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BRAZIL'S BEHAVIORAL ANALYSIS AGAINST THE MOST INNOVATIVE COUNTRIES IN THE WORLD

Análise comportamental do Brasil comparado aos países mais inovadores do mundo

Marisa Moser, Mauri Aparecido de Oliveira
Universidade Federal de São Paulo - Unifesp - Brazil
E-mail: marisa.moser@gmail.com; mauriao2@gmail.com

Abstract: The objective of this study was present the behaviour of Brazil in relation to the most innovative countries in the world when faced with macroeconomic, political and social variables. Through an analysis where the Grouping Technique was use, being considered the Euclidean distance and representing these groups with dendrograms in the years from 2012 to 2016. After this analysis was constructed, a Chebyshev Inequality Test for the year of 2016 with the purpose of identifying how much Brazil needs to improve its positioning in the presented variables to be in the cluster of the most innovative countries in the world.
Key words: Innovation, Technological Innovation, Innovative Countries, Innovative Environment.

Resumo: O objetivo deste estudo foi apresentar o comportamento do Brasil em relação aos países mais inovadores do mundo diante das variáveis macroeconômicas, políticas e sociais. Por meio de uma análise onde foi utilizada a Técnica de Agrupamento, sendo considerada a distância Euclidiana, representando esses grupos com dendrogramas dos anos de 2012 a 2016. Após as análises, foi construído um Teste de Desigualdade de Chebyshev para o ano de 2016 com o objetivo de identificar como o Brasil precisa melhorar seu posicionamento nas variáveis apresentadas para estar no cluster dos países mais inovadores do mundo.
Palavras chave: Inovação, Inovação Tecnológica, Países inovadores, Ambiente Inovador.

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INTRODUCTION

Innovation was the word used by Schumpeter to describe a series of activities that can be introduce into the economic system and substantially change the relations between producers and consumers, and in the definition of the author innovation is the key element for economic development happen. According to Schumpeter, economic development occurs with the growth of production at the same time as its structural change, from the emergence of new technologies, products and industries (SCHUMPETER, 1934).

According to Dosi (1988), innovations refer essentially to the search for, discovery, experimentation, development, imitation and adoption of new products, new forms of organization and new production processes.

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).

Incremental innovation is the result of small but significant improvements. Incremental innovations improve or reconfigure products that already exist to serve another purpose in the market (LUECKE, 2003).

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 & SAMSON, 2001).

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 that can facilitate or hinder the emergence of innovation. The culture of innovation and technological development, national policies, taxes brakes, public spending on R&D, the incentive for innovation may represent these factors (ESTEVES & FELDMAN, 2016).

According to Ashford (2000), technological innovation is the first successful application of a new technical idea. It occurs in institutions and private companies that seek profit.

Within a knowledge-based economy, innovation seems to play a central role. Until recently, innovation processes were not sufficiently understood. At the macro level, there is a substantial body of evidence that innovation is the dominant factor in national economic growth and international trade patterns at the micro level within firms, R & D it´s seen as a factor of greater absorptive capacity and use by the company new knowledge of all kinds, not just technological. (OSLO, 1997).

For the management and elaboration of public policies, there is interest in identifying characteristics and similarities between the innovative countries, so that emerging countries such as Brazil can carry out a benchmark and elaborate a plan of action.

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 belonging to 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, which 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).

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 with 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 contributions that universities can make to the process of enterprise innovation are diverse; universities are sources of more general knowledge needed for basic research activities; train and train engineers and scientists capable of dealing with problems associated with the innovative process in firms (ROSENBERG & NELSON, 1994); create spin-offs by academic staff (STANKIEWICS, 1994).

The formation of inter-organizational networks demands the realization of theoretical-empirical studies that clarify their dynamics, strengths, weaknesses, obstacles and applicability (JONES et al., 2003).

The perspectives of innovation networks have opened up new ways of approach for research aimed at understanding the differences in strategic conduct and performance that exist between companies, the traditional approach highlights the company as isolated and autonomous, and whose competitive advantages are linked to characteristics of the sector (PORTER, 1980).

The development of cooperation networks is associated with the evolution of innovation management models and the increasing adoption of a collaborative model, open innovation. This model assumes that the potential for innovation is found anywhere in the organization's value network, or in a number of external sources, and recommends developing the capacity to absorb new technologies and identifying opportunities in other companies to use their technology. The R & D area becomes an open innovation laboratory, integrating knowledge that can originate from suppliers, distributors, customers and other actors in its strategic network (CHESBROUER, 2007).

INNOVATIVE CONTEXT

This way, the term STEM - which is the abbreviation of "Science, Technology, Engineering and Mathematics" appears. The development of universities in the United States in the 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 problems, 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 is 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 work. 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 and 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 the available information, and this becomes a scarce and required resource, especially in environments where there is no training (FREY & OSBORNE, 2013).

In a world where knowledge and technology renew at a rapid pace, and competition is the around the globe, it is necessary to find new strategies also for the educational processes. These reforms also need to base 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 accessible to all the population and 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 the 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 for economic development. It´s hoped that with the prominence of STEM education, a workforce with knowledge in sciences would be reach, 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. In this way, creating campaigns for diffusion can be a relevant strategy based on school programs, didactic materials, scientific competitions, events, among others (ANDRÉE & 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).

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.

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).

Although in recent years, Brazil has carried out a set of large-scale policies and successful investment programs aimed at fostering innovation. 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) and the Small Business Innovation Research Program (PIPE), the Brazilian Agricultural Research Company (EMBRAPA), the Brazilian Industrial Research and Innovation Company (EMBRAPII) or also Embraer.

According to the FINEP website, it was create 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 and can impact on 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 create with the support of the Federal Government; the operations of the company began in the early seventies and did not stop since, building a history of 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 work 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, it is impossible not to mention EMBRAPA, the company was created in 1973, is 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), etc. 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; for 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).

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) from 2012-2016, 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.

• 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 better 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, it 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 carried out in the nation during a certain period, which includes R&D carried out within a country and financed from abroad, but excludes payments made abroad in R&D.

DATA ANALYSIS

For the data analysis, it was used the grouping technique, using the Euclidean distance and representing 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 2016, to observe the Brazil's position compared to the 30 most innovative countries according to the OECD. On Picture 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).

Figure 1. Bloxpot of the macroeconomic variables of the 30 most innovative countries and Brazil for 2012.

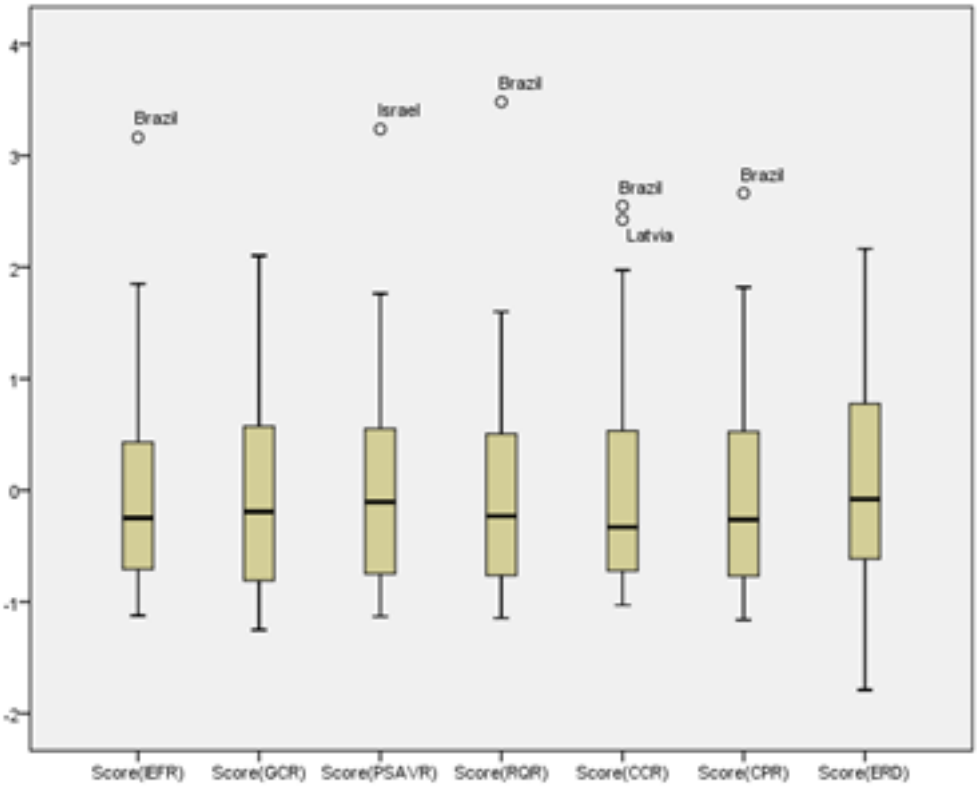


Figure 2. Bloxpot of the macroeconomic variables of the 30 most innovative countries and Brazil for 2013.

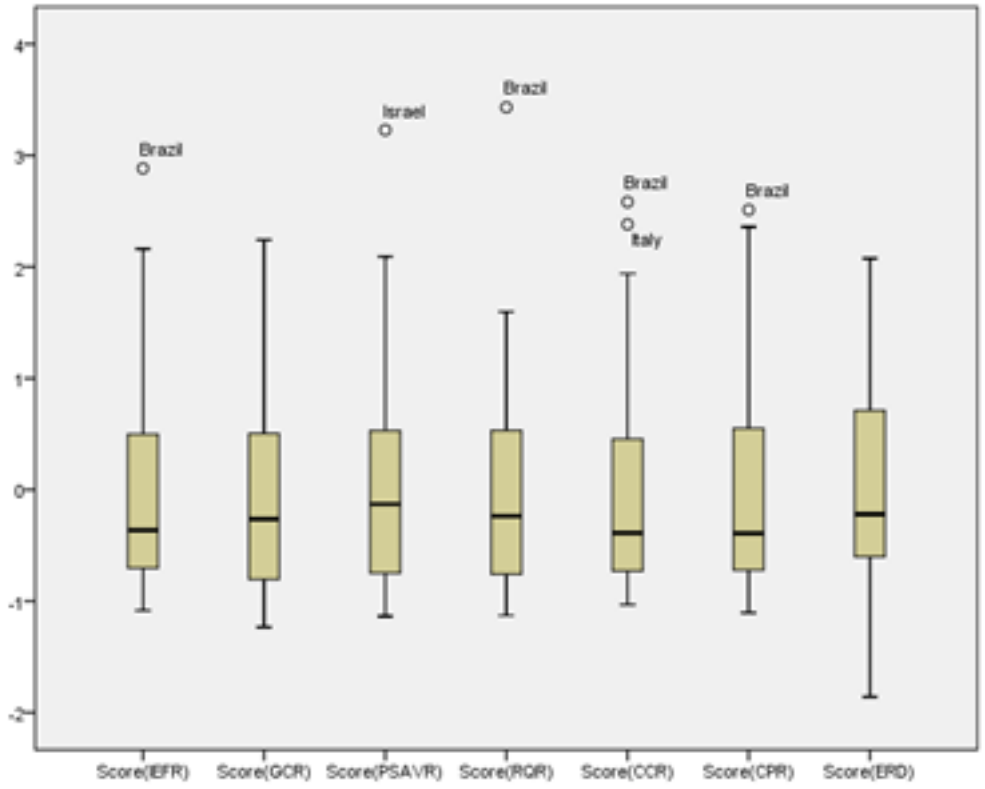


Figure 3. Bloxpot of the macroeconomic variables of the 30 most innovative countries and Brazil for 2014.

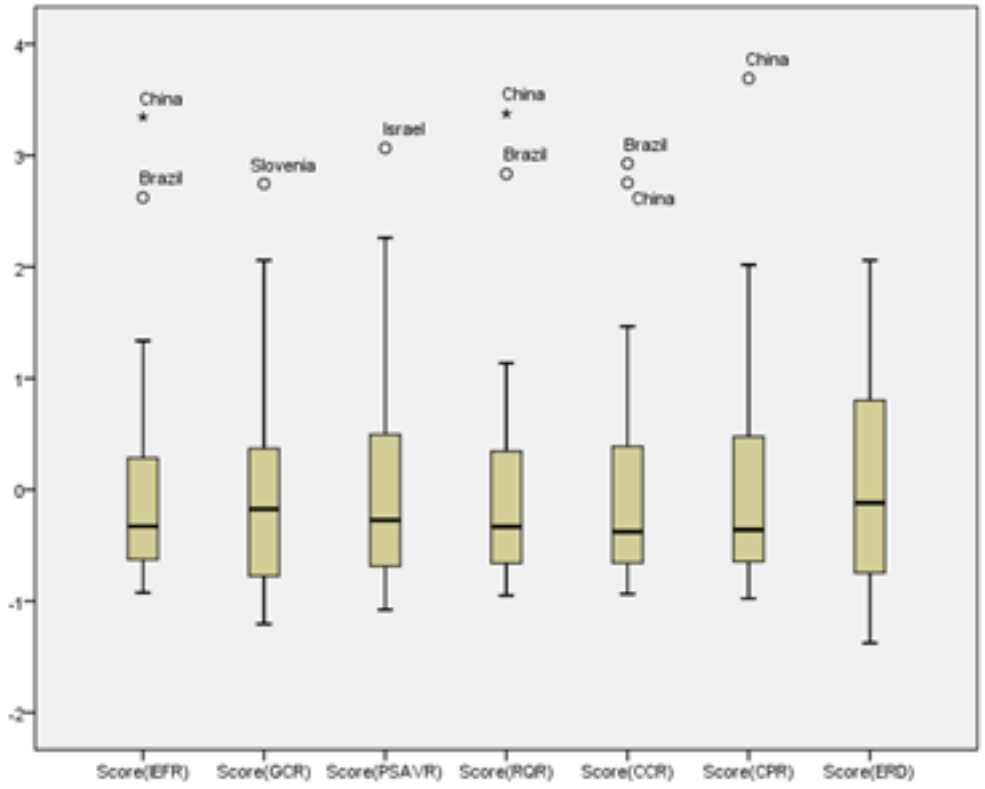


Figure 4. Bloxpot of the macroeconomic variables of the 30 most innovative countries and Brazil for 2015.

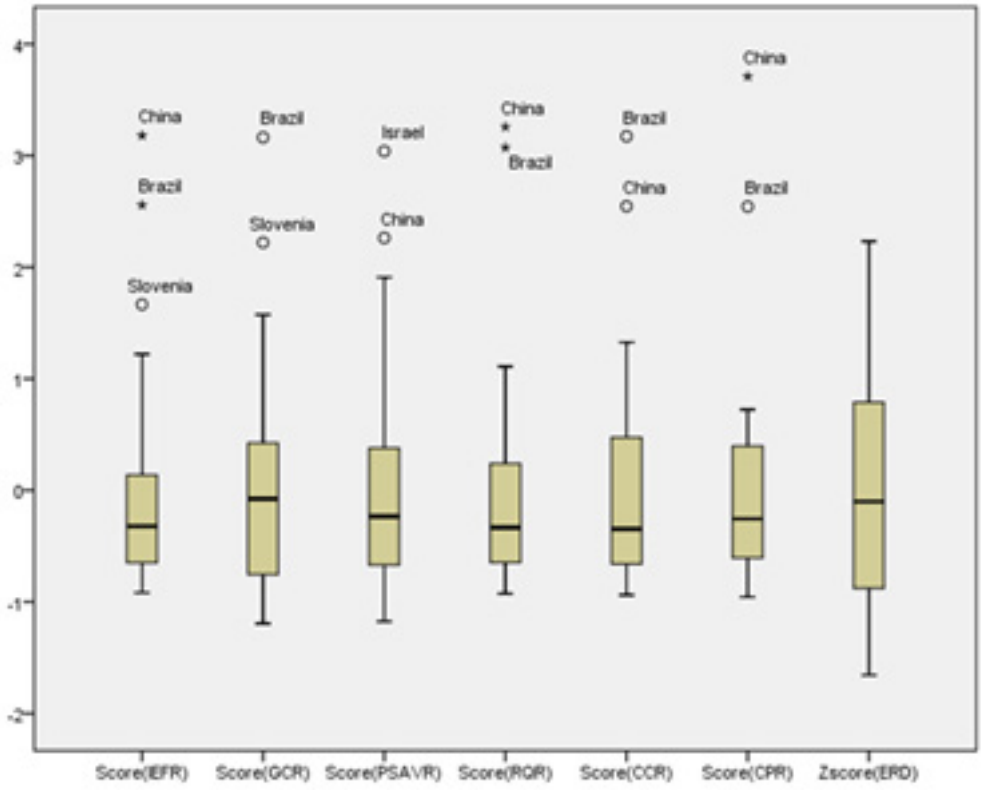
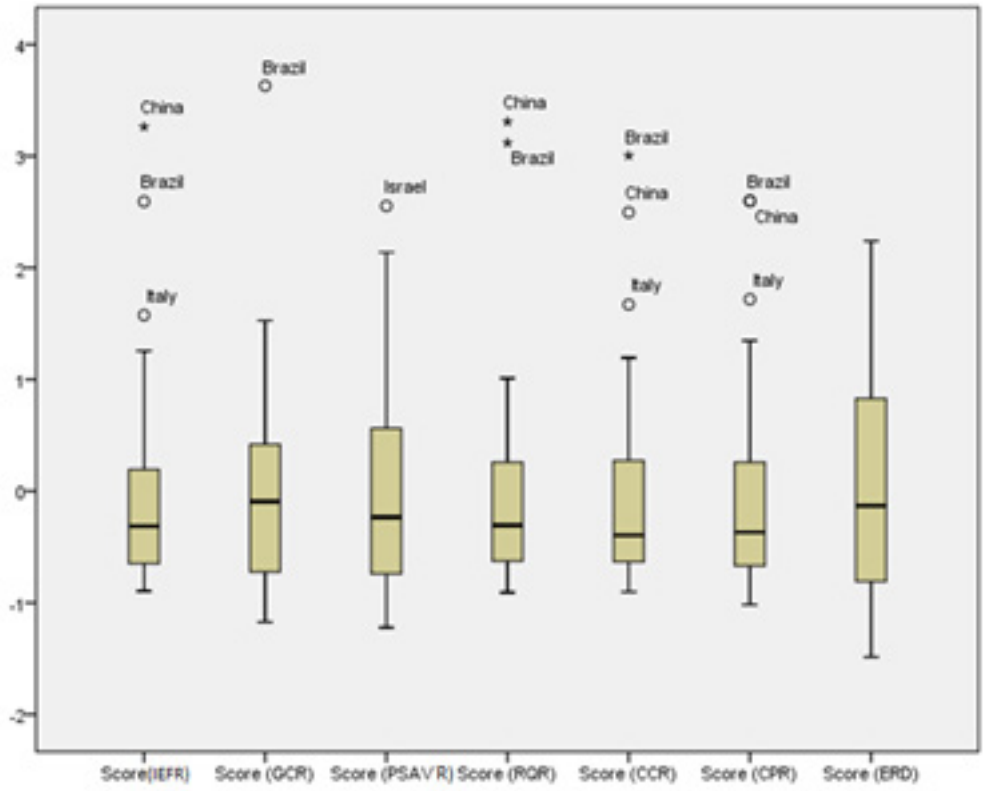


Figure 5. Bloxpot of the macroeconomic variables of the 30 most innovative countries and Brazil for 2016.



During all five consecutive years, Brazil presented a poor performance in three of the 7 analyzed variables, such as the Index of Economic Freedom, Ranking of Regulatory Quality, Ranking of Corruption Control.

In addition to Brazil, other countries systematically present a poor performance in some variables such as Israel, which in every year shows a poor performance in the Political Stability and Absence of Violence index, and China, when it enters the ranking of innovative countries in the year of 2014, presented a weak performance in 4 of the 7 variables analyzed in the last 3 years, Index of Economic Freedom, Ranking of Regulatory Quality, Ranking of Corruption Control and Ranking of Corruption Perception.

Figure 6 shows the clusters formed from the distances between the variables (IEFR, GCR, PSAVR, RQR, CCR CPR and ERD) being added Human Development Index (HDI). If we consider two groups, we notice that Brazil is isolated when compared to the most innovative countries. I.e., 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, and the clusters that will be present to 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.

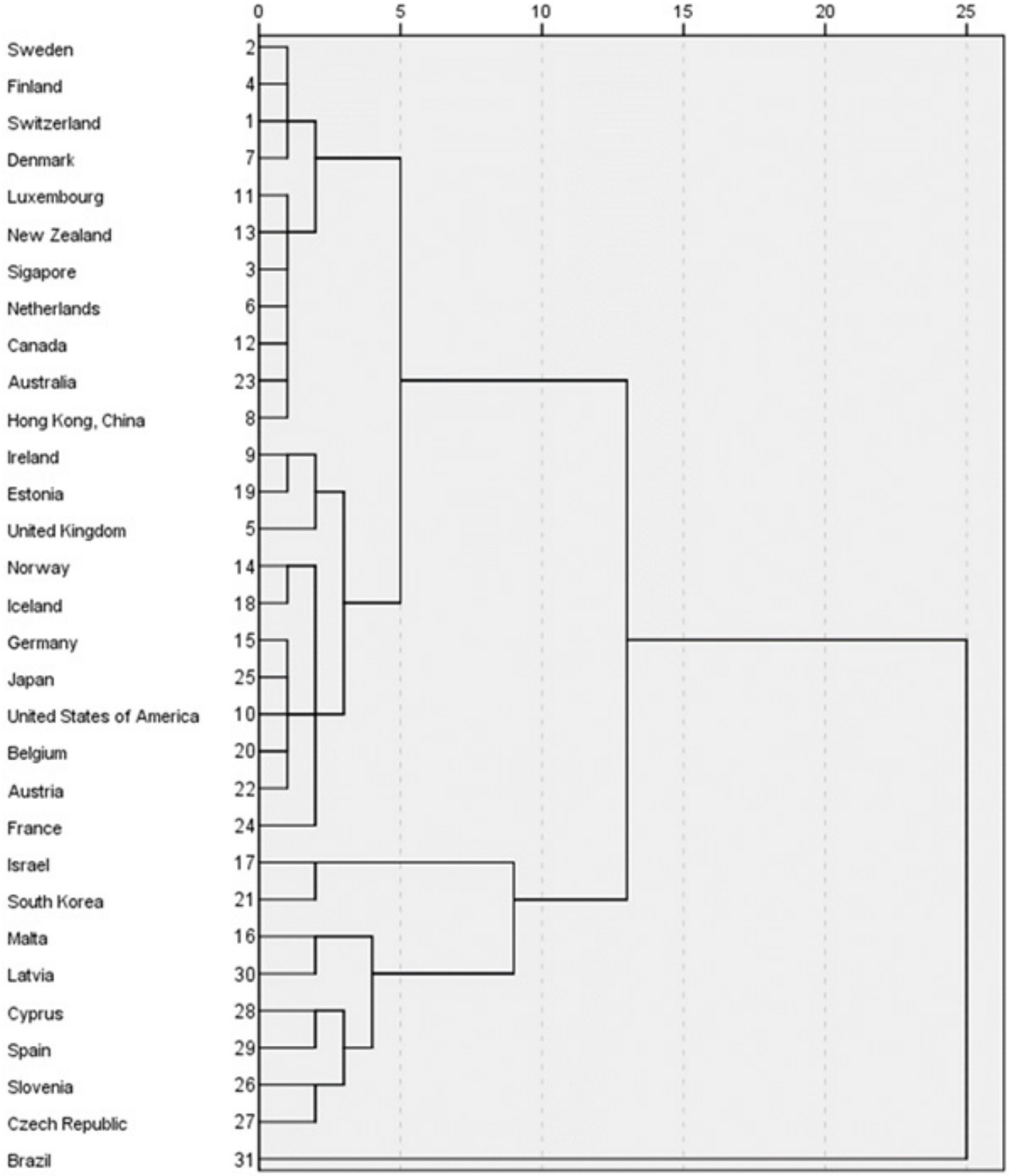
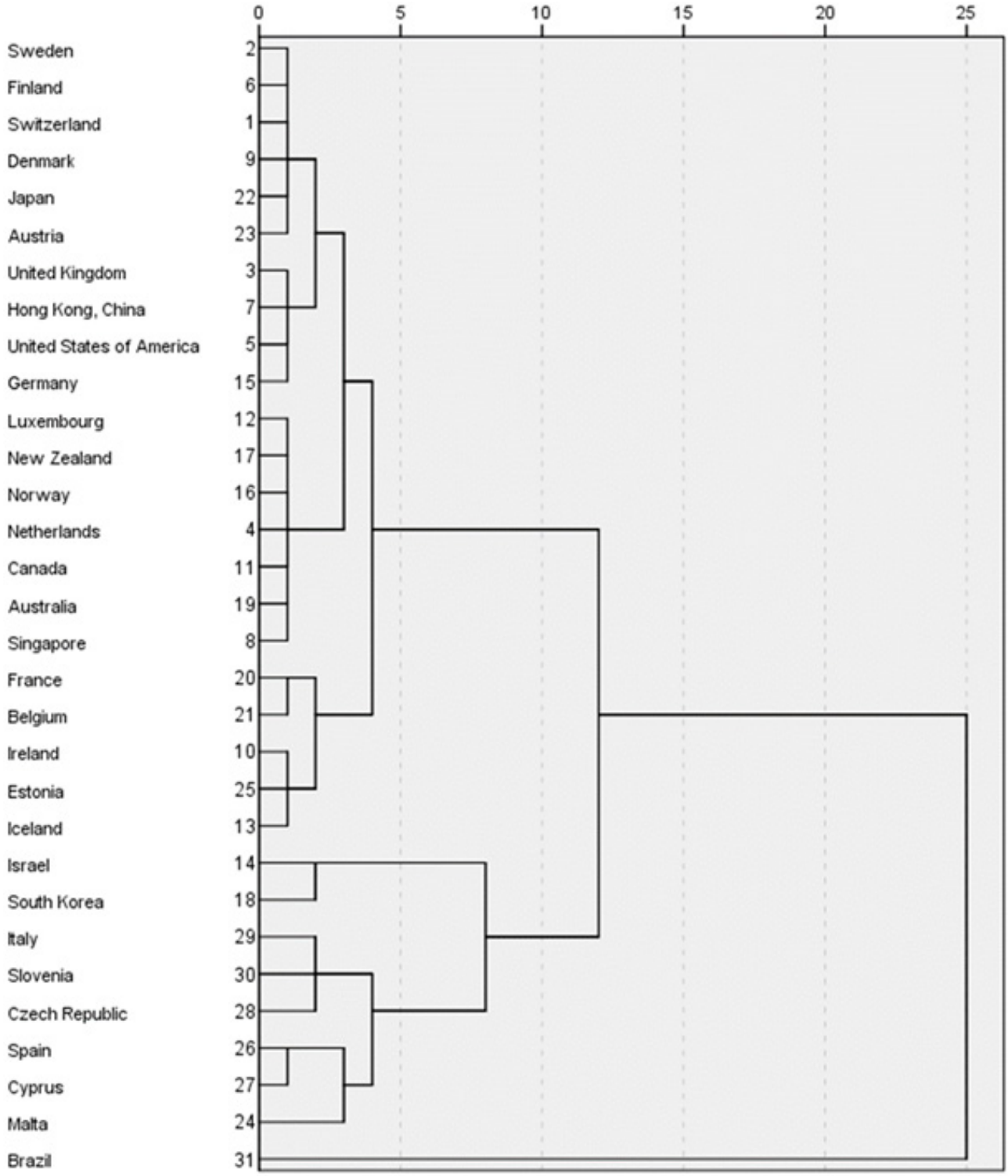
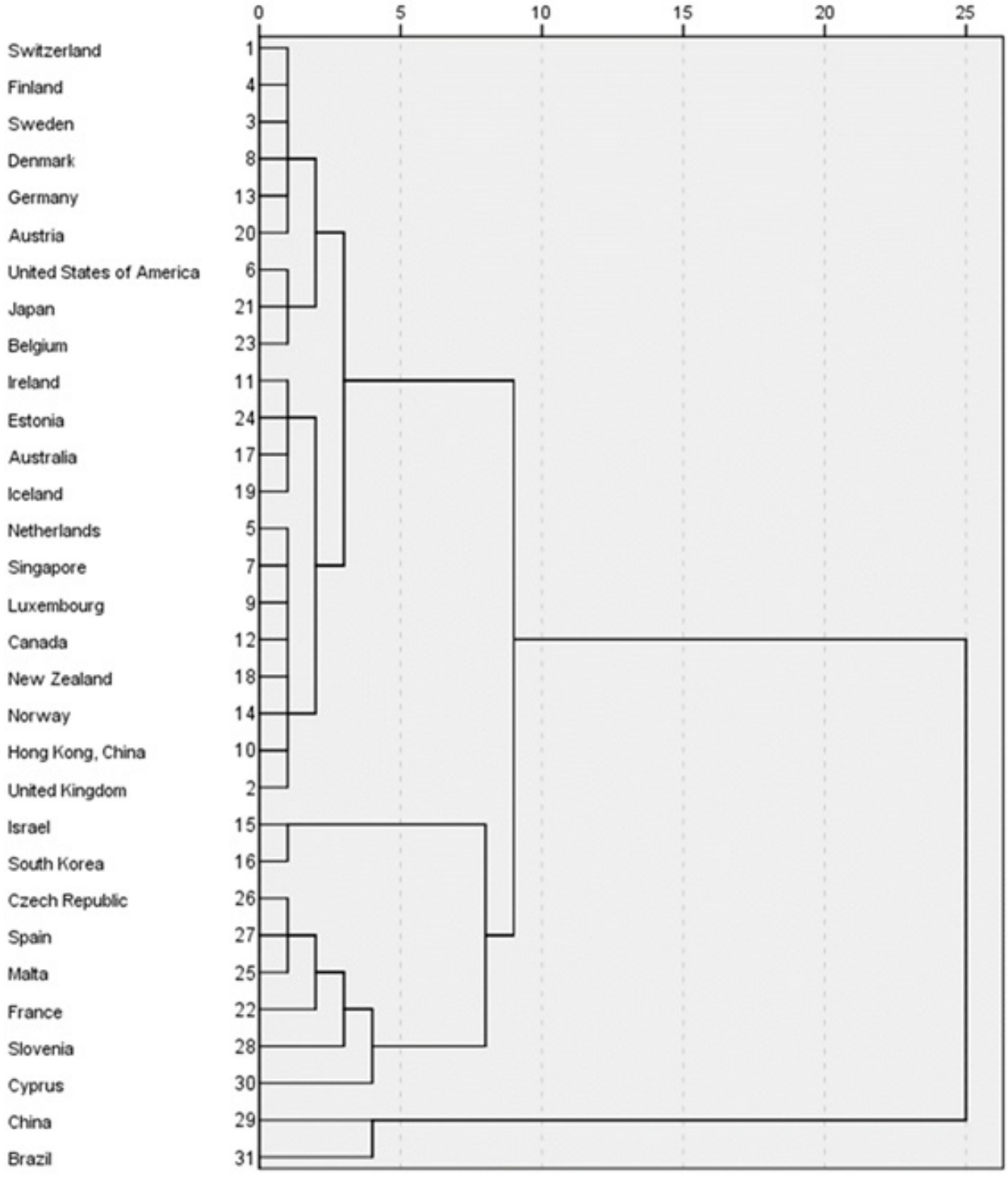


Figure 7. Formation of clusters of the most innovative countries (in 2013) and Brazil's position.



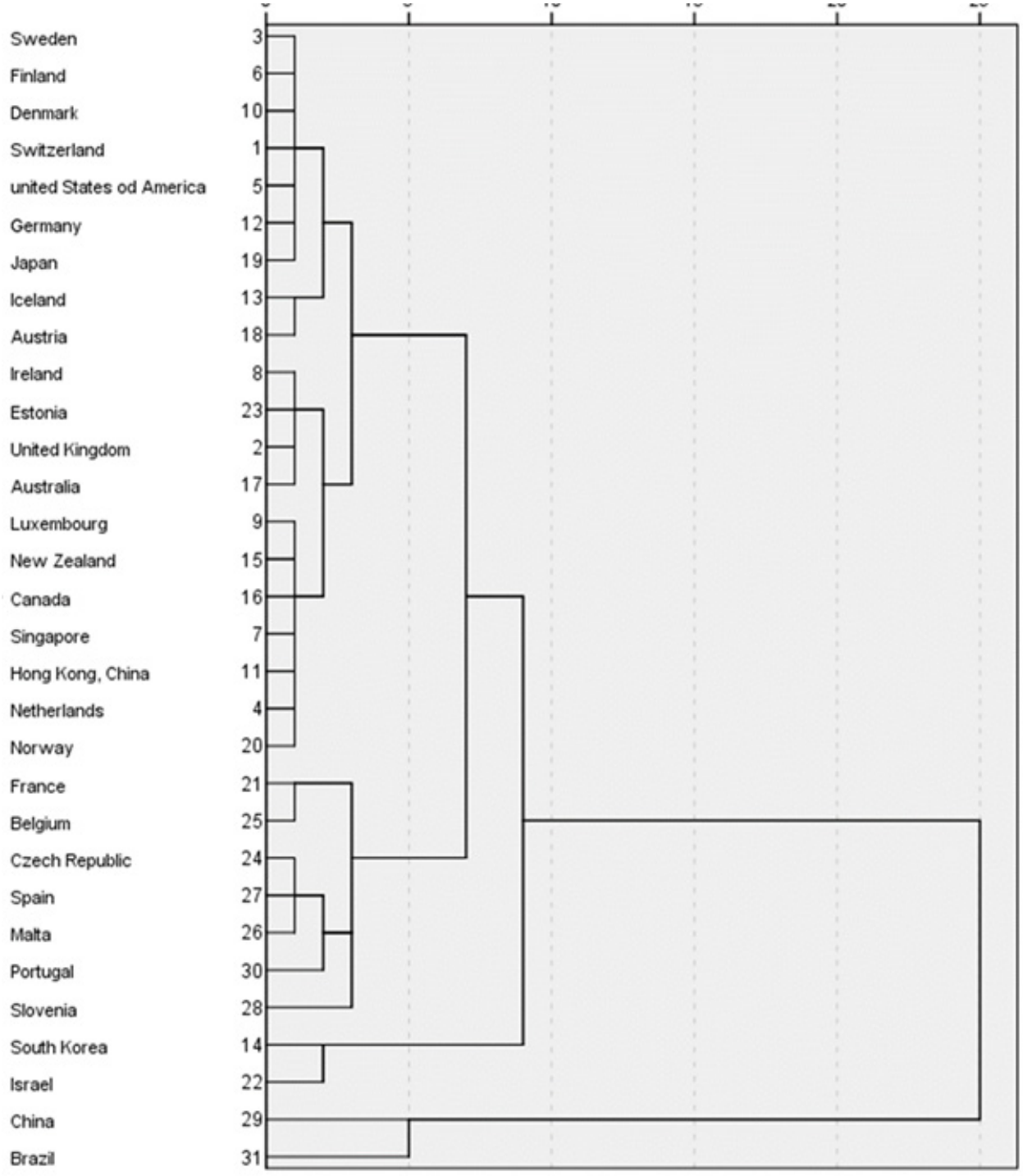
In 2013, the same happens with Brazil, it does not form a cluster with any country, it remains isolated from the others and the previously mentioned pair Israel and South Korea continues in the same cluster. France and Belgium, which in 2012 were in the same cluster, now form an isolated pair. The northern European countries that were grouped in 2012, remain the same, plus 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.



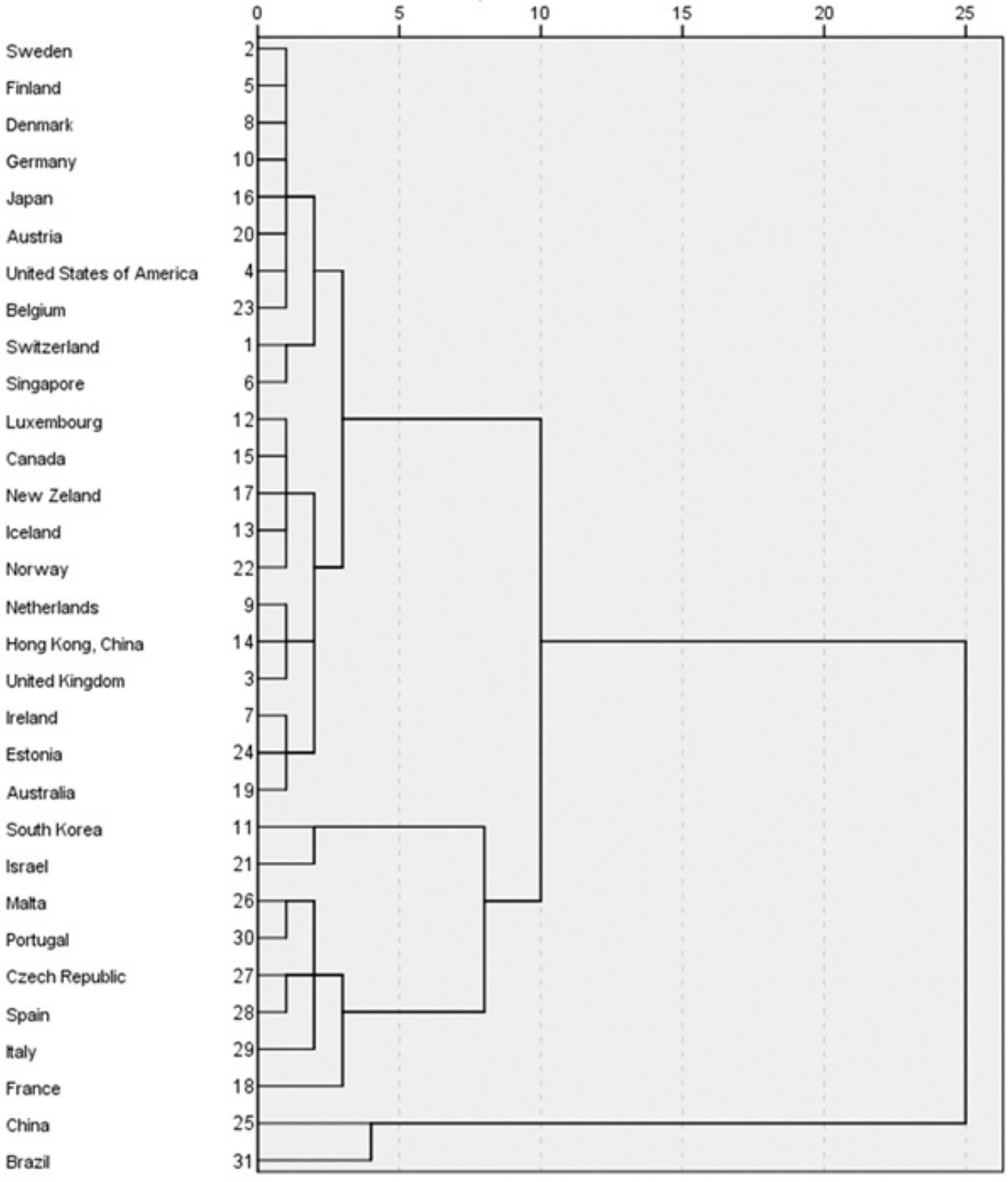
In 2014, China joined the group of the 30 most innovative countries in the world according to the OECD Global Innovation Ranking. We can see in figure 8 that Brazil groups with China and forms a cluster according to the similarity generated by the variables used. This fact reinforces the idea of BRICS, 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 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 the years, 2015 and 2016 Brazil continues to cluster with China, just as South Korea and Israel remain clustered.

Figure 10. Formation of clusters of the most innovative countries (in 2016) and Brazil's position.



The table below ranked the 30 most innovative countries in the world in the year 2016 and the performance of each of them in 07 analysed macroeconomic variables where Brazil was added for comparison purposes.

Table 1 - List of the 30 most innovative countries in the world in 2016 plus Brazil and its performance in 7 macroeconomic variables.

Ranking Global Innovation Index 2016		Index of Economic Freedom Ranking	Global Competitiveness Ranking	Political Stability and Absence of Violence Ranking	Regulatory Quality Ranking	Control of Corruption Ranking	Corruption Perceptions Ranking	Expenditure on R&D as % of GDP
1°	Switzerland	4	1	9	5	9	5	3
2°	Sweden	26	6	35	7	4	4	3.1
3°	United Kingdom	10	7	81	11	13	10	1.7
4°	United States of America	11	3	82	18	22	18	2.9
5°	Finland	23	10	38	8	2	3	3.1
6°	Singapore	2	2	1	1	7	7	2
7°	Ireland	8	23	44	12	16	19	1.4
8°	Denmark	12	12	48	17	3	1	3
9°	Netherlands	16	4	42	4	12	8	2.2
10°	Germany	17	5	56	9	14	10	2.9
11°	South Korea	27	26	96	33	67	52	4.2
12°	Luxembourg	19	20	5	14	6	9	1.1
13°	Iceland	20	27	8	28	10	14	1.8
14°	Hong Kong, China	1	9	49	2	18	15	2.1
15°	Canada	6	15	13	13	11	9	1.6
16°	Japan	22	8	27	21	20	20	3.4
17°	New Zeeland	3	13	2	3	1	1	1.2
18°	France	75	21	112	35	21	23	2.2
19°	Australia	5	22	36	6	15	13	2.3
20°	Austria	27	19	52	19	19	17	3.1
21°	Israel	34	24	165	26	37	28	4.2
22°	Norway	32	11	17	16	5	6	1.7
23°	Belgium	44	17	76	25	17	15	2.6
24°	Estonia	9	30	61	15	33	22	1.8
25°	China	144	28	147	113	108	79	2.1
26°	Malta	55	40	21	31	49	47	0.9
27°	Czech Republic	21	31	33	40	65	47	2
28°	Spain	43	32	75	38	63	41	1.3
29°	Italy	86	44	83	52	82	60	1.3
30°	Portugal	63	46	23	49	39	29	1.3
69°	Brazil	121	81	141	108	124	79	1.2

For purposes of analysis and in order to boost the development of public policies, it was sought to identify how much Brazil would need to improve its positioning in the analyzed variables to be present in the cluster of the 30 most innovative countries in the world in 2016.

For this, the means difference test called the Chebyshev Inequality Test was use where the sample set with mean $\overline{x}$ and standard deviation, the proportions of the total number of observations in the sample were at least 89% where $\overline{x} \pm 3s$

According to Sincich (1982), if a distribution of sample data is in the form of a hill (or bell) with average $\overline{x}$ and standard deviation s then the proportions of the total number of observations within the intervals $\overline{x} \pm s$, $\overline{x} \pm 2s$ and $\overline{x} \pm 3s$ are:

$\overline{x} \pm s$	Generally between 60% and 80%. The percentage will be approximately 70% for distributions that are approximately symmetric, but larger (about 90%) for highly asymmetric distributions.
$\overline{x} \pm 2s$	Nearly 95% for symmetric distributions. The percentage will be higher (close to 100%) for highly asymmetric distributions.
$\overline{x} \pm 3s$	Close to 100%.

Chebyshev's Theorem

For any set of sample measurements with mean $\overline{x}$ and standard deviation s the proportions of the total number of observations in the sample within the intervals $\overline{x} \pm 2s$ and $\overline{x} \pm 3s$ are:

$\overline{x} \pm 2s$	At least 75%
$\overline{x} \pm 3s$	At least 89%

Table 2. Superior Limit Chebyshev Inequality Test

	Index of Economic Freedom Ranking	Global Competitiveness Ranking	Political Stability and Absence of Violence Ranking	Regulatory Quality Ranking	Control of Corruption Ranking	Corruption Perceptions Ranking	Expenditure on R&D as % of GDP
Standard Deviations	30.66513614	12.51959384	41.01108625	22.03521215	26.5770621	19.22629904	0.880340843
Medium	28.83333333	18.53333333	51.23333333	22.36666667	26.26666667	21.06666667	2.25
Upper Limit	120.8287418	56.09211485	174.2665921	88.47230313	105.997853	78.74556378	4.891022529

The upper limit for Brazil to be among the 89% of the least corrupt countries is the 120th position in the ranking; Brazil is very close, in the position of 121. When we go to the ranking of global competitiveness even with the deviation over 3 years, Brazil would not yet enter the cluster, since the upper limit would be the position of 56 and Brazil is in 81 position. Brazil presented the position of 141 in the area of political stability and absence of violence, reaching the upper limit of 174, already in the ranking of regulatory quality where the upper limit was 88, Brazil presented the position of 108, very 89% of the countries.

In the next 3 variables analyzed, Brazil takes no position among the 89% of the countries, in the ranking of corruption control it has position number 124 and the upper limit is 106, in the perception of corruption the upper limit is 78 and Brazil is 79 in need of improvement in only one position to be at the upper limit and finally the percentage of GDP invested and R & D, in 2016 Brazil invested 1.2% of its GDP but the upper limit is 4.

CONCLUSIONS

According to the Global Innovation Index of 2017, policies to keep investments in innovation can help turn economic recovery into growth in the long run. Investments in innovation are a powerful resource against uncertainty, boosting confidence and therefore the investments of economic agents.

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, since the macroeconomic variables presented are related to these improvements. As a result of our research on 7 macroeconomic, political and demographic variables analyzed, Brazil needs to invest in 5 of them to be among the 89% of the most innovative countries in the world.

In order for Brazil to improve its position in the Ranking of Global Competitiveness, Ranking of Regulatory Quality, Ranking of Corruption Control, Ranking of Corruption Perception and its investments in R & D, public policies must be created and the indexes studied so that there is an adequate environment that impels the better performance of Brazil in the variables, thus leading to a better positioning among the most innovative countries in the world, since public policies are directives and guiding principles of public power actions and mediators of actions between the State and society. These policies must be systematized and formulated through programs and financing that stimulate the development and the indices that lead to the technological development of the country.

most innovative countries in the world.

Appendix A – Variables Description

Variables	Sources	Description	Year
Ranking Global de inovação	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 a 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 parity, PPP, income). 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 geometric mean	2012 a 2015
Index of Economic Freedom Ranking	Euromonitor International	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 (business freedom, labor freedom, monetary freedom); Open Markets (trade freedom, investment freedom, financial freedom). Each of the ten economic freedoms within these categories is graded on a scale of 0 to 100	2012 a 2015

Global Competitiveness Ranking	Euromonitor International	Global Competitiveness ranking is obtained from Global Competitiveness index. A high ranking reflects a high score in the index. The Global Competitiveness Index is a tool by World Economic Forum to assess the competitiveness of nations. It measures the microeconomic and macroeconomic foundations of national competitiveness, taking into account 12 subjects - Institutions, Infrastructure, Macroeconomic stability, Health and primary education, Higher education and training, Goods market efficiency, Labour market efficiency, Financial market sophistication, Technological readiness, Market size, Business sophistication and Innovation. All of them are given different weights, which varies across countries to evaluate the stage of economic development of each. Final score is obtained by averaging sub-indices, according to all 12 subjects. The score of each sub-index is from 1 to 7, where the best score is 7.	2012 a 2015	
Political Stability and Absence of Violence Ranking	Euromonitor International	The political stability and absence of violence rankings are obtained from the political stability and absence of violence index. A high ranking reflects a high score in the index. Political stability and absence of violence index measures the perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including domestic violence and terrorism. The index ranges approximately between -2.5 and 2.5 with higher values corresponding to better governance, however there might be some rare exceptions when the index exceeds this range.	2012 a 2015	
Regulatory Quality Ranking	Euromonitor International	The regulatory quality are obtained from the regulatory quality index. A high ranking reflects a high score in the index. Regulatory quality index captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. The index ranges approximately between -2.5 and 2.5 with higher values corresponding to better governance, however there might be some rare exceptions when the index exceeds this range.		

Control of Corruption Ranking	Euromonitor International	The control of corruption rankings are obtained from the control of corruption index. A high ranking reflects a high score in the index. Control of corruption index captures perceptions of the extent to which elites and private interests exercise public power for private gain, including both petty and grand forms of corruption, as well as "capture" of the state. Here it should be noted that because of different sources and calculation methods results of these index might differ from Corruption perception index calculated by Transparency International. The index ranges approximately between -2.5 and 2.5 with higher values corresponding to better governance, however there might be some rare exceptions when the index exceeds this range.	2012 a 2015
Corruption Perceptions Ranking	Euromonitor International	The corruption perceptions rankings are obtained from the corruption perceptions index. A high ranking reflects a high score in the index. Corruption perceptions index relates to perceptions of the degree of corruption as seen by business people and country analysts, and ranges between 10 (highly clean) and 0 (highly corrupt). It is a composite index, making use of surveys of business people and assessments by country analysts. It consists of credible sources using diverse sampling frames and different methodologies. These perceptions enhance our understanding of real levels of corruption from one country to another.	2012 a 2015
Expenditure on R&D as % of GDP	Euromonitor International	Expenditure on R&D as a percentage of GDP. Expenditure on R&D is total intramural expenditure on R&D performed on the national territory during a given period. It includes R&D performed within a country and funded from abroad but excludes payments made abroad for R&D.	2012 a 2015

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