DISCUSSION PAPER [1]

The low-complexity trap in Minas Gerais: a comparison with the other Brazilian States using DataViva platform[2]

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Abstract: Minas Gerais State coexists, for decades, with the challenge of economic diversification. In the attempt to build paths to transform its economy, Minas Gerais Government released the DataViva platform, allowing the application of economic complexity approach in the developmental public policies scope. This work aims at contributing for this study through economic complexity of the Brazilian States analysis between 2002 and 2014, focusing on Minas Gerais. The research reveals that Minas Gerais economy is stuck in a "low-complexity trap" that demands an intense collaboration between public and private sectors to identify and invest in activities that can contribute for economic sophistication.

Key-words: economic complexity - product space – structural change – DataViva – Minas Gerais

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SUMMARY

1 INTRODUCTION

In 2013, Minas Gerais Government released the DataViva platform, a tool developed by public state entities in partnership with the Massachusetts Institute of Technology, MIT Media Lab. In addition to offer interactive visualizations of economic data (international commerce, salary and job, higher education and school census) for all Brazilian Federation units (States and Municipalities), this instrument provides indicators that enable the analysis of the economic situation of Brazilian localities and their perspectives of growth based in the economic complexity approach. This approach, presented by Hausmann et al. (2014), starts from the premise that the process of economic development is related to the capacity of the economies to move in a continuous sophistication of their production structures, developing economic activities increasingly complex and intensive in cutting-edge technology.

To understand the economic sophistication process, the authors developed a methodology based in the product basket exported by different countries, named *product space* (HAUSMANN; KLINGER, 2007; HAUSMANN et al., 2007; HIDALGO et al., 2007). The *product space* is a network that connects the products from the probability of being co-exported by the same country. The premise of this model is that products that are connected share similar productive capabilities. Complex products have higher probability of being co-exported, since they demand a productive structure also complex. Using the product analysis is possible to distinguish the complexity level of the areas and make interferences in the possibilities of future economic sophistication considering the location of the products exported by a specific area on *product space.* The model logic is that the paths to economic sophistication are related to the proximity of the products currently exported in relation to more complex products that can be measured by the network.

Whereas *product space* enables the analysis of economic complexities of countries, the DataViva platform offers an expansion of this analysis for all the Brazilian States and Municipalities, being possible to obtain data about the economic complexity in different levels of regional aggregation. DataViva platform excels as the first tool aiming economic complexity analysis in a subnational level, allowing a display of Brazilian localities on *product space.* For this purpose, DataViva platform was built from information about the foreign trade available in Ministério da Indústria e do Comércio (MDIC) database.

Right after its release, DataViva platform gained great repercussions in the field of public policy makers not only for presenting a user-friendly interface, but also for offering an original approach for the construction of diagnosis and strategies of development based on the concept of economic sophistication. However, three years after its release, the economic complexity approach, afforded by DataViva, still did not managed to settle as a new analytical framework to affect public policies formulations; at least not in its state of origin.

In order to stimulate the application of DataViva in the development public policies context, the main objective of this work is to contribute for the understanding of the economic analysis possibilities offered by DataViva's application for the essence of Hausmann and Klinger (2007) proposal. Specifically, the economic complexity of the Brazilian States between 2002 and 2014 was analyzed, with focus on Minas Gerais. The choice of Minas Gerais attention was first because of the fact that it was the State proponent and financier of DataViva for Brazil. The investment made in this platform reflects a concern of this state's authority in transforming Minas Gerais economy, which is actually concentrated in iron ore and coffee exports. However, in the course of this research, the emphasis on Minas Gerais came out to be even more instigating, because it is the only state that presents, at the same time, indicators of a thriving economy (being one of the main Brazilian economies), and one of the least complex economies in the country, both in actual terms and future forecasts.

The main finding of this research is that Minas Gerais economy is stuck in a low-complexity trap: such as in the egg-chicken dilemma, the current productive structure weakens the economic basis that are necessary for the development of the capacities needed for future sophistication. This result was confirmed from the economic complexity indicators analysis, a prognosis of the complexity and complexity of the products exported by Minas Gerais in the period between 2002 and 2014. The presented analysis suggests that the overcoming of this trap will be ever harder for Minas Gerais than the other Brazilian states. For this reason, the sophistication strategy needs to incorporate the intense collaboration between public and private sectors to identify and invest in activities that can contribute for the increase of economic complexity.

This is the structure of the work: the section 2 offers a review of the economic complexity approach and discusses its main premises and arguments. The section 3 presents the methodological approach made in the analysis and highlights the indicators suggested originally by *product space*

and the ones offered by DataViva platform. This section presents the limits of *product space's* approach for the economic complexity analysis of the Brazilian States. The section 4 presents the results of the 2002-2014 period. It presents a subsection reserved to the comparative analysis between the Brazilian States and another one focused on the economic complexity analysis of Minas Gerais. In the end, the conclusion summarizes the argument, points its limits, and offers paths to the public policies formulations from the analysis afforded by DataViva.

2. THEORETICAL APPROACH

2.1 Economic complexity as a new measure of development

The theory that different productive structures are crucial in the difference between developed and developing countries have been widely defended by the economic literature. The "structuralist" school argues that the economic development process is closely connected with production structure changes, which are, in turn, determined by the availability of production factors and different levels of productivity. [4]David Ricardo (1817) was the first to warn about the differences in the productive structure composition between distinct countries and between different areas that are from the same country. He theorizes about the effect that these differences have in the economic interaction pattern between different localities.

The first lesson about the Ricardian Theory is that countries and regions should specialize in sectors and products that they produce better, in other words, in sectors and products that they have comparative advantage in relation to other localities: on this logic, countries would export what they produce efficiently and import what they do not produce efficiently, in relative terms. For Ricardo the idea of comparative advantage was related with labor productivity, and workforce would be its main factor. This idea served as an inspiration for a whole generation of scholars interested in explaining the international trade logic (HELPMAN et al., 2012). Since then, the economic models have been becoming much more complex. They are not only incorporating other production factors, but also recognizing the production factors mobility between different countries. Even though Ricardian Theory cannot explain the trade relations complexity anymore,

[4]See: Lewis, 1955; Rostow, 1958; Hirschman, 1958; Prebisch, 1962; Furtado, 1964; Kaldor, 1966; Lin, 2012

the idea of the differences between countries and regions concerning productivity levels and its relative advantages remain very important in economic development debate.

One of the main issues about this debate refers to the permanence of the international division of labor between developed and developing countries, despite of the transformations experienced by international trade in the last decades. Deep social, economic, and cultural transformations, influenced by the quick growth of new information and communication technologies, could cause the impression that the world is becoming less divided - or plain, in Friedman (2005) terms. The technological catch-up of newly industrialized countries and their integration to a world with global supply chain and production processes internationally disperses seemed that all types of products could be produced anywhere. In Ricardo's terms, the production internationalization is recreating the comparative advantages of each locality.

However, as Leamer (2007) and other authors have been arguing: the world seems far from economic leveling. First, the geographic distances still matter. As shown by Krugman (1991), the products specialization in each country has given way to production process specialization between different countries from a same region, reaffirming the inequalities between center and periphery areas. Most part of intra-industry trade happens between partners that are nearby each other, as in northern hemisphere, and especially in European Union. Even in Asia and Latin America, the industrial activities are grouped in nearby areas, reinforcing the idea that scale economies still play and important role.

Furthermore, not all the activities can be made in foreign territories – there are tasks that require "explicit" knowledge and there are ones that require "tacit" knowledge. While the first type of knowledge can be passed on easily from a person to another (explicit knowledge can be expressed in commands through guides and manuals) the second type requires time and training to be incorporated (GROSSMAN; ROSSI-HANSBERG, 2006). Tasks that are based on explicit information can be easily executed from a distance of the head office of the company and do not require highly qualified workers – good managers can translate the codes and supervise its subordinates. In contrast, tasks that requires tacit knowledge demand common experiences and cannot be easily transferred without a vis-à-vis exchange.

Due to the great difficulty in incorporate tacit knowledge, the process of production specialization has appeared, either in individual or organization levels. In other words, the production tacit knowledge was fractioned in small pieces, the productive capacities, in order to be easily incorporated. These capacities are a method of stocking knowledge that can be reused in the manufacture of new products (HAUSMANN, et. al, 2014).

More recently, approaches that seek to incorporate the inequalities between countries in relation to tacit knowledge access and accumulation has gained strength on the economic literature (LALL, 1992; ARCHIBUGI; COCO, 2005; HIDALGO; HAUSMANN, 2009). Those approaches retake the structuralist idea, which suggests that the tacit knowledge accumulation is one necessary condition for structural changes. The crucial point of this approach is that tacit knowledge development does not happen quickly on time; the acquisition of new capacities process implies in long-term investment.

In advanced economies, the new capacities development was started simultaneously with the industrialization process. Those countries that historically started early had accumulation and expansion of the gradual production knowledge as an advantage. Therefore, it was easier for them to reach the world-class technological border, because they had significant amount of production knowledge. In countries where the industrialization process started late, where the production knowledge was short, the effort to reach the most technologically advanced countries proved to be ever more dramatic, with diverse strategies and, consequently, have found different results. While East Asian countries reached success in the economic development race, the Latin America countries lagged behind and did not managed to overcome the "trap of medium income countries" [5].

One of the key challenges of the literature destined to the production knowledge and structural changes discussion is to measure de tacit knowledge accumulation of the different localities. How to measure the capacity gain obtained by the East Asian countries? How to measure the Latin America stagnation on those terms? How to contrast the production knowledge required by different economic activities? How to analyze structural change processes from the tacit capacities

[5] The trap of medium income countries refers to the structural inability of some economies, especially Latin America ones, for moving to higher levels of per capita income.

standpoint? Finally, how to measure the relation between knowledge incorporated on the production structure and the economic development of a specific region, country or locality?

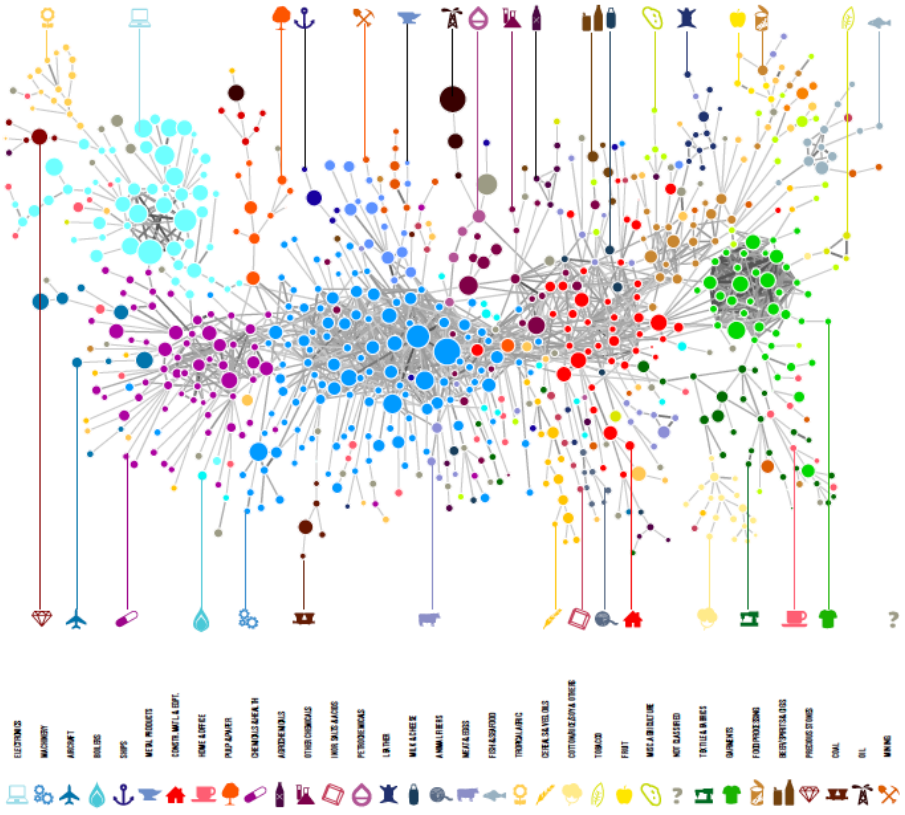
The approach provided by the development of *product space* tries to answer to those questions proposing a measure of production knowledge accumulation from the products manufactured in each locality. According to this approach, made by Hidalgo and Hausmann (2009), the products manufactured by a specific region reflect the capacity stock available in that locality. Thereby, the more complex are these products, bigger are the capacity accumulation of the producing region. From *product space's* viewpoint, the economic development process does not emerge only from de incremental improvement in economic sectors that the economy already has comparative advantage, but from the tacit capacities development that allows an opening of new productive fronts in more complex sectors. The idea of "economic complexity" tells about the multiplicity of tacit knowledge incorporated by a particular locality (country or region), which can be measured by the group of products that this locality is capable of manufacturing.

Since a database with all the products manufactured by all the countries is absence, Hausmann et al. (2014) use foreign trade data as a proxy accumulation of production knowledge. To enable the comparison between countries and products, the authors consider only products that each country has revealed comparative advantage[6]. In other words, the products basket effectively considered is the one that the country (or region) exports beyond what would be its share in the international market. Given the network analysis, connecting the exported products (with comparative advantage) by different countries, the authors classify the products according to the different levels of "complexity" and "proximity". The result is a creation of a products network connected according to their co-export probability, and this representation is the *product space* (see figure 1). The bigger is the co-export probability of two products from a same locality, the bigger is the proximity of this product and, consequently, the bigger is the probability that capacities used in the manufacturing of one of these products can also be used in the manufacturing of the second one. In the picture (see figure 1), each one of the knots represents a different product and its size is proportional to the total world trade of that good. The knots connect the products that present great

[6]See section III - Methodology.

chances of being co-exported and that, therefore, have great possibility of share productive capacities with each other.

Figure 1– Representation of *product space* with international trade from 2006 to 2008



Reference: extracted from HAUSMANN et al., 2014, p. 52

Product space seeks to represent the worldwide production structure, making easier the relationship between economic products and revealing that the worldwide production structure is highly heterogeneous. As it is possible to see in figure 1, some areas from *product space* are made by groups densely connected, showing that this products share productive capacities with a great number of other products. On the other hand, outlying areas of the network presents a large distance between goods, revealing that they have lower capacity in common with their neighbors.

Due to the similarities between capacities required for the production of certain goods, many of them cluster naturally in highly connected communities. Looking at the figure, is possible to realize

big goods clusters taking control of the *Product's Space* central area, group of metallic goods represented in blue, chemical goods in purple, and building materials in red, for example.

Is possible to view several aspects from the exporting agenda of different countries in *product space,* such as how highly connected are the products, and how well located they are in the network – if they are closer to the center or to the edges. The idea of proximity between products is essential to *product space's* methodology, because it is this idea that measures the usage's compatibility of the capacities that are common to the manufacturing process of several products. For example, countries that export computers have greater probabilities of exporting smartphones as well, since the tacit knowledge incorporated by the computers production sector can also be used by the smartphones production sector. On the other hand, countries that export bananas, for example, tend to present much more obstacles to become competitive with smartphones, since they have not the production knowledge required for manufacturing this product.

Apart from the issue of proximity between products, their location on the network also suits as a proxy for measuring the tacit capacities of certain region (country or locality): the closer to the center the products exported by the locality are on *product space*, the greater the economic sophistication of this locality tend to be. Products located on the periphery of *product space* indicates less sophistication in their production process. One of the main contributions of Hausmann et al. (2014) is the demonstration that the economic complexity of a certain region – measured from the complexity of products that it exports with comparative advantage – helps to explain the differences found in countries income levels and, most important, works as a significant mechanism for predicting economic development. Thereby, the authors indicate that the countries that managed to make their exports more complex, moving to the center of *product space*, achieved better per capita income[7].

In an article that compares North Korea and Brazil, Romero et al. (2015) suggests that the big difference between both countries GDPs matches with the major changes that South Korean

[7] According to the economic complexity theory, the complexity of an economic is measured through their capacity of "administrating complex productive knowledge networks from the management of wide networks of organizations and people". Therefore, the productive knowledge accumulation conducts the economic growth of a country – disregarding the income afforded by exploitation of natural resources, the economic complexity would be responsible for explaining 73% of the per capita income variation on the studied countries. The accumulation, in turn, occurs through the diversification of a range of products manufactured by the country, especially the ones with higher complexity.

product space went in direction to the production specialization of highly sophisticated products[8]. When the *product space* of different countries are analyzed, is possible to observe that instead of overcoming barriers, the production internationalization is reinforcing an international division of productive knowledge: tasks that demands high qualification concentrate on few countries that manufacture complex products. For that matter, the integration of developing economies in the global value chain, unfortunately, has not been a guarantee of structural change. In many cases, these economies keep performing tasks that demands low qualification and exporting less complex products (ROMERO et al., 2015).

However, economies that cannot reach the same sophistication level of the developed countries can develop success cases. There are high tech industries based on Latin American countries – and not only foreign industries. For example, Embraer, a Brazilian aeronautical industry, is certainly one of the most famous cases of a national industry that became a worldwide leader in a high-tech industrial sector, which is traditionally dominated by advanced economies. Developing capacities in sophisticated industries such as the aeronautical is important so the incorporated knowledge can migrate to other productive activities. However, as Hasmann et al. (2014) advertise, individual cases of high intensity technology can have their effects reduced if the locality's *product space* presents very long distances.

The desired economic sophistication process concerns not only about the manufacturing of more complex products, but also about the possibility that tacit capacities have of being organically distributed between different industries. Therefore, it is important to note not only how capacities are distributed between different industries, but also how they are organized between localities inside those countries. The next section is dedicated to this discussion.

2.2 The economic complexity approach applied to the Brazilian States: from *product space* to DataViva

[8] Different political strategies allied to different bottlenecks and opportunities brought by the international market explain the divergent results obtained by both countries on the transformation of its production structure. By necessity, this work will not wide the discussion about those differences. For a detailed discussion, see: Amsden, 2001.

According to the previous section, the search for measuring the production knowledge stock of a locality has become central for the approaches based on the economic complexity perspective. The approach provided by *product space* has earned great repercussion by proposing a measure of comparison of the economic complexity between products using its export basket. The basis of this argument is that products exported with comparative advantage serve as a proxy of the productive knowledge of a certain country, and, thereby, the more complex products are exported by a country, the bigger tend to be its economic development potential. The bonding element which connects the complex products export and the economic development is the fact that the exportation of complex products to the rest of the world, made by certain country (region or locality) with comparative advantage, indicates the presence of a stock of complex knowledge, required for economic transformation.

In the absence of data about export in subnational level, Hausmann et al. (2015) analyzed the complexity level of Mexican States from economic activities in which the provinces had revealed comparative advantage. The used logic was the same adopted to analyze the data of countries export: economic activities more complex would be the ones made by few states that could make several economic activities. This same logic can be applied to Brazil with DataViva platform. Through this platform is possible to obtain data about economic complexity of all Brazilian municipalities, which are calculated from exports of Federation units (municipalities and states). With this information, is possible to apply the methodology and the indicators provided by *product space* to the Brazilian location analysis, in different levels of clustering.

This work uses international commerce data as proxy for measuring the economic complexity and seeks to apply the same conceptual and analytical framework of federation units. However, it cannot be separated from the context of Brazil's international inclusion, such as its location in *product space.* Section 3 analyzes Brazil's position in relation to other countries for putting in discussion the comparison between Minas Gerais and the other Brazilian States.

3 METHODOLOGY

The methodology on which it bases the Economic Complexity approach seeks to produce a representation of all exported products in the economy based on the concept of proximity. *product*

space's construction is made from an association between countries/regions data and the products exported by them. It uses as database the international trade of products – classified according to the Harmonized System (HS) of four digits. This association is mathematically represented by a matrix $M_{cp,}$ where M_{cp}=1 if the country c can export the product p competitively.

The theory is based on the idea of revealed comparative advantage (RCA), developed by Balassa (1965) and can be defined by:

$$RCA = \frac{X_{cp}}{\sum_c X_{cp}} / \frac{\sum_p X_{cp}}{\sum_{c,p} X_{cp}},$$

where x_{cp} is the export value of c region of p product.

In other words, it is possible to say that a certain region c has comparative advantages in the production of p in a given year if the percentage of p product in the export agenda of region c is bigger than the percentage of p product in the world trade (RCA>1).

Using RCA data is possible to infer the similarities between production process of k and h products through the calculation of Proximity index between products as follows:

$$\varphi_{k,h,t} = min\{P(RCA_k > 1 | RCA_h > 1), P(RCA_h > 1 | RCA_k > 1)\}$$

The Proximity concept, developed by Hidalgo et al. (2007), can be interpreted as the chance of a pair of products co-export with revealed comparative advantage, that is to say, the co-export probability between two products reveal how similar are they in terms of required capacities for their production. Therefore, before proximity information of all pair of products available on international trade is possible to form a network (*product space)* that shows the existing connections between those products. Hence, products that have high probability of co-export presents a connection in *product space,* indicating that they have manufacturing structures that uses capacities that are relatively similarities with each other.

This information is important because, according to the Economic Complexity approach, similar products that are highly connected share great quantities of capacities required for the production of those goods. Therefore, a certain region that presents a *product space* which the majority of

products are close to each other is a region that holds potential for raising its economic complexity in the future.

Using the calculation of the Proximity index is possible to calculate the Distance between the current production structure and a certain product (HAUSMANN; KLINGER, 2007). The Distance measure reflects "the quantity of new productive knowledge that a region needs for acquiring to manufacture and export a certain product with comparative advantage. In other words, the bigger the distance is, the greater is the knowledge that will need to be acquired and longer (or harder) will be the path for advantage in this product export (DATAVIVA, 2016). The distance measure varies from 0 to 1, being 1 the maximum value for distance, and can be calculated as follows:

$$distance = \frac{\sum_{c=1}^{N}(1 - M_{cp})\varphi_{cp}}{\sum_{c=1}^{N}\varphi_{cp}}$$

In turn, measures of Proximity and Distance are used for calculating three other indexes that have as purpose the analysis of the complexity of certain region's production structure. They are Economic Complexity Index (ECI), Product Complexity Index (PCI) and Complexity Outlook Index (COI).

The ECI and PCI are based on the concepts of diversity and ubiquity developed by Hausmann and Hidalgo (2009). According to these authors, the diversity of products that a specific country can manufacture is directly related to the number of productive capacities (know-how) that it holds. Complex products, that require many capacities, are rarer, because their production demands that a wide range of productive capacities be present in the same country. As such, the number of countries/regions/states that can manufacture a certain product is related to the variety of capacities that each good requires for its production. Within this context, the authors introduce the concepts of diversity and ubiquity. In turn, complex products are the ones that require a great variety of capacities. Diversity and ubiquity are, respectively, proxy used for picturing the variety of available capacities in a specific country and capacities required for manufacturing a certain product. The ideas of diversity and ubiquity can be calculated as follows:

$$Diversity = k_{c,N} = \sum_{p} M_{cp}$$

$$Ubiquity = k_{p,N} = \sum_{c} M_{cp}$$

From those formulas is possible to realize that both concepts have a linkage between them, in such a way that the diversity can be used to correct ubiquity data and vice versa. Therefore, the authors used a reflection method to produce a symmetrical group of variables for countries and products:

$$k_{c,N} = \frac{1}{k_{c,0}} \sum_p M_{cp} k_{p,N-1} \quad (1)$$

$$k_{p,N} = \frac{1}{k_{p,0}} \sum_c M_{cp} k_{c,N-1} \quad (2)$$

Is possible to measure de Product Complexity Index (PCI)[9] from calculating the average diversity of the studied regions – countries or states – that manufacture a specific product and calculating the average ubiquity of other products that this region manufacture.

Is important to emphasize that PCI of a certain product considers the interaction between diversity and ubiquity that is based on its exports in the world trade. In other words, it is a measure calculated from countries export data and its value does not depend on a specific region. In contrast, the Economic Complexity Index (ECI), that measures the complexity of a certain locality, considers only the amounts of complexity (PCI) of the products that are exported with revealed comparative advantage (RCA), which is weighted by the participation of those products in the total exportat of this locality. Therefore, the Economic Complexity Index (ECI) is:

> "A measure of the knowledge in a society that gets translated into the products it makes. The most complex products are sophisticated chemicals and machinery, whereas the world's least complex products are raw materials or simple agricultural products. The economic complexity of a country is dependent on the complexity of the products it exports. A country is considered 'complex' if it exports not only highly complex products (determined by the PRODUCT COMPLEXITY INDEX), but also a large number of different products". (CID, 2016)

In DataViva, the ECI Index had to be adapted for capturing the complexity of states and municipalities. It was calculated from the following formula developed by Freitas and Paiva (2014):

$$ECI = \sum_{p} \frac{x_{pl}}{\sum x_p} RCA_p \, PCI_p$$

[9]The formulas for this index calculation can be found at: http://atlas.cid.harvard.edu/about/glossary/

where : x_{pl} represents the exported value of p product by l region,
x_p represents the exported value of p product by Brazil ,
RCA_p represents the revealed comparative advantages of p product in l locality,
PCI_p represents the complexity of p product.

The measures of product complexity (PCI) and economic complexity (ECI) reveal, therefore, how complex are the products that form the export basket of a certain region and how complex this region can be considered, according to the basket of products exported with comparative advantage. DataViva platform provides the PCI index of all the products exported by Brazil in the period from 2002 to 2014, just as well the ECI index of all the federation units, states and municipalities, considering the export basket in each year of the period. From those indexes, is possible to analyze not only the complexity evolution of the export basket, but also the economic complexity evolution of the Brazilian localities. Therefore, the indexes of product complexity and economic complexity are measures that help the understanding of tacit capacities found in a locality.

The third index, COI, correspond to an index built from the distances between products that a certain region currently manufacture and products that it still does not manufacture. Countries, which present a high Complexity Outlook Index, have abundance in NEARBY[10] products, due to the configuration of its current export basket in *product space.*

$$COI = \sum_i density_{i,c,t} \left(1 - x_{i,c,t}\right) PCI_{i,t}$$

Under the Economic Complexity perspective, the COI is responsible for significantly predicting of future changes in the ECI of a specific region. Therefore, ECI and COI data are going to be used for analyzing the Brazilian production structure, comparing the federation units in terms of complexity and ease in acquiring new productive capacities in the future. From this information, it

[10] "a qualitative term to describe when two or more products require similar know-how to manufacture. If the unique productive knowledge (or capabilities) it requires to make a specific good do not already exist in a country, it will prove highly difficult for the country to manufacture it. Instead, countries adapt existing capabilities to produce goods that require similar capabilities to ones already manufactured; these products are said to be nearby or in the adjacent possible. When a country has an abundance of nearby products, it has an easier path to capability acquisition, product diversification and development. Formally, two products are considered nearby if CAPABILITY DISTANCE is low" (CID, 2016).

will be possible to observe how the export basket of Brazilian States configures in terms of the complexity displayed by the exported goods, and then, it will be possible to understand how the economic complexity of the Brazilian States configures.

It is important to emphasize that there are certain limitations in the use of *Product's Space* approach to analyze the Brazilian production structure. All the measures mentioned here are built from export data (FOB), which are used as proxy for certain region's (country, state or municipality) manufacturing. Consequently, those indexes do not take into account the part of the manufacture that is not exported. In countries with great domestic demands, which are not oriented for exports, such as Brazil, the usage of export production proxy can distort the analysis of current tacit capacities. For example, if a certain industry, even if it is a highly complex one, is oriented for domestic market, products manufacture by it will not be incorporated in the analysis and, consequently, the tacit capacities of this industry will not be extracted by the template.

Other limitation of *product space* is that its indexes picture only the supply side. The capacity of a locality's manufacturing of a certain product is analyzed without considering the real demand for this product. Thereby, a certain region can have its economic complexity reduced if there is a retraction in the demand for products exported with great values of economic complexity, without necessarily losing the economic sophistication at short-term.

Finally, the economic sophistication analysis does not include the services industry. With the fast technological advance, the services industry is becoming even more intense in technology and many economies are prioritizing this industry to become globally competitive. However, the available data of services export are still short and unreliable.

It is true that DataViva platform acknowledges those limitations and seeks to overcome them by offering information that transcends the international trade data. However, still there is not a consistent theoretical background that enables interferences on economic sophistication from other proxies. For this reason, the exercise proposed in this work is limited to the application of *product space's* indexes, already explored in the literature, for the Brazilian State's analysis in terms of economic complexity, enabled by DataViva platform. Consequently, the work also adopts the premise of export as an productive proxy, considering the reservations above.

4 RESULT ANALYSIS

This section offers a descriptive analysis of the international trade path of the Brazilian States from the economic complexity perspective. The objective of this section is to apply the three main indexes suggested by *product space's* approach, Economic Complexity Index (ECI), Complexity Outlook Index (COI) and Product Complexity Index (PCI), and related indexes – Revealed Comparative Advantage (RCA) and Distance – in order to make interferences over the relationship between international trade and economic sophistication in the Brazilian State's context, focusing on Minas Gerais, the DataViva's proponent.

The first subsection (4.1) aims at a short overview of the Brazilian aggregate date, the second subsection (4.2) is dedicated to the comparative analysis of the Brazilian States and, finally, the third subsection presents the analysis of Minas Gerais economic complexity, specifically. Therefore, although interesting, the objective of this section is not the identification of the possible causes for different paths of the States. On the other hand, the importance of the commodities price increase in the international market for the exportation leverage of great part of the Brazilian States (especially the ones that have their export agenda concentrated in mineral products) is recognized.

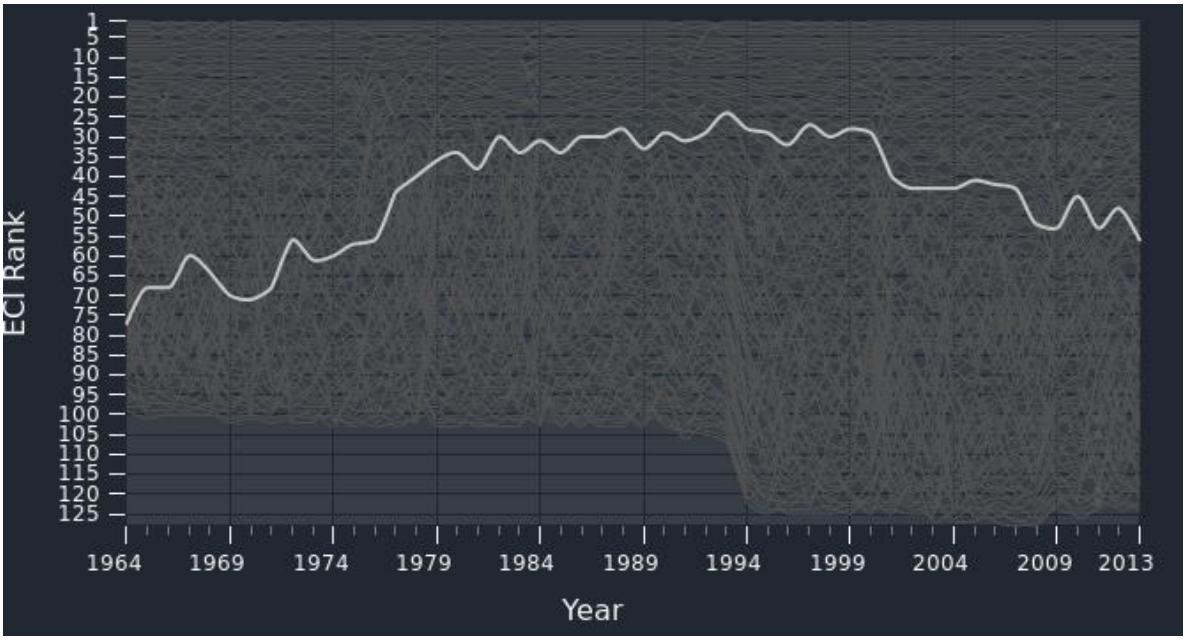
4.1 Brazil in *product space*

In 2014, the Brazilian GPD reached a total of 2.42 trillion of dollars and Brazil was considered the 23th world's larger exporter. According to the ranking[11] developed by the Observatory of Economic Complexity – OEC (2016), Brazil was considered the 32nd more economically complex country, presenting an Economic Complexity Index of 0.805. According to OEC (2016) data, in the last 50 years, Brazil has managed to ascend 45 positions on this ranking, overpassing, for example, China (37th ranked), Argentina (43rd ranked) and India (50th ranked). However, is important to note that during only one year, from 2013 to 2014, the country climbed 24 of the 45 positions. As we can observe in the graphic 1 below (see white line highlighted), the economic complexity of the

[11] The ranking developed by the Observatory of Economic Complexity (OCE) classifies 144 countries according to their Economic Complexity Index. It can be visualized in: http://atlas.media.mit.edu/en/rankings/country/2014/

country, in relation to other ranked countries, started to grow faster at the end of the 70s, and then started to fall at the beginning of the 00s.

Graphic 1 – Evolution of Brazil's economic complexity ranking in relation to the other countries – 1964 to 2013



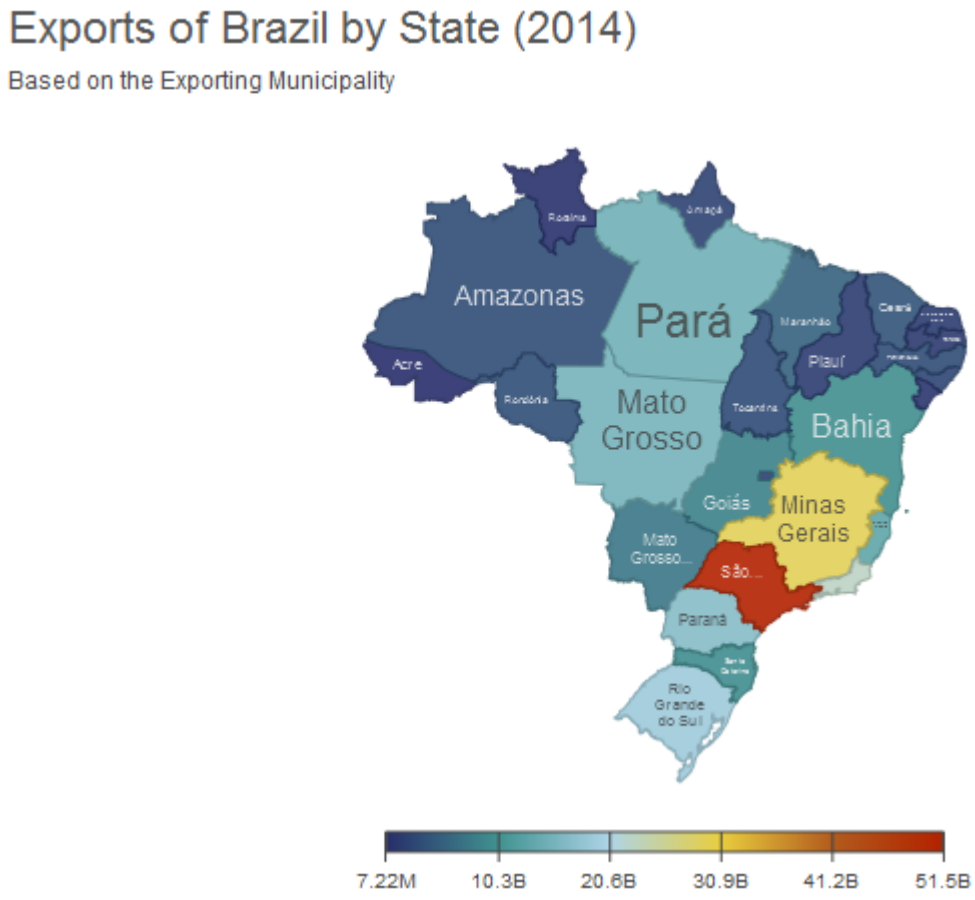
Source: OEC

From 2009 to 2014, Brazilian exportations rose, on average, in an annual rate of 7.6%, totalizing 220 billion dollars at the end of this period. However, when the Brazilian export basket is analyzed, it can be noticed an intense participation of goods based on the exploitation of natural resources. Among the exported products, at least five of greater participation are natural resources. They are: Iron Ore ($26.9B/11.8% of the export basket), Soybean ($23.6B/10.3%), Crude Petroleum ($16.4B/7,2%), Crystal Sugar ($9.8B/4.3%) and Poultry Meat ($7.21B/3,2%). An export basket with great concentration of natural resources and raw materials indicates that the Brazilian export basket is not much sophisticated and, consequently, indicates that its production structure is not much complex.

In terms of big Brazilian regions, the Southeast is the main responsible for Brazil's export, representing 52.54% ($116B) of the total exported value of Brazil in 2014, following by South Region, that represented 19.92% ($44B) of the total exported value as shown in the map below. Considering the Brazilian States, São Paulo leads the ranking, exporting 51.45 billion dollars in

2014. Its exportation represented 23.29% of the Brazilian foreign sales, following by Minas Gerais, which exports totaled 29.32 billion dollars, corresponding to 13.27% of Brazilian exports in 2014.

Figure 2. – Exports of Brazil by State (2014)



Source: Secex/ DataViva, 2016

4.2 Concentration and diversification in Brazilian States exporting agenda

Firstly, the study results indicate that between 2002 and 2014 all the Brazilian States increased their international trade participation. The trade chain (which represents the sum of the total exported and imported) presented a positive variation in all States, as illustrated in Table 1. Those results mean that in the period in question all the States managed to increase the value of their exports and, at the same time, they had their economies directly affected by the foreign products entrance.

Table 1 – Trade Chain of Brazil by State - 2002-2014

UF	2002			2014			02-14 Variation		
	Exports	Imports	Trade Chain	Exports	Imports	Trade Chain	Exp.	Imp.	Chain
AC	3827088	19371795	7216960	7462829	21022350	16750226	95%	9%	132%
AM	1064860331	1107106562	943486129	4147026698	7947165771	13865138208	289%	618%	1370%
AP	16366660	127980515	425348295	24590497	180843322	536837500	50%	41%	26%
PA	2266867807	7925093138	14259474775	2510931881	8564385216	15225991437	11%	8%	7%
RO	73341159	457551800	1082531077	162308437	525357247	1724803593	121%	15%	59%
RR	6411373	16761068	19208559	9201306	17837798	29303642	44%	6%	53%
TO	16208565	154981621	859755828	40256459	227949467	1098283102	148%	47%	28%
AL	298651146	663761504	629474408	423160995	903584336	1210807534	42%	36%	92%
BA	2412278005	7408728507	9309739676	4289905943	12823326229	18604994752	78%	73%	100%
CE	545023335	1148357273	1471111769	1180933086	2556223420	4473063785	117%	123%	204%
MA	652386714	2177154787	2795509943	1520997741	4530324632	9863739205	133%	108%	253%
PB	117818256	236142610	179120957	196874966	541572192	835202586	67%	129%	366%
PE	319995933	870556751	943857385	1163984443	2590638443	8281262856	264%	198%	777%
PI	48065232	56653743	255971635	60911809	100405673	502205355	27%	77%	96%
RN	223718224	380128187	251356829	339261215	531766097	565054172	52%	40%	125%
SE	37630499	144759688	77974723	139516532	284955677	308220222	271%	97%	295%
DF	27292665	81527975	330708917	613018348	1213095082	1605809456	2146%	1388%	386%
GO	649313998	3184780418	6979883720	976054400	4886705670	11399109617	50%	53%	63%
MS	384238042	1297176760	5245499753	808146284	3487064734	10482396458	110%	169%	100%
MT	1795852919	5130866400	14796823287	2004901960	5884151572	16564999302	12%	15%	12%
ES	2597074891	6871954867	12689540909	4616621127	13510464176	19565850241	78%	97%	54%
MG	6353218803	18355152652	29320645006	8867861789	24859999985	40322512167	40%	35%	38%
RJ	3658806992	14315694020	22619317443	9056133679	23878309371	44199446896	148%	67%	95%
SP	20155516694	51734202981	51458040451	39989909366	1.00153E+11	1.36267E+11	98%	94%	165%
PR	5703081036	12351936472	16332120489	9036473153	21369924165	33625855300	58%	73%	106%
RS	6383693246	15017594858	18695564443	9915178073	25185839477	33643536254	55%	68%	80%
SC	3160456173	7381839477	8987359285	4091851405	12382060825	25007203328	29%	68%	178%
Average							**78%**	**68%**	**100%**

Source: own elaboration based in data from SECEX/MDIC, available in: dataviva.info.

The increase in the exported value, however, did not necessarily mean a rise in the basket of products exported with revealed comparative advantage: as shown in Table 2, the Brazilian States presented different paths. The results indicate that Minas Gerais and 11 other Brazilian States - Roraima, Bahia, Ceará, Paraíba, Pernambuco, Piauí, Distrito Federal, Goiás, Mato Grosso do Sul, Espírito Santo and Rio de Janeiro – reduced their basket of products with revealed comparative

advantage in the period between 2002 and 2014 (considering RCA >=1). That means that those States suffered a greater concentration of their exports because they reduced the number of products exported with comparative advantage.

Table 2 – Size of the basket of products with revealed comparative advantage, by State

UF	2002 Number of Products with RCA>1	2007 Number of Products with RCA>1	2014 Number of Products with RCA>1	2002-2007 Variation	2007-2014 Variation	2002-2014 Variation
AC	17	29	40	70.59%	37.93%	135.29%
AM	34	44	47	29.41%	6.82%	38.24%
AP	7	10	7	42.86%	-30.00%	0.00%
PA	36	41	36	13.89%	-12.20%	0.00%
RO	22	23	27	4.55%	17.39%	22.73%
RR	17	11	12	-35.29%	9.09%	-29.41%
TO	5	12	9	140.00%	-25.00%	80.00%
AL	9	10	11	11.11%	10.00%	22.22%
BA	106	96	77	-9.43%	-19.79%	-27.36%
CE	59	66	56	11.86%	-15.15%	-5.08%
MA	13	17	14	30.77%	-17.65%	7.69%
PB	36	36	33	0.00%	-8.33%	-8.33%
PE	70	78	49	11.43%	-37.18%	-30.00%
PI	25	23	19	-8.00%	-17.39%	-24.00%
RN	37	46	44	24.32%	-4.35%	18.92%
SE	16	17	21	6.25%	23.53%	31.25%
DF	20	9	13	-55.00%	44.44%	-35.00%
GO	44	42	40	-4.55%	-4.76%	-9.09%
MS	32	39	27	21.88%	-30.77%	-15.63%
MT	18	28	21	55.56%	-25.00%	16.67%
ES	36	35	29	-2.78%	-17.14%	-19.44%
MG	116	120	82	3.45%	-31.67%	-29.31%
RJ	86	65	44	-24.42%	-32.31%	-48.84%
SP	226	227	232	0.44%	2.20%	2.65%
PR	103	119	118	15.53%	-0.84%	14.56%
RS	128	150	142	17.19%	-5.33%	10.94%
SC	104	137	145	31.73%	5.84%	39.42%
Average	**53**	**57**	**52**	**11.43%**	**-8.33%**	**0.00%**

Source: own elaboration based in data from SECEX/MDIC, available in: dataviva.info.

According to the data presented in Table 2, is possible to observe a change in the behavioral trend during the analyzed period. In the first sub-period, 2002 to 2007, before the financial crisis that

shook the international market, there was an upward trend in the basket of revealed comparative advantage export, which had an average variation of 11%. In the next moment, between 2007 and 2014, there was a shrinkage of 8%, contributing for a null average variation in the total period 2002-2014.

The analysis of the measure – size of the comparative advantage basket – of all Brazilian States, in the 2002-2014 period, allows the conclusion that despite of the expansion in the international trade participation of all States, many of them increased the concentration of their export basket. If we think about the *product space's* approach, a basket with less products (HS4) means a smaller range of productive capacities available for future recombination in the manufacturing of new complex products. In other words, those States which had a smaller diversity in their revealed comparative baskets, probably, will have more trouble trying to produce more complex products in the future and, therefore, will lose the opportunity of becoming competitive in the export of a great number of goods and, consequently, of having a more sustainable economic development (FREITAS; PAIVA, 2016).

Minas Gerais, just like Rio de Janeiro, was one of the States that experienced a concentration path, with the decrease of the number of products with comparative advantage. Both States, however, remained in the first positions of States with greatest export value ranking, occupying, respectively, the 2nd and 3rd place in the ranking of 2014, behind only of São Paulo. In Minas Gerais, this result is due to the great participation of iron ore and coffee in the State's export. Together, both products represented more than 60% of the exporting agenda in 2014. In Rio de Janeiro, on the other hand, crude petroleum represented 57% of the exporting agenda in the same year (DATAVIVA, 2016).

Table 3 – Ranking position of exported value, by State

FU	2002	2007	2014
SP	1	1	1
RS	2	3	4
MG	3	2	2
PR	4	5	5
RJ	5	4	3
SC	6	8	10
ES	7	9	8
BA	8	7	9
PA	9	6	7
MT	10	10	6

AM	11	15	17
MA	12	12	13
GO	13	11	11
CE	14	14	14
MS	15	13	12
PE	16	16	16
AL	17	17	19
RN	18	19	23
PB	19	20	24
RO	20	18	15
PI	21	25	22
SE	22	22	25
DF	23	24	21
AP	24	23	20
TO	25	21	18
RR	26	27	26
AC	27	26	27

Source: own elaboration based in data from SECEX/MDIC, available in: dataviva.info.

The impact of the commodities price raise in the concentration of the exporting agenda of States with comparative advantage in products profited by the "commodity boom" is irrefutable. As revealed comparative indexes point, the increase of the exported value of those States contributed for a heavier dependence on commodities, because they left the export of other products with comparative advantage.

If until 2014 Brazilian States lived a favorable external environment concerning favorable international prices to the mineral and agricultural commodities – especially coffee, iron ore and petroleum – the current scenario of price drop of those products in the international market points a variety of concerns to those States. It is true that the fears in relation to a "concentrated exporting agenda" in unsophisticated products are not anything new: the dependency on a limited product basket generates a high vulnerability in relation to price movement in the foreign market. However, this does not seem to be the worst consequence. According to *product space's* approaches, changes in a locality's Revealed Comparative Advantage (RCA) can be considered structural changes proxies (HAUSMANN; KLINGER, 2007). Thereby, under this perspective, the reduction of the basket with products with RCA can have more serious implications than dependency and concentration. Ultimately, this reduction can affect the complexity level of a region and,

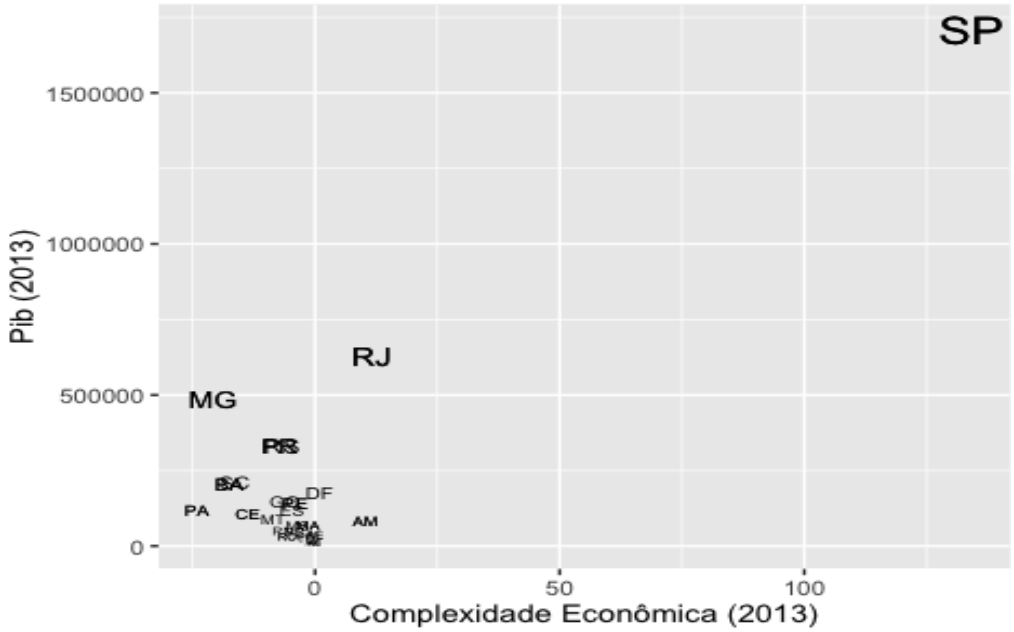
consequently, their development perspectives. The next section explores some measures of *product space* that aims to advance in the comparison between Minas Gerais and the other Brazilian States.

4.3 Brazilian States from the economic complexity stand point

So far, this analysis considered only 'quantitative' features of the Brazilian States export basket. The incorporation of *product space's* measures, also available in dataviva.info, allows us to advance in a qualitative description of the products of this basket.

The graphic 2 represents the Brazilian States positions in relation to the GDP and the economic complexity in 2013 (last available GDP data for federation units). The size of abbreviations is proportional to the size of their GDPs.

Graphic 2 – Total production and economic complexity level, by State, 2013



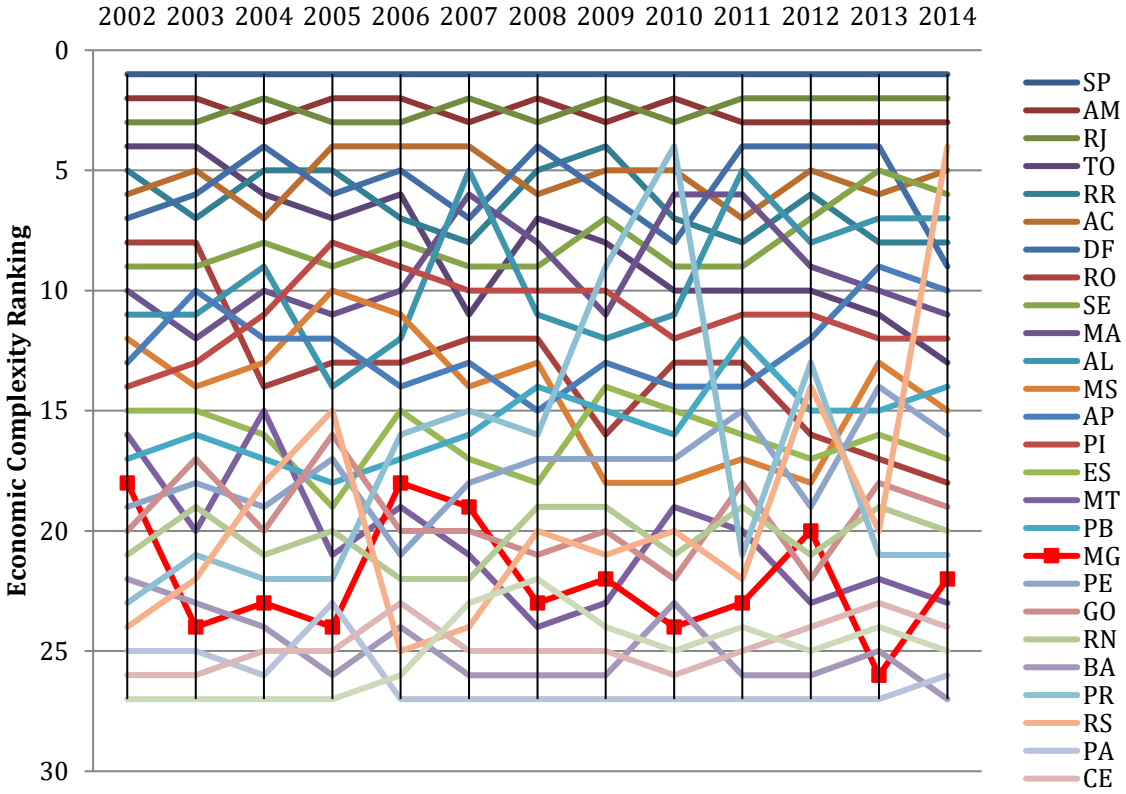
Source: own elaboration based in data from dataviva.info.

As show in graphic 2, São Paulo highlights not only for presenting the highest GDP between all Brazilian States, but also for having the greatest economic complexity of the country. Rio de Janeiro and Minas Gerais, which are, respectively, the second and the third biggest economies of Brazil, are significantly different in terms of economic complexity. The data analysis indicates that, while Rio de Janeiro presents a positive measure of complexity, Minas Gerais presents a negative

result and is one of the least complex States of Brazil. In other words, Minas Gerais not only is one of the States with the lowest complexity level, but also is one of the States with the worse performance in this index, because of its total production level or GDP.

Graphic 3 shows the position of the Brazilian States in the economic complexity ranking, in the period between 2002 and 2014. The 1st place refers to the greatest value of this index (ECI). The analysis of the evolution of the economic complexity indexes, from their ranking position, allows us to visualize comparatively the States courses in time. In this regard, the results of the study indicate that São Paulo presented the higher economic complexity index of the country during the analyzed period. Rio de Janeiro, on the other hand, alternated with Amazonas between second and third position during great part of the period since 2011. However, Rio de Janeiro kept his position of second State with greater economic complexity. Minas Gerais, in turn, are in the last positions of the ranking. In the analyzed period, Minas Gerais lost position, dropping from 18th to 22nd place. In 2013, Minas Gerais was in second-to-last position, only above Pará.

Graphic 3 – Evolution on complexity ranking, by State, with emphasis in Minas Gerais (2002 to 2014)



Source: own elaboration based in data from dataviva.info

Still with regard to the relation between GPD and complexity, the contrast between the relatively comfortable position of Amazonas and the unfavorable classification of Minas Gerais, in terms of the economic complexity level, as show in graphics 2 and 3, highlights. Though it has not an outstanding position in terms of economic size, accounting for only 1.57% of the Brazilian GPD in 2013, a relatively favorable position is recorded for Amazonas, in terms of economic complexity, positioning as the third Brazilian State, losing only for São Paulo e Rio de Janeiro – States that, respectively, correspond to the two biggest GPDs of the country. In turn, Minas Gerais – third biggest State in terms of economic production size – occupies the twenty-sixth place in terms of economic complexity (in 2013).

This contrast is associated to the regional economic basis that, in the case of Minas Gerais, relies on the mineral and agricultural commodities export (products with low complexity, in terms of knowledge incorporation). In the case of Amazonas, it reflects the international trade of products that are relatively more complex, associated to the Zona Franca de Manaus electronic polo. The industrial policy and international trade measures, by promoting the consolidation of Zona Franca de Manaus – created in 1967 - certainly developed an important role for the expansion of the productive capacities of the local economy, which was settled, especially, in the vegetal extraction and forestry sectors. Authors like Rocha and Dufloth (2009) analyzed indexes of technological innovation business in large Brazilian regions and pointed to the positive influence of sectorial funds of science and technology in the North of the country (for example, the CT-Amazônia) that certainly contributed for the favorable development of that State in terms of economic complexity.

Studies like the one developed by Rocha (2003) analyzed indexes directed to the scaling of science, technology and innovation state systems for South and Southeast regions of Brazil and also came to the conclusion of the uncomfortable position occupied by Minas Gerais in terms of technological innovation and innovation regional system. Although this is not a recent study, it cannot be discarded the possibility that the low complexity of the third largest economy of Brazil can be associated with the fragilities and low consolidation level of the science, technology and innovation system of Minas Gerais.

Other relevant aspect revealed by the analysis of the economic complexity between Brazilian States talks about the size of the economic production of a certain region or locality. It is widely acknowledge in the specialized literature that the region participation in GDP increases its economic development level. On the other hand, there are strong evidences that the inputs of knowledge incorporated to the production tend to influence the economic sophistication level of a certain region. Clearly, the study's results indicates that, when it comes to regional economic diversification, aiming to raise its economic complexity, the formulation and implementation of a effective policy of technology innovation – in other words, a process of construction and implementation capable of giving more synergy between industrial policy and international trade policy – can build a significant tool of transformation of the productive structure of a specific region or locality.

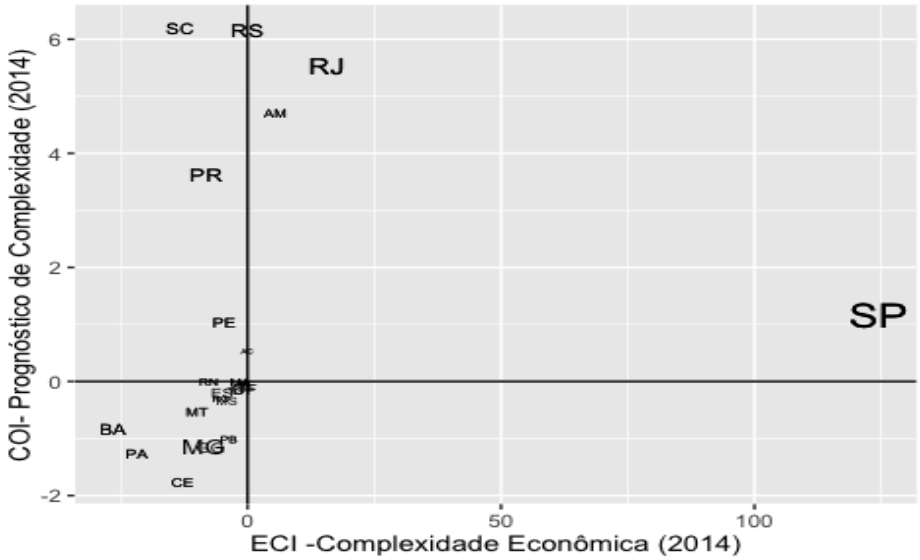
According to the economic complexity approach, the evolution of the economic complexity index would be a proxy of transformation of the Brazilian State's productive structures. The interpretation of this index suggests that the states that made progress in their economic complexity indexes would have managed to incorporate new capacities in their productive production process and, as result, enabled them to reach revealed comparative advantage in products that are more complex than the previously exported.

It can be observed that, in general, the States kept their relative positions in the economic complexity ranking during the analyzed period. It is known that the process of new capacities formation is slow and gradual. For this reason, it was expected that the change of position in the ranking would be also gradual. However, another interesting result revealed by the study tells about the States that changed their ranking position abruptly from one year to another. For example, Paraná dropped from the fourth position in 2010 to the twentieth in 2011, while Rio Grande do Sul left the ninetieth position in 2013 to the fourth in 2014. Those quick and significant changes can indicate that, although those States export products with high economic complexity, the products are not consolidated in the international market with comparative advantage. In other words, in the years that those products are exported with comparative advantage, there is a significant improvement in the economic complexity index of the States that exported them. It is worth remembering that product space allows only the analysis on the supply side, disregarding the demand oscillations in the international trade market.

In this context, a further analysis is necessary: the observation of the behavior of products still not exported with comparative advantage. The Complexity Outlook Index (COI) allows the measuring of the future perspective of some region's economic complexity, given the complexity and proximity level between products that do not have RCA and the basket of products exported with comparative advantage. According to Hausmann, Espinoza and Santos (2015), a region with low economic complexity (ECI) that have a high complexity outlook (COI), would be in better conditions to progress in the transformation of its productive base in comparison with a region that has high complexity.

The graphic 4 compares the Brazilian States from the Outlook Complexity Index. The States which presented the greatest values, in 2014, were Santa Catarina, Rio Grande do Sul, Rio de Janeiro, Amazonas and Paraná. These results allow us to say that the current economic structure of those States is relatively close to complex products, when compared to the others Brazilian States. Therefore, for those States, the sophistication process would be relatively easier. In turn, the States that presented low economic complexity indexes and low outlook complexity not only present an economic structure not complex, but also are distant from sophisticated products. In such cases, the development of more sophisticated productive capacities requires substantial investments.

Graphic 4 –Complexity Outlook Index, 2014



Source: own elaboration based in data from dataviva.info

Still with regard to the Complexity Outlook Index, as shown in graphic 4, the performance of Minas Gerais, in 2014, also was not favorable, considering that the State had the fourth worst result of COI between Brazilian States. The outlook index of Minas Gerais significantly moves away from the other States that have a similar GDP level, such as: Rio de Janeiro, Paraná e Rio Grande do Sul. For that matter, the paradox confronted by Minas Gerais is worrying. It is the third biggest Brazilian State in terms of total production, but turns up to be little complex and with few possibilities of sophisticating its economic base.

Therefore, although the expansion of the exporting agenda's concentration was registered in the majority of the States (table 2), the revealed comparative advantage loss is reason for bigger concerns when the raise of the exports concentration does not lead to an economic complexity improvement, neither to a complexity outlook improvement in a specific location. On both aspects, Minas Gerais presents a peculiar path, which is different from the other States with the biggest GDP: the path of Minas Gerais exports during 2002-2014 contributed for a higher concentration, with comparative advantage losses, and for a worsening of the complexity indexes. Bearing in mind the singularity of Minas Gerais case, the next section engages to the comprehension of the difficulties encountered by this State to overcome the low economic complexity.

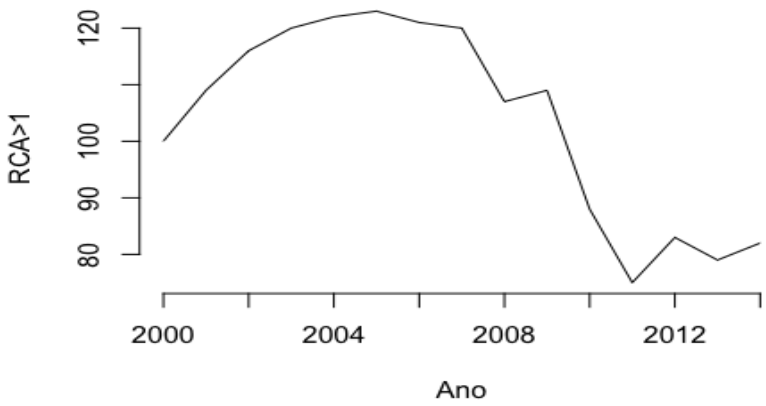
4.4 Minas Gerais and the low complexity trap

Generally speaking, according to the Brazilian economic trend, Minas Gerais presented economic growth. Between 2003 and 2008, boosted, among others, by the exports increase – mainly of mineral, steel and coffee products – the State's GDP grew, on average, 5.04% per year. In 2009 – year when the negative impacts of the global financial crisis started in the North-American market affected Brazil – Minas Gerais GDP suffered from a 4% retraction. In addition, in the next year (when the Brazilian overall economy also presented recovery), it is registered a significantly acceleration rate of the State's GPD, 8.9%. In 2011, the positive rate was of 2.8% and, since then, it is registered a growth slowdown, with a 2.5% rate in 2013 (FJP, 2013).

Under the international trade perspective, the results of this study show that, between 2002 and 2007, period before the global financial crisis, Minas Gerais lived a process of expansion of its basket of products with comparative advantage. From 2008, however, this process was reversed in such a way that the export agenda became even more concentrated (see graphic 5). As analyzed in

the previous sections, the export basket concentration during the period of 2002-2014 was not a process lived only by Minas Gerais, but also by all the States that were rich in commodities, especially in mineral resources. However, differently of the other States that also suffered from a retraction of the basket of products with comparative advantage, Minas Gerais kept a diversification level relatively high of its export agenda: in 2014, Minas Gerais had the 5th largest basket of products with comparative advantage, comparing to the other Brazilian States. In other words, even after suffering from a strong concentration of its export basket, in the period between 2002 and 2014, Minas Gerais still have one of the most competitive export basket of the country.

Graphic 5 – Evolution of the basket of products with comparative advantage, Minas Gerais, 2002 to 2014

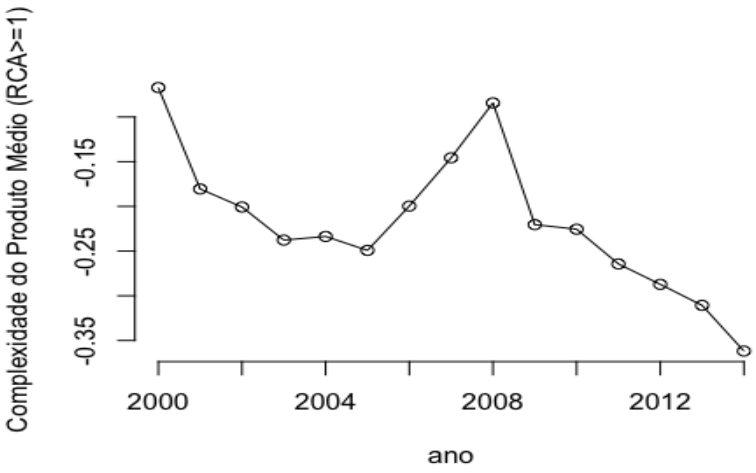


Source: own elaboration based in data from SECEX/MDIC available in dataviva.info

The main problem of Minas Gerais international trade, therefore, is not only the concentration of its export basket; in this aspect, Minas Gerais is in a better position than most of the Brazilian States. The most serious problem is that the loss of comparative advantages during the analyzed period, especially after the global crisis, happened with the products with relatively higher complexity. The graphic 5 presents the evolution of the complexity average value of the products exported with comparative advantage during the period. Between the years of 2000 and 2005, the comparative advantage gain occurred with low complexity products: there is a decrease of the average complexity of the products. Between 2005 and 2008 Minas Gerais again exported more complex products, contributing for the increase of the average complexity. From 2008, however, Minas Gerais not only started to lose comparative advantage, increasing their basket concentration,

but also stopped exporting products that were relatively more complex. In 2014, the average complexity of the products exported with comparative advantage was the smallest in the historical series.

Graphic 6 – Complexity evolution of the products with RCA



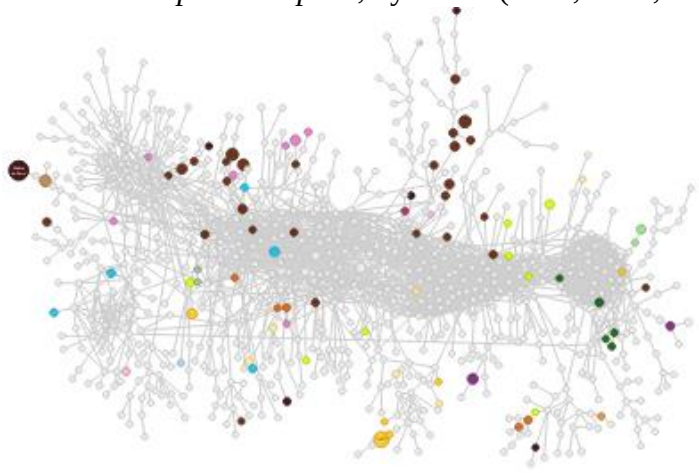
The comparative advantage loss, associated with the loss of complex products affects directly the *product space's* evolution of Minas Gerais in the period, as observed in the figure 3. Between 2002 and 2007, it can be noted that Minas Gerais *product space* "walked" slightly to the center with the export of products from the machinery and transport facilities groups, represented by light and dark blue colors (see figure 3). From 2007 to 2014, some groups are not part of Minas Gerais *product space* anymore. First, there is a reduction of products from the machinery and transport facilities groups. Second, the textile goods group, represented by the dark green color, at the bottom right corner of the network is no longer exported with comparative advantage. Another group, which loses strength, is the foodstuff one, represented by the greenish yellow color. Finally, a decrease of chemical products, represented by the pink color, it can also be observed.

The figure 4 presents the *product space* of Minas Gerais in the same reference years – 2002, 2007 and 2017 – but with emphasis on products sorted by their complexity level, being green the most complex and orange the least complex. It is possible to observe that the products in green are located in the center of the network, while the products in orange are dispersed into the edges of the network. This confirms the ascertainment of Hausmann et al. (2014) that countries that progress to the center of *product space* become more sophisticated. In the case of Minas Gerais, there is a

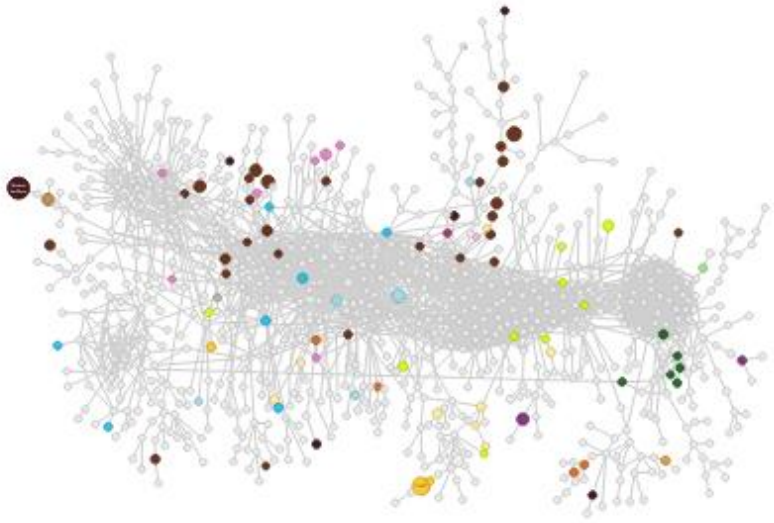
predominance of low complexity products, located in the periphery of the network, what confirms the State's low economic complexity.

Figure 3 – Minas Gerais *product space*, by sector (2002, 2007, 2014)

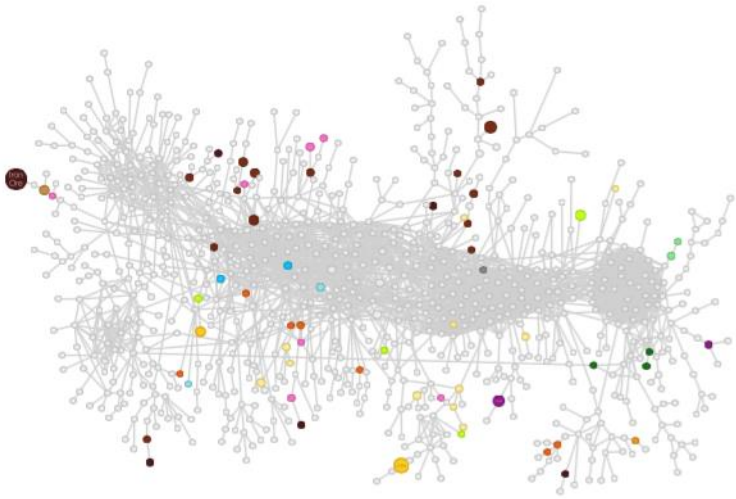
2002



2007



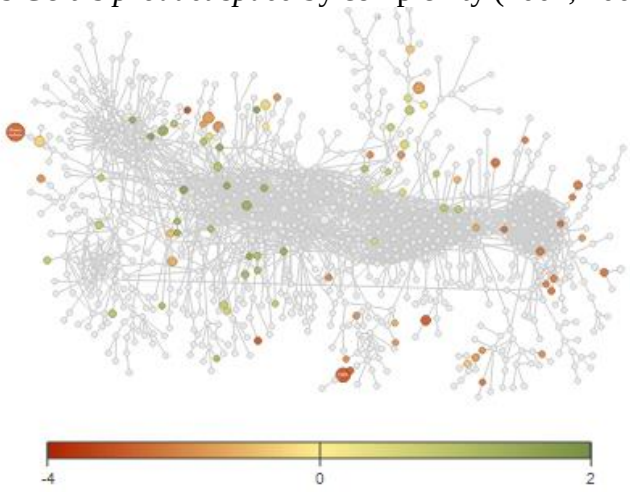
2014



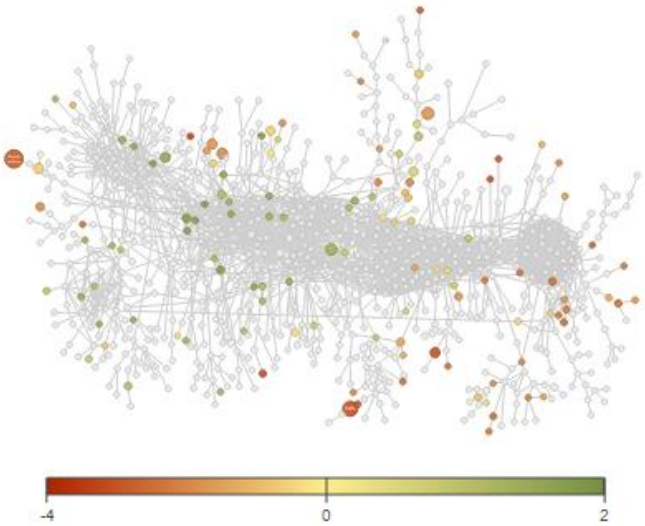
O que são estes ícones acima?

Figure 4 – Minas Gerais *product space* by complexity (2002, 2007, 2014)

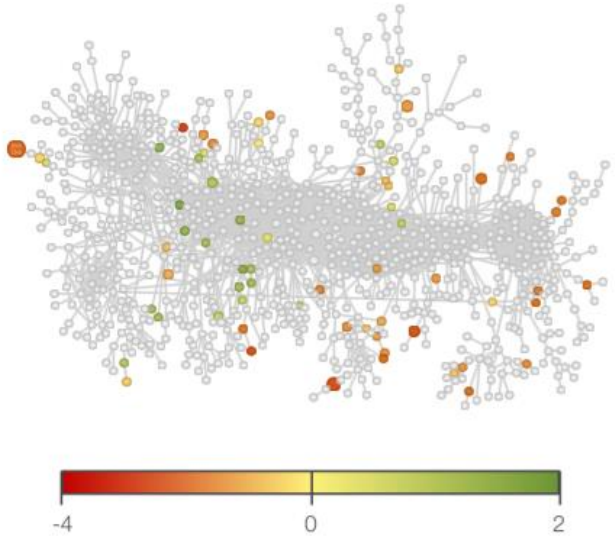
2002



2007

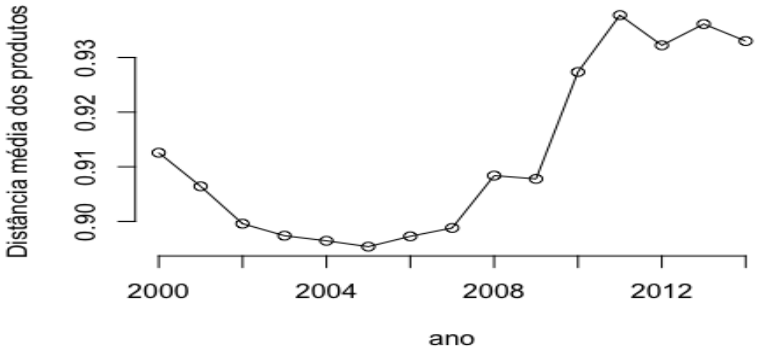


2014



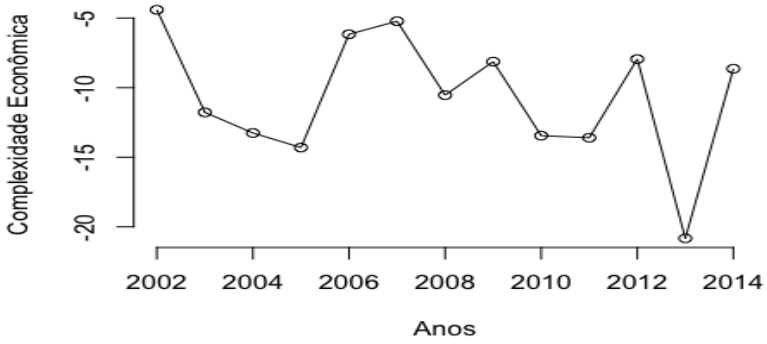
Another way of analyzing the evolution of Minas Gerais *product space* is observing the evolution of the products average distances over time. In Minas Gerais, the products average distance kept around 0.9 over the analyzed period with a gradual increase from 2008 (see graphic 7). This means that the products of Minas Gerais not exported with comparative advantage (RCA <1) are distant from products with comparative advantage (RCA>1), and this distance expanded even more from 2008. According to Hausmann and Klinger (2007), "a particular product's proximity to existing areas of comparative advantage is one of the most significant determinants of whether a country will develop an advantage in that product in the future". For that matter, Minas Gerais current location in *product space* brings few opportunities for a productive matrix transformation.

Graphic 7 – Average distances evolution in *product space*, Minas Gerais (2002-2014)



A *product space* organically little connected, with long distances and products with weak connections, contributed for keeping the Economic Complexity Index in low levels over the analyzed time (graphic 8).

Graphic 1 – Economic Complexity Evolution, Minas Gerais (2002-2014)



Minas Gerais is, therefore, in a path that matches the concentration increase and the complexity reduction of its productive structure. Furthermore, its current location in *product space* does not indicate exciting perspectives for the development of new capacities. The long distances in *product space*, in conjunction with the low prognostic complexity value, suggest that the sophistication process will face serious coordination problems, due to the need for investment in products and sectors of low participation in the international market, that still are surrounded by doubts.

The situation lived by Minas Gerais during the period between 2002 and 2014 is similar to what Hausmman et al. (2015) identified as a “low complexity trap”: a vicious circle which the low

complexity complicates the movement of a region's capacity to more complex products and, therefore, expand the distances and the sophistication difficulty. Just like in the chicken and egg problem, the current productive structure weakens the economic base needed for the development of capacities required for the productive structure sophistication. For an increase of sophistication in Minas Gerais, the economic agents need to invest in the production and export of more complex products. The better the economy goes and the current structure benefits from export gains, the lower are the incentives for investment in new areas. Therefore, at the same time that Minas Gerais lived an export *boom* in low economic complexity products, their opportunities of sophistication were progressively reduced, feeding the vicious circle of low sophistication.

5 CONCLUDING REMARKS

This work analyzed the export evolution of the Brazilian States from the indexes presented by the *product space's* approach. For this purpose, a premise used by Hausmann et al. (2014) ~~it~~ was adopted, whereby products exported by a certain region (in this case, Brazilian States) with revealed comparative advantage serve as a proxy of production knowledge stock of that region and, consequently, as a proxy of economic sophistication. Therefore, theses States were compared in terms of economic complexity level and economy size. The singularity of Minas Gerais case was noticed. The main argument of this work is that Minas Gerais is stucked in a low complexity trap, because the State, that have the third largest economy of the country, presents one of the most unfavorable results in terms of current and future economic complexity. According to the Hausmann et al. (2014) analysis, this result suggests that Minas Gerais will have more trouble than the other Brazilian States that have a similar income level, because they will need to maintain significantly economic growth rates. If Minas Gerais continues in this trap for a very long time, the possibility of its economy be overcome by other States cannot be discarded, especially by the Southern ones. Actually, the Southern States have a smaller GPD then Minas Gerais and they have also low values for the Economic Complexity Index. In contrast, the results reveal that the Complexity Outlook Indexes are much more uncomfortable for Minas Gerais.

Concerning the possible reasons for Minas Gerais low complexity trap, the study reveals that at least three explanatory keys can be driven. The first one, associated with the institutionalist literature of the "natural resources tragedy", suggests that the income concentration in the mining resources sector, such as iron ore, would contribute for the weakening of the institutions needed for economic diversification, such as: venture capital market, information system and education infrastructure. Another explanatory key, also related with the mineral commodities export, and related with the economic literature, suggests that the currency appreciation resulted from the entry of foreign currency, originating from commodities exports, would take them to a competitiveness loss in the industrial sectors and conduct it to a deindustrialization process of those economies. Finally, the third possible explanation – closer to the theoretical approach used in this work – suggests that the absence of a production knowledge stock shared between the different economic activities raises the costs of discovering new business opportunities, which creates an embarrassment to the entrepreneurial activity. The identification of the low complexity trap causes

of Minas Gerais would demand, therefore, an additional investigation, which would test the hypothesis suggested above.

The work has some limitations. In this respect, is important to say that, although it considers the existence of an association between complexity and economic development, the study, differently from Hausmann et al. (2014), does not start from the premise that exists a causal relationship between both dimensions. The discussion advances over the casual relationship between both dimensions would demand a construction of robust analytical model that escapes from the work scope. It is know that the absence of an explicative capacity estimator of economic complexity over the economic growth of the Brazilian States restricts the range of the interpretations elaborated here. It is considered that this work did not intend to explain the observed differences between the Brazilian State's economies. This type of analysis can be reserved for future studies and can expand its data source and its interpretation possibilities beyond the ones induced by DataViva platform and the economic complexity approach.

Another restriction involves the use of the information in DataViva. The study focuses on the international trade indexes. However, the analysis of other data and indexes – for example, the ones related to the school census, college education and employment – could clear up about aspects not treated in the analysis. None the less, as alleged in section 3, great part of the analysis based on the economic complexity approach still are limited by the use of export data as a complexity proxy. Accordingly, the study opted to follow this strategy in order to insert a brainwork about economic complexity of subnational units in a broader debate.

About their limitations, the relevant results that were revealed in the study are understood and signal a warning for the economic development policy-makers. In the case of Minas Gerais, the historical vocation for mining activities are contributing not only for the concentration increase and the economic dependency in low add value sectors – features exhaustively treated by the economic literature – but also for the distancing of Minas Gerais from *Product Space's* center. Minas Gerais economic challenge is not only diversification, but also becoming competitive in the manufacturing of more complex products, that actually are distant from products that Minas Gerais has comparative advantage on. The greater this distance, the greater is the effort needed for sophistication. That is why the success of this transformation depends on a continuous strategy of medium and long terms.

In the long term, an institutional infrastructure would be necessary for the formation and accumulation of production knowledge, especially through investment in education and innovation. In low complexity economies there are still few governmental and business efforts devoted to continued education, since the demand for more developed capacities are limited to certain technological niches. Breaking this path and stimulating the capacities formulation in wide scale and organically would be a State's responsibility. The prioritization of high school quality improvement, for example, could contribute for that matter. In medium and short terms, the lesson taught by the economic complexity approach points that the public policies should prioritize economic activities that simultaneously are "close" to the actual production structure and contribute for a greater sophistication. This prioritization demands an exercise for both private and public sectors: a "self-discovery" of the current State's economic potentials, main production bottlenecks, and definition of goals that can enable the comparative advantage gain in more complex products. This economic sophistication process is not simple. However, international experiences serve as inspiration. They show that is possible to create highly innovative spaces in territories traditionally set by economic activities of low and medium added value. Advance in the knowledge of difficulties that are inherent to this process is the first step for formulating a promising strategy.

6. REFERENCES

ARCHIBUGI, D.; COCO, A. Measuring technological capabilities at the country level: A survey and a menu of choice. **Research Policy**, 34, p. 175-94. 2005.

BALASSA, B. Trade liberalization and revealed comparative advantage. **Manchester School of Economics and Social Studies**, 33, pp. 99-123. 1965.

CENTER FOR INTERNATIONAL DEVELOPMENTAT HARVARD UNIVERSITY (CID).**The Atlas of Economic Complexity**. Available at: <http://www.atlas.cid.harvard.edu> Access in: 5 jan. 2016.

DATAVIVA. Glossary. Available at: http://pt.dataviva.info/about/glossary. Access in: 10 jan. 2016.

FUNDAÇÃO JOÃO PINHEIRO (FJP). **Perfil de Minas Gerais 2013.** Belo Horizonte, 2013.

FREITAS, E.; PAIVA, E. **Diversificação e sofisticação das exportações**: uma aplicação do product space aos dados do Brasil. Belo Horizonte. In press 2016.

FRIEDMAN, T. L. et al. **O mundo é plano:** uma história breve do século XXI. 2005.

GROSSMAN, G. M.; ROSSI-HANSBERG, E.. **Trading tasks:** A simple theory of offshoring. No. w12721.National Bureau of Economic Research, 2006.

HAUSMANN, R.; KLINGER, B. **The structure of the product space and the evolution of comparative advantage**. Center for International Development at Harvard University, 2007.

HAUSMANN, R.; HWANG, J.; RODRIK, D. What you export matters. **Journal of economic growth**, v. 12, n. 1, p. 1-25, 2007.

HAUSMANN, R.; HIDALGO, C. A., et al. **The atlas of economic complexity:** mapping paths to prosperity. 2014.

HAUSMANN, R.; ESPINOZA, L.; SANTOS, M. A. **Diagnostico de crecimiento de Chiapas**: la trampa de la baja productividad. 2015.

HELPMAN, E. **Trade and inequality:** from theory to estimation. National Bureau of Economic Research, 2012.

HIDALGO, C. A. et al. The product space conditions the development of nations. **Science**, v. 317, n. 5837, p. 482-487, 2007.

HIDALGO, C. A.; HAUSMANN, R. **The building blocks of economic complexity**. 2009.

JANKOWSKA, A.; NAGENGAST, A.; PEREA, J. R. **The middle-income trap**: comparing Asian and Latin American experiences. 2012.

KRUGMAN, P. **Increasing returns and economic geography.** No. w3275. National Bureau of Economic Research, 1991

LALL, S. Technological capabilities and industrialization, **World Development**, 20, p. 165-186. 1992

LEAMER, E. E. A flat world, a level playing field, a small world after all, or none of the above? A Review of Thomas L. Friedman's" The World is Flat". **Journal of Economic Literature**, p. 83-126, 2007.

RICARDO, D. **On the principles of political economy and taxation:** London. publisher not identified, 1817.

ROCHA, E. **Indicadores de inovação:** uma proposta a partir da perspectiva da informação e do conhecimento. 2003. Tese de Doutorado. Tese (Doutorado em Ciência da Informação)-Escola de Ciência da Informação, Universidade Federal de Minas Gerais, Belo Horizonte, 2003.

ROCHA, E.; DUFLOTH, S. Análise comparativa regional de indicadores de inovação tecnológica empresarial: contribuição a partir dos dados da pesquisa industrial de inovação tecnológica. **Perspectivas em Ciência da Informação**, v. 14, n. 1, p. 192-208, 2009.