions can be the drivers of staff training. The structural conditions correspond to entities that would support the development of innovation such as financial institutions, the legal context, market access, among other promoting sources. The transfer factors represent human, social, and cultural factors; which include the interactions, the cooperation and the information channel for the efficient operation of the innovation at the organisational level. Finally, the dynamo of innovation portrays a complex system of factors that conform the innovation in the organisational level and include the employees involved, the structure, internal facilities, strategy, financial structure, among other corporate aspects. The need to develop internal and external competencies for innovation to materialize is also noted (Vasconcellos and Amato Neto, 2012; OECD, 1997).

When analysing the specific case of Brazil in patents indices, scientific publications, and the number of students with a background in science, technology and engineering, one can note that Brazil does not occupy a relevant position in these indices (Esteves and Feldman, 2016).

2. Research and Development in the Innovative Process

In Brazil, the sectoral funds for research development resemble the American process. The Federal Government allocates part of the proceeds from contributions levied on the result of the exploitation of natural resources belongingto the State and portions of the Industrialized Products Tax (IPI – in Portuguese) from certain sectors to create an investment fund to finance science, technology and innovation in companies, universities, technological institutes and other public or private institutions. To receive financing for project execution, the interested bodies must submit their proposals, which are evaluated by the Management Committee, that is composed of representatives from various segments of the Federal Government, academia, business and the like. In the case of universities and research institutions, a non-profit foundation supported by the Ministry of Education can play this role (Dietrich et al., 2013).

The allocation of public resources destined for Science and Technology becomes increasingly scarce since the resources destined to this area compete with areas considered priority by the government as health, education and security (Contini et al., 1998).

Companies in established sectors that dedicate part of their resources to R&D and innovate regularly can be challenged if they cannot interpret signs of transformation in their markets and technology. In dynamic environments, you need to develop skills to capture some signs of change as well as competence and agility to move to new areas and technologies that emerge. This means developing and building capacities, adapting and absorbing new knowledge when necessary, and surpassing redundant or obsolete knowledge (Tidd et al., 2001).

To keep innovating, companies carry out internal and external efforts. Internal efforts include internal R&D activities, internal training of human resources for skills development, use of financial resources to support developments, ability to deal with change, and others. External efforts include outsourcing R&D, use of new technologies, acquisition of external know-how materialized as know-how, patents and licenses, acquisition of software, external training of the team, among others. In general, innovating corresponds to engaging efforts in several innovative activities (Anpei, 2009).

There are places that the ability to innovate is concentrated, as it is the case of the already developed countries in Europe, USA, and Japan. However, this assumption is beginning to change with emerging markets as China and India that are transitioning their production capacities to an innovative capability (Altenburg et al., 2008).

In Brazil, systematic and sustained efforts to innovate are still incipient, according to the Brazilian Institute of Geography and Statistics (IBGE – in Portuguese). Most innovative activities correspond to the acquisition of machines and equipment, followed by industrial project, and market innovation. Few companies carry out R&D activities; or acquire external knowledge or even the use patent licenses. These results differ when compared to other countries, as mentioned before - e.g., with European countries, although they also use the acquisition of machines and equipment associated with innovation, they are also more involved in R&D activities (Anpei, 2009).

The role of Research and Development is to boost innovation, and they are fundamental for increasing the productivity and competitiveness of the countries. According to the global competitiveness report of the World Economic Forum (2015-2016), the competitiveness corresponds to a set of institutions, policies and factors that determine a level of productivity of a country. From competitiveness, it is possible to calculate an indicator – the Global Competitiveness Index – that essentially contemplates the key factors responsible for the economic growth and the prosperity level of a country. This index is composed of the following pillar: institutions; infrastructure; macroeconomic environment; primary health and education; higher education and training; efficiency in the market of goods; efficiency in the labour market; development in the financial market; availability of technologies; the size of the market; sophistication of business, and, finally, innovation. Although all pillars are important, developing innovative activities can generate better indices, and, consequently, achieve better competitive positions. Thus, R&D activities contribute to innovation and consequently the competitiveness of the countries.

It also collaborates with the index which proves the innovative process of the countries. This index is called as the Global Innovation Index that is published by the Cornell University, INSEAD Business School, and the World Intellectual Property Organization (WIPO). Global Innovation Index takes in consideration 82 indicators related to innovation. In 2016, Brazil ranked 69th, what turned out to be the worst positioned country among the BRICS. China was the 25th, Russia was 43rd and South Africa was 54th (WIPO, 2016). This way, it is necessary to encourage efforts in R&D, focusing on the market so that the development can be achieved by production and marketing of goods as well as services that meet the expectations of the society.

According to UNESCO, Brazil invested 1.2% of its GDP in 2015 for R&D, and in the same year ranked 69th in the Global Innovation Index, while Switzerland, which was in the first place, invested 3% of its GDP in this field. The table below shows the 10 most innovative countries in the world. Table includes ranking of countries based on their expenditures on R&D as % of GDP for the period of 2012-2015.

Table 1. Top 10 Innovative Countries and Brazil based on Expenditures on R&D as % of GDP (2012-2015)

Rank	Ranking Global Innovation Index 2016	Expenditure on R&D as % of GDP 2015	Expenditure on R&D as % of GDP - 2014	Expenditure on R&D as % of GDP - 2013	Expenditure on R&D as % of GDP - 2012
1º	Switzerland	3.0	3.0	2.9	3.0
2º	Sweden	3.3	3.1	3.3	3.3
3º	United Kingdom	1.7	1.7	1.7	1.6
4º	United States of America	2.7	2.7	2.7	2.7
5º	Finland	2.9	3.2	3.3	3.4
6º	Singapore	2.0	2.2	2.0	2.0
7º	Ireland	1.3	1.5	1.6	1.6
8º	Denmark	3.0	3.0	3.0	3.0
9º	Netherlands	2.0	2.0	2.0	1.9
10º	Germany	2.9	2.9	2.8	2.9
69º	Brazil	1.2	1.2	1.2	1.1

Source: OECD: Cornell University; INSEAD; WIPO.

We can notice on Table 1 that, among the most innovative countries in the world, considering the top 10 in the ranking, only two invest less than 2% of its GDP on R&D, and when compared to Brazil which has the 69th place, they also have an increase of 0.5% in investment. Thus, it is possible to perceive that there is one way to influence the technological innovation process. That is by investing in research and development. The increase in R&D investment has contributed to the emergence of patents, and these have played an important role in the market. Because through them, companies show a greater competitive advantage. The increasing use of patents is related to the changes in patents regime of the countries, making them more valuable and easier to obtain through the enabling environment generated (OECD, 2004).

3. The Importance of Patents for Technological Innovation

According to the OECD glossary of terms, a patent is a sole right granted by a government to an inventor in exchange for the use of the invention. This authorizes the inventor to prevent third parties from using the invention in any manner for an agreed period. According to the Science, Technology and Innovation in Europe (Eurostat, 2008) report, an invention must meet several conditions to be patentable; it must involve an innovative step and be fit for the industry. A patent is a right of intellectual property for inventions of technical nature and it is valid for 20 years. Although patents do not cover all types of innovation, they include a large proportion of them. It is important to note that patents are territorial. This means, they only prevent use by third parties in countries where they have been required. There are good reasons why patents have become one of the broader data sources in the construction of indicators for innovations of results.

Patents aim to promote innovation in the private sector, allowing the inventor to benefit from their inventions, but the positive effect of patents on innovation as an incentive mechanism has been traditionally contrasted with the negative effect on the competition and the diffusion of technology. The patents have been considered, on the one hand, a representative of the compromise between the incentive for the innovation and on the other, market competition and the diffusion of technology. The impact of patents on innovation and economic development is complex and adjustment in patent design is crucial to becoming an effective policy instrument. Increasing levels of business patents help inventors to match their investment returns and facilitate cooperation through market-based knowledge transactions (OECD, 2004).

4. The Role of Stem in Technological Innovation

Another factor that can affect the development of technological innovation is education, more properly science and technology education. This way, the term STEM - which is the abbreviation of "Science, Technology, Engineering and Mathematics" comes to the scene. The development of universities in the United States in nineteenth century, World War II and its countless scientific and technological developments, such as the launch of Sputnik by the former Soviet Union and the space race contributed to initiatives in STEM education (White, 2014).

The technological education is based on learning from problems of science, engineering and technology, using technological devices as means of learning. It is intended to technologically educate citizens since scientific knowledge has become a crucial factor in the production and distribution of wealth. That is the teaching of science in schools as justified by economic logic (White, 2014). This fact is fully confirmed by the rapid transformation of society that happened in the twentieth century, with the increase of urbanization; development of new production techniques; development of computing and the internet; creation of new chemicals and inventions in the health area; space exploration; nuclear energy, among many others. These advances contributed to the individuals who, after this period, sought a basic understanding of scientific concepts and had the ability to communicate, synthesize, and exploit this knowledge in an applied way. This started to motivate greater requirements from people according to their occupations. The new requirement was the ability to solve complex problems in a creative manner, self-management, sophisticated communication, ability to solve unconventional problems, building and evaluation of arguments based on proof and systematic as well as critical thinking. It means that in an environment where there is an excessive supply of information, it is essential to be able to make sense of available information, and this becomes a scarce and required resource, especially in environments where there is no training (Frey and Osborne, 2013).

In a world where knowledge and technology renew at a rapid pace, and competition is around the globe, it is necessary to find new strategies for educational processes. These reforms also need to be based on the evaluation of identified market needs. The excuse is that to face the challenges of globalization and market requirements, improvements in education and training are essential. People compete for jobs not only locally, but also internationally, based on the knowledge. Therefore policymakers, educators and researchers need to create educational and training programs based on assessments of real needs. besides the revindication for educational systems should be accessible to whole population, not only the wealthy portion (Mouzakitis, 2010; OECD 2013).

Thus, it is possible to perceive that the problem of the poorest countries does not only correspond to the fact that they have fewer resources, but also to the inability to create and benefit from scientific knowledge generated from these resources (Thomas & Watters, 2015). STEM education has its importance at national, regional, local and individual levels. The US government and private companies understand that investments in this type of education can contribute to the economy and competitiveness of the country, as it will form individuals capable of making decisions of political engagement, democracy and social development. On the other hand, training students in science and technology can guarantee increased income and employment (Saxton et al., 2014).

The STEM education is an essential element for the solution of several problems faced by society and economic development. It is hoped that with the prominence of STEM education, a workforce with knowledge in sciences will be reached, with the ability to use tools and technological products in the workplace to increase productivity. In addition, there are expectations that these professionals will have research experiences to apply them in the industry; be able to plan and implement change and develop new technologies (Egarievwe, 2015).

A group of actors is involved in this type of education: representatives of the government, the scientific community and private companies that aim to stimulate science education, since in many Western countries there is a low interest of the students in this area. That way, creating campaigns for diffusion can be a relevant strategy based on school programs, didactic materials, scientific competitions, events among others (Aandree and Hansson, 2015). Countries that wish to maintain leadership positions in the world economy know their dependence on STEM Education. This is justified as the world becomes more and more technological, and dependent on a more technical workforce (Christensen et al., 2014).

There is no international examination that measures the ability of students or society, in knowledge in Science, Technology, Engineering and Mathematics. However, there is an approximate way, through PISA. The PISA - Program for International Student is a sample and comparative evaluation organized by the OECD considering students enrolled in the 8th year of elementary school. The evaluation has national coordination in each participating country. There are currently 34 member countries, but additional countries are invited to the mentioned program as well. The PISA assessments occur every three years and cover the areas of Reading, Mathematics and Science. It aims to create indicators that provide information for the analysis of the quality, equity and efficiency of school systems in the participating countries and to provide support for the creation of policies to improve education, as well as comparison with other participating countries. The premise of the results is that every country has room for improvement, including those with the highest performance indices (OECD, 2017).

Evaluation systems like PISA seek to assess more than knowledge per se. There is an attempt to respond to the economic demands of a population, supported by creativity and innovation. On the other hand, it is important to highlight that these tests have an impact on the content to be addressed by the communities. The reason is that, for teachers and the schools, it is not interesting and appealing to present low grades in these tests, causing schools to focus on areas and practices that will be evaluated. In this way, it is possible to note the influence of these tests on the construction of the curriculum (Frey and Osborne, 2013).

Ethnic and socioeconomic aspects tend to influence careers in STEM areas. Low-income youth and minority groups often lack the fundamentals needed to develop skills in the areas of science and technology. These courses are often considered difficult and unrelated to the realities of these groups. This is generally due to lack of scientific background (Christensen et al., 2014).

Brazil has participated in PISA since its first edition, beginning the work with this group in 1998. In 2000, 4893 students were evaluated, with participation increasing in the following years of 2003, 2006, 2009, 2012, reaching 23141 students in 2015, focusing on Science (INEP, 2017). PISA aims to evaluate if the students can reproduce the knowledge acquired and extrapolate this knowledge, applying in unknown fields, such as situations inside and outside the school. This new approach reflects the fact that for modern economies, it is important that individuals not only know a certain content but, that they also know how to take advantage of their knowledge by solving complex and real problems (OECD, 2016).

Concerning Brazil, the performance of students is below the OECD average in Science (Brazil = 401 points, OECD = 493 points), Mathematics (Brazil = 377 points, OECD = 490 points) and Reading (Brazil = 407 points, OECD = 493 points). The average in science has remained stable since 2006, without significant change. The same occurred in reading since 2000. There is a small improvement only in mathematics, with an increase of 21 points in the average of students between 2003 and 2015. However, when analysing the period of 2012-2015, we can see a decline of 11 points on average (OECD, 2016).

When analysing the accumulated expenses per student aged 6-15, this value is equivalent to 42% of the average in relation to the OECD countries. In the 2012 assessment, this figure was 32%. In contrast, when analysing countries such as Colombia, Mexico and Uruguay, it was found that these countries with lower costs per student, obtained better results in 2015 compared to Brazil (OECD, 2016). This may bring some thought, such as probably the amount itself brings some results. However, better management of this resources can result in greater impact.

Some countries have satisfactory results in PISA such as Canada, China, Finland, Japan and Singapore. Performance is closely related to the distribution of learning opportunities, spending on education, teacher quality, and the economic context of these countries, which have a variety of educational policies and practices that can serve as a model (OECD, 2011). At PISA 2015, Singapore has outperformed all other participating countries, represented by major economies such as Japan, Estonia, Finland and Canada. Another important fact is that approximately 20% of students are below level 2. That is, these students have a low level of science proficiency. In addition, this becomes alarming when considering scientific literacy linked to economic growth. It means that to find complex solutions to a range of problems, including environmental problems, one cannot rely solely on the support and engagement of future scientists. There will be problems to be faced by all citizens. However, in most countries, science performance has remained unchanged since 2006, apart from Colombia, Israel, Macau (China), Portugal, Qatar, and Romania (OECD, 2016).

5. Innovation in Brazil

Finally, it is necessary to discuss and reflect on innovation in Brazil. Studies on innovation in emerging countries are still not frequent. Most research is on innovation in countries that have well-structured and mature innovation systems, as already mentioned. Brazil is one of the largest emerging economies in Latin America, with an incipient national innovation system. In this context, Brazil stands out in general for maintaining low investments in R&D; economic and political volatility; high levels of corruption; decline in recognition of the number of workers in slave condition; low quality of education, low capacity of industries to generate innovation, often transferred from foreign sources and financial constraints. Another disadvantage is the percentage of GDP invested in R&D that is below 1.2%, while EU countries invest over 2% and OECD members above 2.5% (Frank et al, 2016).

But, Brazil has carried out a set of large-scale policies and successful investment programs aimed at fostering innovation in the recent years. The National Innovation System has evolved in recent years between 1980 and 2008, with increased investments in R&D, increased intellectual property, implementation of policy instruments that support innovation, improvement in education, improvement in the performance of Science and Technology institutions (S&T) in terms of publications, visibility and innovation; institutional support to more structured innovation and development modalities being created by the Financier of Studies and Projects (FINEP – in Portuguese), or by the National Bank for Economic and Social Development (BNDES – in Portuguese) (Frank et al., 2016). There is a set of research, development and business institutions that play a major role in Brazilian innovation, such as FINEP, the São Paulo State Research Foundation (FAPESP) the Small

Business Innovation Research Program (PIPE), the Brazilian Agricultural Research Company (EMBRAPA), the Brazilian Industrial Research and Innovation Company (EMBRAPII), and Embraer.

FINEP was created in July 1967 to finance the preparation of studies for economic development projects and programs, as well as to improve national technology. With the creation of the then Ministry of Science and Technology (MCT) in March 1985, FINEP became associated with it. According to FINEP's Operational Policy (2016), lines of action have been developed for types of innovation, such as: (a) Pioneering innovation: strategic innovation plans that present a high degree of innovation and relevance for the economic sector, resulting in innovations through the development of products, processes or services unprecedented for Brazil; (b) Innovation for competitiveness: strategic plans of innovation focused on the development or improvement of products with the potential to impact the competitive ranking of the company in the market; (c) Innovation for performance: innovation of products in the scope of the company that can impact the productivity of the company, costs or the performance of products and services; (d) Pre-investments: pre-investment projects, which include technical feasibility studies.

FINEP's financing was responsible for several Brazilian technological innovations. One of them was the prototype of the BEM-312, the first Brazilian military training turboprop aeroplane. In addition to financing the project, FINEP contributed funds for the development of another Embraer defence aircraft, used by the Brazilian Air Force (FAB) and others, such as the Super Tucano.

Embraer was created with the support of the Federal Government. The operations of the company began in the early seventies and did not stop since. Embraer's history was always subject to challenges and overcoming. Today Embraer is one of the largest aerospace companies in the world. In 2012, the L.I.F.E Project (Lighter, Integrated, Friendly and Eco-Efficient Aircraft Cabin), a joint project between Embraer and a consortium of Portuguese companies was the winner of the Crystal Cabin Award in the category of Visionary Concepts (Embraer, 2017).

PIPE-FAPESP supports the scientific and technological research in micro, small and medium-sized business in the state of São Paulo, with the aim of promoting technological innovation, business development and business competitiveness (FAPESP, 2017). When it comes to innovation in Brazil, not mentioning EMBRAPA is not possible. The company was created in 1973 and it was linked to the Ministry of Agriculture, Livestock and Food Supply (MAPA), with the mission of enabling research, development and innovation solutions for the sustainability of agriculture of the Brazilian society. EMBRAPA has accumulated international, national and regional awards. It also actively participates in the elaboration and execution of several government policies, such as the Brazil without poverty scheme (Brasil Sem Miséria, in Portuguese), which promotes the participation of family farmers in the markets and several others such as the Amazon Fund (Fundo Amazônia), National Plan of Agroecology and Organic Production (PLANAPO - Plano Nacional de Agroecologia e Produção Orgânica). Its mission as defined in the Master Plan (V PDE 2008-2023) is to research for feasible solutions, development and innovation for the sustainability of agriculture, and the benefit of Brazilian society. Finally, EMBRAPII is an association that aims to cooperate with public and private research and technology institutions focusing on business demands and the targeting of risk sharing in the pre-competitive phase of innovation. Thus, by sharing project risks with companies, they feel more comfortable to invest in internal R&D programs (EMBRAPII, 2017).

6. Methodology

The research used macroeconomic variables from the 30 most innovative countries in the world according to the Global Innovation Index, which is carried out by Cornell University, INSEAD and the World Intellectual Property Organization (WIPO) for 2012-2015. In addition, Brazil was added to this group of countries.

The variables were taken from the Euromonitor International's Passport database, and are presented below:

Human Development Index (HDI), which provides a composite measure of three dimensions of human development: living a long and healthy life (measured by life expectancy), knowledge (measured by adult literacy) and having a decent standard of living (measured by purchasing power parity and income).

Index of Economic Freedom Ranking (IEFR), based on 10 quantitative and qualitative factors, grouped into four broad categories, or pillars, of economic freedom: Rule of Law (property rights, freedom from corruption); Limited government (fiscal freedom, government spending); Regulatory Efficiency (business freedom, labour freedom, monetary freedom); Open markets (trade freedom, investment freedom, financial freedom). Each of the ten economic freedoms within these categories is rated on a scale of 0 to 100, where the highest score presents best economic freedom. The overall score of a country is obtained by the average of these ten economic freedoms, with equal weight each. The ranking is obtained from the index that reflects the best score in a higher position.

Global Competitiveness Ranking (GCR), which is obtained from the Global Competitiveness Index, a high position in the ranking reflects a high score in the index. It measures the microeconomic and macroeconomic fundamentals of national competitiveness, taking into account 12 pillars: institutions, infrastructure, macroeconomic environment, health and primary education, higher education and training, goods market efficiency, labour market efficiency, financial market development, technological readiness, market size, business sophistication, and innovation. All of them have different weights, which vary from country to country to evaluate the stage of economic development of each. The final score is obtained by the average of the subscripts, according to the 12 pillars. The scoring of each subscript is from 1 to 7, where the best score is 7.

Political Stability and Absence of Violence (PSAVR), measures the perception of the probability of political instability and/or politically motivated violence, including terrorism.

Regulatory Quality Ranking (RQR) measures the perception of the government's ability to formulate and implement sound policies and regulations that allow and promote the private sector development.

Corruption Control Ranking (CCR) measures perceptions about the extent to which public power is exercised privately, including both small and large forms of corruption, as well as the "capture" of the state by elites and private interests.

Corruption Perceptions Ranking (CPR), is obtained from the Corruption Perceptions Index, a high position in the ranking reflects a high score in the index. It is a composite index and uses surveys with businessmen and reviews from analysts of these countries.

The percentage of the Gross Domestic Product (ERD) invested in R&D is formed by the investment of GDP in R&D. It is carried out in the nation during a certain period, which includes R&D carried out within a country and financed from abroad. But, it excludes payments made abroad in R&D.

7. Data Analysis

For the data analysis, grouping technique was used. This technique uses the Euclidean distance and represents the groups through dendrograms. The software used as computational support was IBM SPSS.

Before showing the results with the clusters generated from the variables of interest, the distributions of these variables are presented from 2012 to 2015, to observe the Brazil's position compared to 30 most innovative countries according to the OECD. On Figure 2, we have the boxplots considering the variables:

IEFR – Index of Economic Freedom Ranking

GCR - Global Competitiveness Ranking

PSAVR - Political Stability and Absence of Violence

RQR - Regulatory Quality Ranking

CCR - Corruption Control Ranking

CPR - Corruption Perceptions Ranking

ERD - Percentage of Gross Domestic Product (GDP) invested in R&D

For the variables that are being used, the larger the Boxplot value the worse the country's situation for that macroeconomic variable, except for the Gross Domestic Product (GDP) invested in R&D (ERD).

Thus, in 2012, Brazil presented a weak performance in four of the seven variables surveyed, moving away from the most innovative countries and approaching Latvia to a bad position in the ranking of corruption control (CCR).

On figure 2, Israel appears as the worst country in terms of political stability and absence of violence.

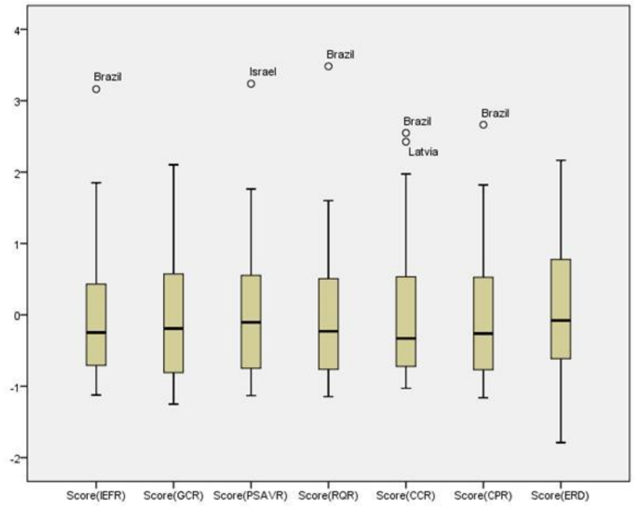

Figure 2. Bloxpot of the Macroeconomic Variables of the 30 Most Innovative Countries and Brazil for 2012.

In 2013, Brazil still had a poor performance in four of the seven variables. But this time Italy joined it also with a poor position in the ranking of corruption control, as it can be seen on figure 3.

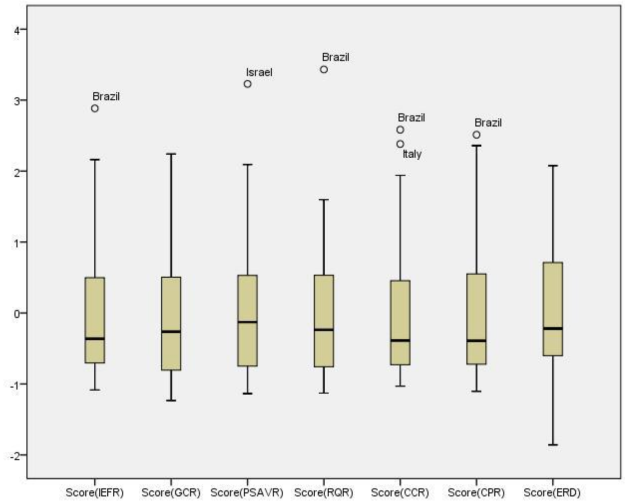

Figure 3. Bloxpot of the Macroeconomic Variables of the 30 Most Innovative Countries and Brazil for 2013.

In 2014, Brazil's performance in terms of the macroeconomic variables analysed remained below the most innovative countries. but this time China entered the ranking in the category of innovative country. Both China and Brazil are BRICS countries. But what can be observed for the years 2014 and 2015 is that these countries show inferior results jointly, when compared to the traditionally more innovative countries. It is highlighted on figure 4 that China, even belonging to the 30 most innovative countries, had the worst ranking in terms of Human Development Index, Ranking of Regulatory Quality and Ranking of Corruption Perceptions. In that year, Slovenia appears alone with the worst positioning in the Global Competitiveness Ranking.

That is, the 30 most innovative countries change annually as they are improving and evolving in terms of their macroeconomic, political, social, technological and other variables. Despite this, the distancing of Brazil is so great that it cannot be within the distribution of typical values of these variables.

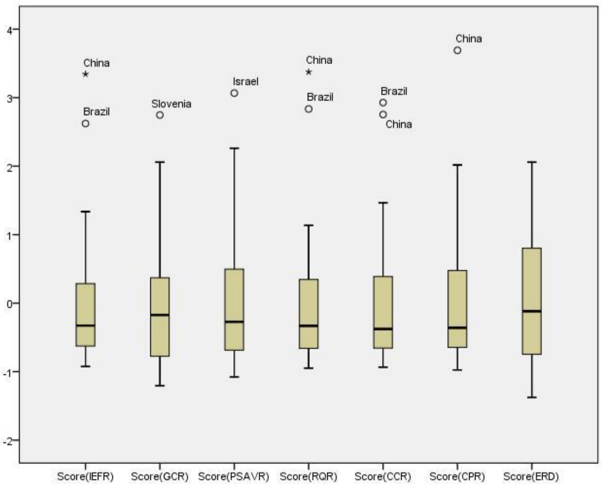

Figure 4. Bloxpot of the Macroeconomic Variables of the 30 Most Innovative Countries and Brazil for 2014.

By 2015, Brazil, by the results presented of the variables of interest, could be considered a country with little economic freedom, the second worst in regulatory quality and the most corrupt among the 31 countries analysed. Compared with the other more innovative countries, Brazil had the worst corruption control and the second worst foreign perception.

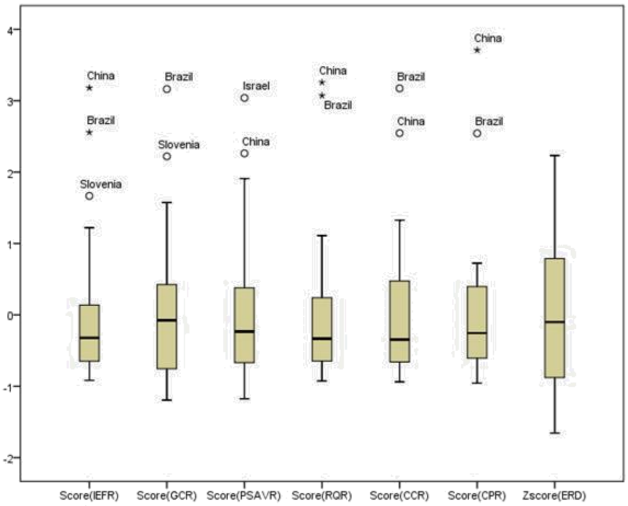

Figure 5. Bloxpot of the Macroeconomic Variables of the 30 Most Innovative Countries and Brazil for 2015.

Figure 6 shows the clusters formed from the distances between the variables (IEFR, GCR, PSAVR, RQR, CCR CPR and ERD), where Human Development Index (HDI) is also added. If we consider two groups, we notice that Brazil is isolated when compared to the most innovative countries. It is an outlier, has no similarity in terms of macroeconomic, political and social variables present in other countries classified as the most innovative in 2012. In that year, the northern European countries (Switzerland, Finland, Sweden and Denmark) formed an isolated group. Israel and South Korea are similar in accordance with the criteria used in the formation of clusters. Also, the clusters that will follow these two countries will always be close. The other countries form clusters as shown in figure 6.

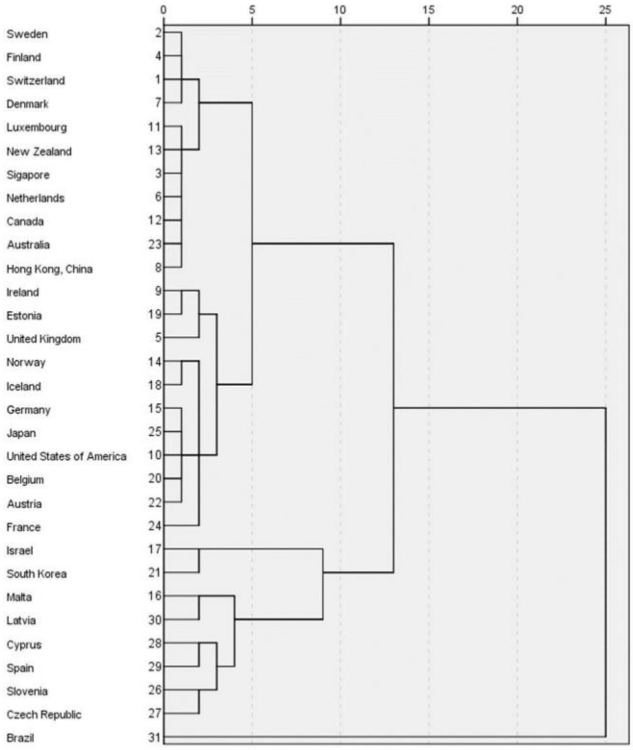

Figure 6. Formation of Clusters of the Most Innovative Countries (in 2012) and Brazil's Position

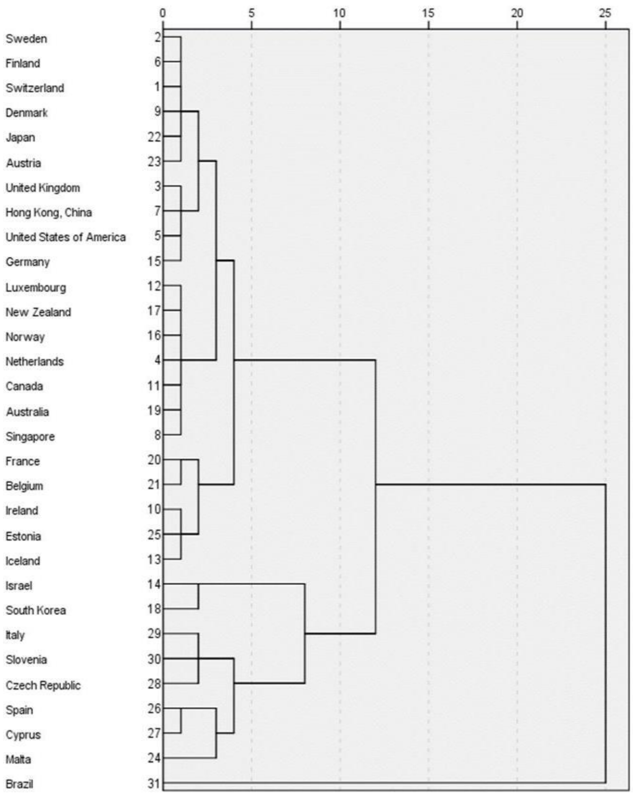

Figure 7. Formation of Clusters of the Most Innovative Countries (in 2013) and Brazil's Position

In 2013, the same happens with Brazil. It does not form a cluster with any country. It remains isolated from the others and the previously mentioned pair Israel and South Korea continues in the same cluster. France and Belgium, which in 2012 were in the same cluster, now form an isolated pair. The northern European countries that were grouped in 2012, remain the same, just like Japan and Austria. The United States and Germany show the same pattern of characteristics being in the same cluster as in 2012. Singapore, New Zealand, the Netherlands and Canada remained similar in the four years analysed.

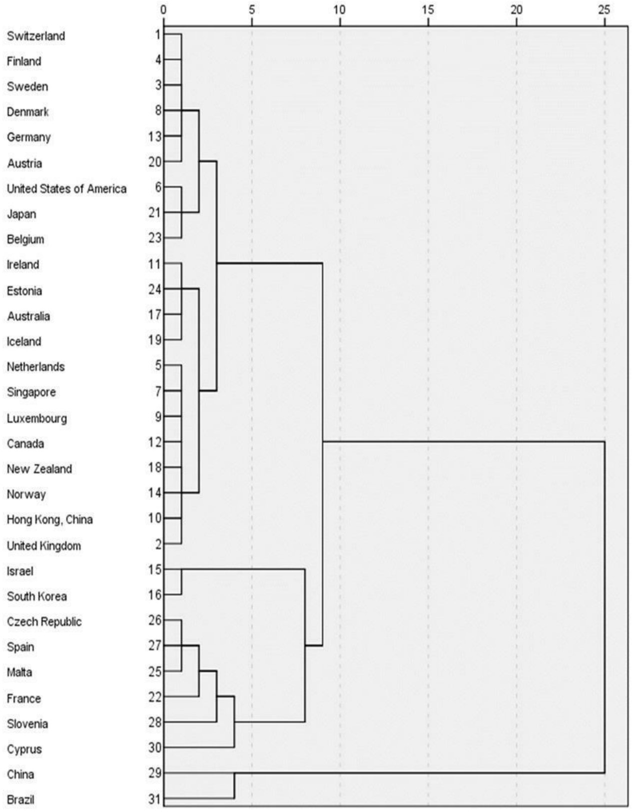

Figure 8. Formation of Clusters of the Most Innovative Countries (in 2014) and Brazil's Position

In 2014, China joined the group of the 30 most innovative countries in the world according to the OECD Global Innovation Ranking. We can see in figure 8 that Brazil groups with China and forms a cluster according to the similarity generated by the variables used. This fact reinforces the idea of BRICS, a group of the main emerging economies, which consists of Brazil, Russia, India, China and South Africa. For that year, we had seen that China among the 30 most innovative countries had the worst Economic Freedom Index, the worst Regulatory Quality Ranking, and the second worst country rank in terms of Corruption Control. Even so, China joined the group of most innovative economies and Brazil was in the 61st position.

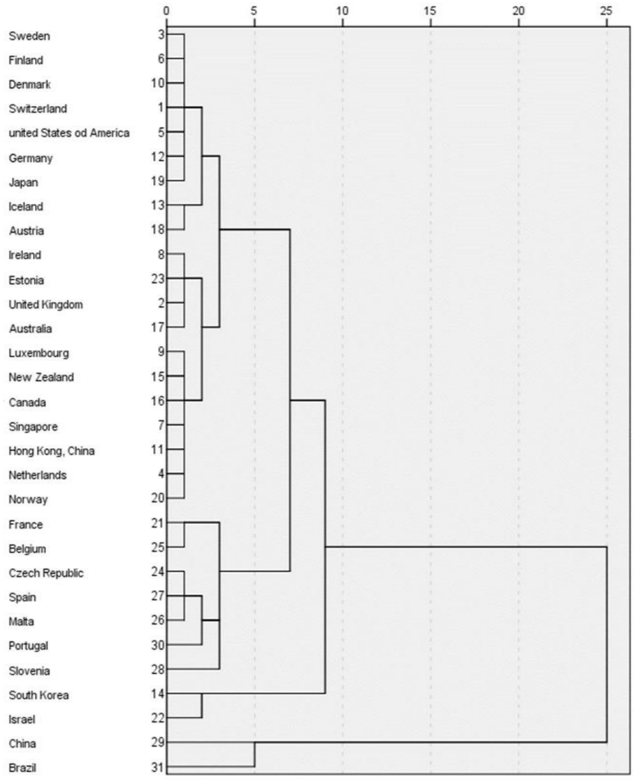

Figure 9. Formation of Clusters of the Most Innovative countries (in 2015) and Brazil's Position

In 2015, Brazil continued to cluster with China, just as South Korea and Israel remained clustered. Northern European countries (Denmark, Finland, Iceland and Sweden) also remained in the same cluster.

8. Final Considerations

We have seen the importance of technological innovation in the economic development of a country and how this development is linked to the improvement of the living conditions of this population. The macroeconomic variables presented refer to these improvements such as the Human Development Index, which has a more qualitative concept including the allocation of resources by the different sectors of the economy, to improve indicators of economic and social well-being. Brazil seems to move slowly in the innovative process, which entails a series of negative characteristics for the country as reduction in the number of patents and a low performance in macroeconomic, political and social variables.

By the help of our analysis, we presented an unfolding of the relevance of variables associated with innovation as Percentage of GDP invested in R&D, number of patents, public spending on education, and focus on STEM education among others. In cluster analysis, we identified Brazil as distant from all the countries on the list, approaching China only when it appears in the years 2014 and 2015. To that fact, we can make an association with the BRICS, which is an international political mechanism of cooperation among Brazil, Russia, India, China, and South Africa. The only country belonging to BRICS that appears in the list of the most innovative countries is China, which stood out with Brazil presenting bad results in many presented variables.

According to the BRICS 2017 Innovation and Competitiveness report, science, technology and innovation are crucial driving forces in the development of a country and a society. In the context of globalization, a country with such solid capabilities is in a more advantageous position against others, which do not reflect these capabilities. The BRICS has already been a reason for high expectations. But currently according to the IBGE website, when we compare BRICS GDP growth with the Group of Seven (G7) that consists of Germany, Canada, the United States, France, Italy, Japan and the United Kingdom, it is well below the seven world powers.

This shows how the role of government is fundamental in the innovation of a country. It is essential that the government promotes partnerships between public and private institutions, provides a suitable environment for research, invests in education, has political and economic stability, and reflects control against corruption. In the four years analysed, from 2012 to 2015, Brazil went from 58 to 70 in the ranking of global innovation. The Lava a Jato operation which is the largest corruption investigation in the country's history began in 2014 to investigate politicians and suspects involved in corruption schemes and money laundering. So far, 198 temporary and preventive arrests were made, which gives us hope that, in the years to come, Brazil will be among the 50 most innovative countries in the world.

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Appendix A – Variables Description

VARIABLES	SOURCES	DESCRIPTION	YEAR
Ranking Global de inoaçao	The Global Innovation Report (Cornell University, INSEAD, WIPO)	Provides detailed metrics about the innovation performance of 127 countries and economies around the world. Its 81 indicators explore a broad vision of innovation, including political environment, education, infrastructure and business sophistication	2012 s 2015
Human Development Index	Euromonitor International	The Human Development Index (HDI) is an index used to rank countries by level of "human development". The HDI provides a composite measure of three dimensions of human development: living a long and healthy life (measured by life expectancy), being educated (measured by adult literacy and gross enrolment in education) and having a decent standard of living (measured by purchasing power income).	2012 a 2015
Index of Economic Freedom Ranking	Euromonitor International	The HDI sets a minimum and a maximum for each dimension, called goalposts, and then shows where each country stands in relation to these goalposts expressed as a value between 0 and 1, where 0 shows the lowest HDI value and 1 shows the highest. The scores for the three HDI dimension indices are then aggregated into a composite index using the geometric mean Economic freedom based on 10 quantitative and qualitative factors, grouped into four broad categories, or pillars, of economic freedom: Rule of Law (property rights, freedom from corruption); Limited Government (fiscal freedom, government spending); Regulatory Efficiency	2012 a 2015