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# **ECONOMIC COMPLEXITY AND REGIONAL DEVELOPMENT:** an empirical study for Brazilian states

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# **ECONOMIC COMPLEXITY AND REGIONAL DEVELOPMENT:** an empirical study for Brazilian states

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Orientador: Prof. Carlos Eduardo Iwai Drumond

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**TOMÁS BRAGA E BRAGA**

**COMPLEXIDADE ECONÔMICA E DESENVOLVIMENTO REGIONAL: UM ESTUDO EMPÍRICO PARA OS ESTADOS BRASILEIROS**

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**ECONOMIC COMPLEXITY AND REGIONAL DEVELOPMENT:** an empirical study for Brazilian states


## ABSTRACT

Structuralist literature affirms that industrialization is a key process in economic growth. Since the 1980's economic structuralism has utilized mathematical neoclassical tools to test their hypothesis. From its creation, the Economic Complexity Index (ECI) has been tested as the explanatory variable for economic growth and catching up effect among countries. According to the most recent structuralist literature, ECI is a relevant proxy for measuring a country's productive capabilities and relevant for both growth and convergence patterns. The current thesis utilizes the ECI measured for Brazilian states from 1997 to 2017 and tests it as an explanatory variable for both economic growth and converge effects on an intra-national level. It utilizes a Barro and Sala-i-Martin type growth regression. The regression results do not corroborate structuralist premises and literature explaining economic growth patterns for Brazilian states. Absolute and relative convergence are observed, but ECI shows no statistical significance.



Key-words: Economic structuralism. Economic convergence. Catching up.

**COMPLEXIDADE ECONÔMICA E DESENVOLVIMENTO REGIONAL:** um estudo empírico para os estados brasileiros

## RESUMO

A literatura estruturalista afirma que a industrialização é passo fundamental para o crescimento econômico. Desde os anos 1980, o estruturalismo econômico tem buscado utilizar ferramentas matemáticas neoclássicas para testar seus postulados. A partir da criação do Índice de Complexidade Econômica (ICE), tal índice tem sido testado como variável explicativa para o crescimento econômico e ferramenta de *catching up* entre países. Segundo a literatura estruturalista mais recente, O ICE é uma proxy relevante para medição do desenvolvimento do tecido econômico de um país e se mostra significativa tanto para crescimento quanto para convergência. O presente trabalho utiliza o cálculo do índice de complexidade para os estados brasileiros e os testa em uma regressão de crescimento de estilo Barro e Sala-i-Martin para sua significância como argumento para crescimento e convergência de renda entre os estados brasileiros no período de 1997 a 2017. Os resultados das regressões não corroboram a teoria estruturalista tampouco os resultados presentes na literatura para países e regiões estudados. Resultados apontam convergência absoluta e relativa de renda para os estados brasileiros, mas ICE não apresentou significância estatística.

Palavras-chave: Estruturalismo econômico. Convergência de renda; *catching up*.

**SUMMARY**

## 1. INTRODUCTION

The debate over how and why economic and social development takes place is one strongly present in Social Sciences. Such investigation tries to define the variables through which a country - or a region - creates and distributes wealth in a manner that it reaches a comfortable state of wellbeing. One fact that comes up in these discussions is that inequality seems to be present in every level of comparative analysis: from continents to neighborhoods, economic and social development seem to spread in unequal manners, resulting in few rich developed areas surrounded by poorer underdeveloped ones.

When it comes to Economics, different schools of thought focus on specific variables as explanatory factors for development: Marxian economics focuses on class struggle through historic materialism; institutionalists see the solidity of institutions as the main factor for development, liberals tend to look at freedom of markets and business environments utilizing the methodological individualism approach and so on. This multitude of approaches is possible because economic and social development are human-driven phenomena and such phenomena tend to be multifaceted and complex, allowing for different interpretations and possible outcomes.

At the international level, different labels have been used throughout history to differentiate poor and rich countries: Developed vs underdeveloped; first vs third world countries, center vs periphery. Whichever label is chosen, countries and regions that are poor desire to reach the levels of income and wellbeing acquired by the developed groups. From such desire, many questions emerge, such as: Is there a set of conditions that ought to be met for a poor region or country to reach the levels of wealth creation and distribution of richer ones? Are these conditions limited to individual action or are they part of a larger structural scheme? Are these conditions endogenous or exogenous and are they influenced by past events? Are these conditions also determined by political action in a geopolitical sense? Answers will vary according to the theoretical approach applied.

This thesis utilizes the theoretical premises of the Structuralist school of economics in both its Anglo-Saxon roots as well as its Latin American branch. Also, the neoclassical influences absorbed by the structuralists, resulting in the *neo-*

*structuralist synthesis*, are utilized as an empirical tool. These terms will be explained in greater detail later.

To illustrate economic inequality at national levels, there are distinct rankings and methodologies applied. According to the United Nations in its 2020 World Economic Situation and Prospects (WESP), 36 countries composed the "developed economies" group and of those, 28 were European. There were no countries from South and Central Americas or Africa on that list. The UN methodology consists of three groups labelled "developed", "in transition" and "developing" economies. The UN utilizes different indicators when composing its overall rankings. The economic ones are gross domestic product (GDP) growth rates and per capita income. There are also productivity related analyses regarding levels of industrialization, exports, and technological development. The social aspects include unemployment rates, working conditions and educational attainment. (WESP, 2020). In this ranking, Brazil forms the "developing economies" group, alongside 129 other nations such as China, Mexico, and Israel.

Another way of analyzing a country's economy is by looking solely at its GDP per capita. According to the World Bank, in 2019, the richest nation in the world was Bermuda, with a GDP per capita of $117.089,28. On this list, the United States (US) appear in eighth place with a sum of $65.297,51 per capita. Brazil comes up with a GDP per capita of $8.717,18 in the 78$^{th}$ position from 186 applying countries. The poorest country listed is Burundi, with an average GDP of $261,24 per capita. In this definition, the US is considered a high income country; Brazil is considered an upper-middle income country and Burundi a low income country.

Another approach to understanding socioeconomic development is the Human Development Index (HDI). Developed by the United Nations Development Program (UNPD) the HDI attempts to offer an alternative understanding to development when compared do pure GNI per capita analyses. It condenses four variables into a final number ranging from 0 to 1 where the more developed a country is, the closer to 1 their index will fall. The variables considered are life expectancy at birth, mean years of education, expected years of education and the GNI per capita at purchasing power parity (PPP). Countries are then stratified into four possible categories: low (≤ .549), medium (.550 - .699), high (.700 - .799), and very high (≥ .800).

Although the very definition of what it means to be a “developed country” is disputed, a few guidelines can be found in literature. Applied economics uses per capita income and growth as a proxy for economic development. According to Bresser-Pereira (2008), the distinction made between economic growth and economic development is usually only formal. Although there are cases where the income per capita increases without the structural and institutional conversion that defines what developed economies look like, that is hardly the case. Increases in wealth tend to lead to changes in the very fabric of a society. Bresser-Pereira points out, however, that the exact order of magnitude and which variable is prominent in that process is also disputed (2008). Thus, applied economics uses the variation of income per capita as a proxy to understand economic development and test other variables to magnify their influence on income convergence and divergence between poor and rich countries and regions. The present work utilizes this convention when testing economic growth and convergence patterns as proxy to economic development.

The reasons for choosing the Structuralist school of Economics in both its original Anglo-Saxon contribution as well as it’s Latin-American branch - represented mostly by the United Nation’s Economic Commission for Latin America and the Caribbean (ECLAC) – is that its methodology embraces the idea that capitalism is a political system and as such, can’t be described as a natural phenomenon the same way natural sciences work. Economic development is seen as a regional-influenced and history-driven process. Structuralism focuses on the productive structures as the key variable in economic development. It is through the transformation of the productive structure, moving from less to more productive sectors that enables a country to amplify employment, productivity, and income per capita, reducing poverty. (Gala et al, 2018). In such argument, the autonomous industrialization process of an economy is not an accessory facet of its development, but the main force that drives it. Also, the government is a key player in planning and facilitating guided economic investments. According to Bresser-Pereira (2016), understanding the economic development through the structuralist view enables for creation of policies directed to promoting specific sector to climb the technological ladder that leads to levels of income of developed economies.

The theoretical propositions of early classical structuralists such as Ragnar Nurkse, Albert Hirschman and Gunnar Myrdal criticized neoclassical economists and

saw market mechanisms as insufficient for promoting economic development. They introduced new variables to understand the effects of industrialization and its attracting and dispersing effects that directly influenced its surroundings (SANCHES-ANOCHEA, 2007). In the Latin American branch of the debate, Raul Prebisch introduces the *center-periphery* dichotomy, stating that the capitalist system is intrinsically unequal in its productive structures especially regarding poor countries whose economies rely heavily on commodities (PREBISCH, 2000). Prebisch (1949) also emphasizes the productive gains obtained when more technological sectors are present, and stresses that such migration from less to more sophisticated production is a key part of improving income per capita. The Prebisch-Singer hypothesis challenges the neoclassical theory of international trade concluding that over time there is a degradation of exchange terms between commodities and manufactured goods. (SILVA et al, 2015) Thus, investing in commodity production for labor intense countries as defended by the neoclassical view is not an effective long-term strategy to promote economic development. This is corroborated by other classical structuralists authors ideas (HIRSCHMAN, 1958; NURKSE, 1962; ROSENSTEINRODAN, 1943).

Over time, the theoretical propositions from the structuralist school have received a formal treatment, incorporating the use of mathematical models as well as the use of econometric approaches to test their premises (Gala et al, 2018; Cimoli and Porcile, 2014). This movement is known as *neo structuralist synthesis*.

At around 2008, Cesar Hidalgo and Ricardo Hausmann introduced the Economic Complexity Index (ECI). Although not directly linked to the Latin American structuralist school, this index could be pointed, at least in some degree, as something that translates as an index part of the idea of diversification strongly present in the structuralist literature. As pointed by Cimoli and Porcile (2014, p.216), central (or north's) economies are diversified and show levels of labor productivity relatively homogeneous across groups, while the periphery economies tend to specialize in a narrow set of commodities with large differences in labor productivity, within and between sectors.

The ECI index consists of a ratio between the diversity and ubiquity of a country's export basket. The premise is that the rarer and more complex a product is, the more difficult it must be to produce it, therefore the more sophisticated is the economy that can produce it. To avoid misconceptions regarding naturally scarce

products, such as diamonds, the theory also accounts for the diversity of production in that said economy. In summary - for the introductory reason is this section -the greater the number of highly technological and non-ubiquitous products a country produces, the higher their ECI, therefore, the more complex their economic tissue is. The result of such work is the Economic Complexity Atlas. The Atlas is a compilation of data from over 50 countries and 1000 products that enables to test divergence and convergence between poor and rich countries according to the complexity levels of their productive systems.

Since Solow's (1956), classic work regarding economic growth and GNI per capita convergence patterns between countries in the stationary state, economics has modified the base model to include innumerous variables when trying to determine which one has greater influence in the economic growth phenomenon. Neo-structuralist literature has utilized those ECI results and applied them to neoclassical modeling, such as growth regressions for correlation with GNI per capita and convergence and divergence effects. According to Gala et al (2018) ECI levels have shown statistical significance and capacity to predict a country's path of development.

The present study utilizes a modified neoclassical growth model to test the effects of ECI on economic growth and convergence patterns from 1997 to 2017 having Brazilian national states as unities of analysis. The empirical model consists of a Barro and Sala-i-Martin based conditional convergence regression.

Based upon the historical contributions of the structural view of economic development and the newer mathematical models used to investigate countries' development paths and its advances in the theory beyond the neoclassical explanations, the current thesis considers the following statements as analytical realizations: Capitalism is intrinsically unequal; this inequality is present in every scale of analyses; industrial development is key to understand economic development; the economic complexity index is an important variable to understand and predict growth rates for countries. Thus, it tries to answer the following question: Can economic complexity be used to explain growth patterns within Brazil utilizing its states as unities of measurement? By understanding if increasing economic complexity leads to greater economic growth and catching up effects on an intranational level, there can be better grasping of which kind of industrialization processes increase the chances of economic

development in the long term. Thus, specific localized investments and policies can arise from such empirical evidence.

For such question, the main objective is to test the hypothesis by regressing ECI against per capita income variation in a panel data set consisting of four 5-year intervals. Control variables such as average years of education and fecundity rates were also utilized. The secondary objective consists of descriptive statistics exemplifying Brazil's regional inequalities.

The present work is structured as follows: The second chapter presents the theoretical framework that envelops this investigation. First, the classical work of Anglo-Saxon structuralist authors will be presented, such as Hirschman and Nurkse. Also, the Latin American branch of the debate is unraveled by the contributions of Raul Prebisch. In the same chapter, the Structuralist Synthesis and the Economic Complexity theory are presented. The second chapter ends with the presentation of the endogenous growth theory. The third chapter consists of a literature review showing results for the applied theory of economic complexity as a convergence argument for income per capita as well as other empirical convergence results. Chapter number 4 brings the methodology utilized as well as data sources. The fifth chapter shows results and discussion, and the sixth chapter encloses the final remarks.

## 2. THEORETICAL FRAMEWORK

Up until the mid-1930s the prominent economic theory used to explain and predict growth and development had neoclassical roots and was strongly imbedded in the Ricardian comparative advantages view. Basically, countries were incentivized to invest in producing goods for which they possessed comparative advantages. As such, countries whose productive factors were labor, and land had advantages in producing commodities compared to smaller, less fertile, and less populated countries. On the other hand, countries with developed manufacturing sectors could produce goods at lower costs and higher efficiency. When all those goods produced were combined at the international markets, the overall trading results were to be positive for every economy involved in it.

According to Missio et al (2012), for the neoclassical theory to work as a positive science derived from market laws it must abandon the investigation of specific

productive structures, institutions and other sociological factors that influence economical scenarios. In this model, human behavior is essentially motivated by utilitarianism and monetary incentives in a methodological individualism. The critique of such theorical approach put forth by orthodox economists is the basis of the structuralist school of thought.

After the crisis led by financial markets crashing in 1929 and the world economy suffering a significant halt at the end of World War II, new ideas and concepts about economic and social development gained strength led by the Keynesian influence. Those included the role of national state led policies, the constriction of unregulated markets and the tackling of market-based flaws. (CARDOSO, 2012). New variables related to economic development and wellbeing began to make their way into the academic and public debate, in opposition to the economic-growth related approach, such as health, education and nutrition indicators. Economic growth, however, remained as a necessary, but not exclusive, goal for developing economies in their attempts to overcome their structural restrains (MICHELS; COSTA, 2013). Fiori (1999) underlines other factors that contribute to the rise of development economics such as the decolonization processes in Asia and Africa as well as the Cold War dynamics in which different models of social and economic planning and development were being directly measured against one another.

As the frictions and contradictions of the neoclassical economic framework deepened, more contributions by critical authors began to take place. On the Anglo-Saxon structuralism, names such as Rosestein-Rodan, Ragnar Nurkse, Gunnar Myrdal, Albert Hirschman, amongst others helped create and understand the theorical outlines that permeate classic economic developmentalism.

According to Michels and Costa (2013), although the Anglo-Saxon authors mainly stood for strong national states, interventions in economic policy and protectionist measures, they remained faithful to some degree to the Ricardian theory of international trade and that ambiguity weakened the developmentalist strategy for political projects. Mainly, each author had a specific vision regarding the role of the state and public policies in economic development.

According to the Sanchez-Ancochea definition (2007) the structuralist literature can be understood divided into two groups whose ideas intertwine but are also fundamentally different: the Anglo-Saxon school, which this chapter briefly discusses

presenting some of the main ideas from a few selected authors, and the Latin American branch that will be looked upon later.

Furthermore, the *neo structuralist* movement is presented as a synthesis that incorporates neoclassical criticisms and tools from the 1980s on to some classical premises from early structuralists. Recently, this approach has resulted in the Economic Complexity theory that utilizes big data, networking, and computational techniques to create an index of how complex a country's productive system is. This index, in term, is tested as de explanatory variable in economic convergence, divergence and growth patterns.

## 2.1 Anglo-Saxon Structuralism

To situate the theorical basis of the Anglo-Saxon structuralism, four of its main authors ideas will be briefly recollected: Paul Rosenstein-Rodan, Ragnar Nurkse, Albert Hirschman, and Gunnar Myrdal.

Rosenstein-Rodan and his *Big Push* theory can be regarded as the first contribution in this field of study (Gala et al, 2018). The author focuses on the eastern European economies for they are considered relatively similar and can be the object of comparison to the central European industrialized countries. For Rodan, this theory isn't one of traditional static equilibrium, but one that understands the unbalanced growth processes that mark economic development (CARDOSO, 2012).

For the author, the main variable that attracts industries is the wealth of a region. Since the urbanized regions have higher per capita wealth, industries allocate in such areas. Expanding the thought process to countries, richer countries will attract industries and poorer countries will remain rural and this dynamic tends to perpetuate when left under market regulation (CARDOSO, 2012). According to Rosenstein-Rodan, markets are unable to satisfactorily solve the concentrations of industrial activities in richer regions, aggravating the unequal development process. The author emphasizes that industrialization occurs when capital drifts towards surplus labor and not the opposite, where labor is encouraged to move to industrialized sites. Therefore, to develop poorer regions whose attraction powers to capital are limited, state-based incentive programs are needed to create such environment. Here, the positive effects

of industries rely on dynamic externalities and increasing returns to scale (Gala et al, 2018).

According to Cardoso (2012), Rosenstein-Rodan defends a model of industrialization for poorer countries that respects the international division of labor by inserting such sites into de international trade markets, attracting foreign capital and focusing on light, labor intensive activities. Also, it is necessary to improve agricultural productivity, releasing work force to the new industrial sector. Regarding the type of policy needed for such endeavor, the author defends investing in work force training and complementary industrial chains to minimize eventual demand insufficiency. This type of investment, where industrial chains are promoted via state policy and coordination, aims to minimize risk, and create an attractive environment for capital flow. Also, the vertical and horizontal externalities brought by such industries and the complimentary demand nature it creates help balance out the development process in a Keynesian aggregate-demand point of view (CARDOSO, 2012). This is the so called balanced growth theory for which both Rosenstein-Rodan and Ragnar Nurkse are known for.

In a later writing, Rosenstein-Rodan (1984) recognizes that the development process is an uncertain one, where the outcomes are not fully predictable. However, there must be an initial traction resulted from investment in infrastructure without which economic development is unviable. This initial push must be done in block instead of incrementally. The author also stresses that these initial investments are imperative - although not sufficient - for creating the environment for economic development.

Ragnar Nurkse is another pioneer of economic structuralism and focuses his analysis on economic factors such as capital accumulation. In a similar approach to Rosenstein-Rodan, Nurkse (1952) stresses that poor countries are poor because they are poor, meaning that the structural conditions for economic production are key factors, although not exclusive, for explaining why some countries remain poor. There is *vicious circle of poverty* that entraps underdeveloped countries in which low productivity per worker leads to low levels of income, low demand for goods and services and ultimately a scarce accumulation of capital. This effects both supply and demand sides of an economy. Also, the type of goods being produced can be related to the underdevelopment of such an economy (Gala et al, 2018).

To overcome such vicious cycle, Nurkse defends the development of more robust internal markets in underdevelopment economies, as well as the investment in agricultural technology to reallocate labor onto more productive industrial sectors (CARDOSO, 2012). Although it is possible to attract foreign capital to promote such steps, Nurkse emphasizes the importance of developing capital internally and, since economic development is not a spontaneous phenomenon, State policies are key for creating the conditions and directing the investment processes that lead to autonomous capital accumulation by internal economic agents (CARDOSO, 2012). Nurkse emphasizes that these processes are not universal, and the internal logic of each country must be considered when trying to develop the conditions for autonomous capital accumulation and the eventual overcoming of the poverty cycle.

Albert Hirschman and Gunnar Myrdal are the next pioneers of Anglo-Saxon structuralism whose ideas will be briefly explored. According to Gala et al (2018), this distinction is relevant as it shows the differences in approaches between authors of the same school of thought going from a balanced theory of economic growth focusing on classical arguments such as dynamic externalities and increasing returns to an unbalanced one.

Hirschman (1958) defends that economic development goes beyond optimizing production factors and resources, but also identifying existing underutilized abilities and resources already present. Also, economic development is seen as an intrinsically unbalanced process where disequilibrium in one area can lead to opportunities in another.

According to Gala et al (2018), while Rosenstein-Rodan and Nurkse focus more on consumer goods sector, Hirschman stresses the importance of developing intermediate and capital goods sectors. One key point in Hirschman's contribution is the notion of linkages between sectors caused by a certain industry. The author proposes backward and forward linkages that in essence translate to how much previous production a certain industry demands for its goods and how many opportunities of forward demand do such goods bring about. According to Hirschman (1958), any non-primary good will demand the production of previous supplies that can by locally produced. On the other hand, any non-final good creates the opportunity for further utilization by other sectors of the economy. Therefore, intermediate goods sectors present both strong backward and forward linkages. It is important to stress

out that to Hirschman, many of the development processes happen while the development is occurring. What this means is that not all factors of economic development need to be present for the process to begin, since many of them come by trial and error and by learning in an endogenous, retro feeding manner (CARDOSO, 2012). The tensions that arise in this unbalanced growth theory bring about the elements to deal with and overcome such tensions as decision-making practices improve over time.

To finalize the Anglo-Saxon structuralist review, the work of Gunnar Myrdal will be briefly presented. This order represents the influence Myrdal's work had on other unorthodox approaches to economic development, such as the Latin American structuralism (Gala et al, 2018).

Myrdal (1957) introduces the notion of *circular cumulative causation* as an explanation to inequality in economic development between countries. A critic of the equilibrium growth theory, the author emphasizes that classical theory fails to account for non-economic factors that are key in understanding the circular causations that can trap certain regions in subdevelopment. This happens because certain social changes do not create compensatory effects that lead to equilibrium in other areas; in fact, those changes lead to reinforcements in that same direction, in a cumulative and unbalanced manner (MYRDAL, 1957).

Understanding how those factors interact with one another, allows for public intervention and control to direct the cumulative causation onto a positive path (CARDOSO, 2012). As an example, trade between countries is a factor that has cumulative causation that can lead to positive or negative effects, named by the author as *spread effects* or *backwash effects*, respectively (Gala et al, 2018). This happens because market-forces tend to cumulatively aggravate distortions and regional disparities and, when not controlled, generate a backwash effect for the poorer region. According to Cardoso (2012), Myrdal's idea of the State role is of reinforcements of factors that lead to positive cumulative effects on the road to economic development, with a national development plan, that requires a strong public institutional stability aiming for national integration and a large scale planning for industrial development.

## 2.2 Latin American Structuralism

The Latin-American branch for the structuralist school of thought in economics is widely known for the contribution from the Economic Commission for Latin America and the Caribbean (ECLAC). The ECLAC is an organization created by the United Nations in the post-World War II era as an attempt to aid developing countries in their quest to understand and overcome the intrinsic difficulties related to economic and social growth outside of the industrialized world. Preeminent intellectuals have their work bonded to the ECLAC such as Celso Furtado, Aníbal Pinto, Maria da Conceição Tavares among many others. However, it is in Raul Prebisch, widely considered the pioneer for such approach in the Latin American region, that this thesis focuses.

It is important to stress what theoretical framework is being criticized by Prebisch and other structuralists. Up until the mid-1900's the neoclassical model knows as HOS (Heckscher-Ohlin-Samuelson) stated that benefits from international trade spread out evenly between countries. Since prices for commodities tend to drop slower than industrialized goods, it would be advantageous for poor countries to invest resources improving productivity in labor intensive sectors in detriment to trying to industrialize and compete with already efficient countries. From that logic, there would be a positive trade off in remaining commodity based since terms of exchange would make manufactured goods more affordable over time. Prebisch demonstrates – in what would be titled the Prebisch-Singer[1] hypothesis – that deterioration in the exchange terms between commodities and manufactured goods occurs due to two main reasons: The tendency for technological innovation to stay in the central economies, and the mechanisms by which the losses during the retraction phases of the prices cycle punish peripherical labor in the form of reduced wages and benefits.

In 1949, Prebisch released his manifesto titled *the economic development of South America and its principal problems* in which the author proposes the center-periphery dichotomy to explain how the international trade market works opposing industrialized and agriculturally based countries. Using international trade data from 1876 to 1947, the author observes a deterioration of 36,5% in the exchange terms affecting commodity producers contradicting neoclassical theorists (PREBISCH,

[1] Hans Wolfgang Singer was a German development economist whose work also focused terms of trade degradation toward primary economies around the same time as Raul Prebisch.

1949). Prebisch goes on to identify that structural causation for such relative inequality regarding the fruits of international trade.

The author underlines the cyclical nature of prices in capitalism, which he states is the very intrinsic logic of the system. That means that during the expansion phase, industrialized countries demand for commodities pushes prices upwards; those prices rise higher than those of manufactured goods due to elevated productivity levels in central economies, which tends to lower costs of production. Relatively, there should be an incremental valorization of commodities that over time would enable primary countries to consume ever more manufactured goods, confirming the *comparative advantage theory* defended by neoclassical economists. However, Prebisch demonstrates that while prices for commodities do grow higher during the expansion phase, they also drop lower during the retraction portion of the price cycle. The explanation lies in the level of competition and labor availability between center and periphery economies. Industries that produce manufactured goods are fewer than the ones that produce commodities which enables an oligopoly-like price structure. Also, labor is scarcer in central economies. That forces business to compete more aggressively for labor during the expansion phase, resulting in higher wages.

Although this logic also applies for primary economies during the expansion, with higher remuneration for all factors, the structural difference occurs during the retraction phase of the price-cycle. When the demand retracts and prices drop, the central economy business find it more difficult to preserve profit margins by compressing labor remuneration due to the strong labor unions active in central economies. That drives central capitalists to hedge their losses by reducing demand for commodities and forcing prices down. Those losses are, in turn, passed along to the periphery labor force where it is more abundant and labor unions weaker. That makes compression of remunerations, both profits and wages, easier in the periphery (PREBISCH, 1949).

Although a critic of the intrinsic inequalities in trade relations between center and periphery, Prebisch states the international trade is the path necessary for poor countries to accumulate capital and develop their industrial sectors, which in turn are essential for improving per capita income and wellbeing indicators. However, under the structuralist approach, there are implicit limits to this enterprise when left to the forces of free market logic. The key element is that technological progress does not

spread uniformly across countries that are inserted in international trade. Industrialized countries present a shortage in labor combined with strong union organizations that enables for higher wages as well as propels technological innovation that replace that said short-handed labor for machinery in a constant push for more technological innovation (MISSIO et al, 2018). This effect results in increasing capital density for some sector that eventually spreads out to other sector of the economy. The growth in productivity is accompanied by increase in wages that allow for the sustainment of capital accumulation. Therefore, remaining as a primary exporter is not advantageous for poor countries trying to reach the income levels of central economies.

Autonomous industrial development is proposed by Prebisch as the way out to the structural trap reserved for primary economies. Industrialization can help in absorbing labor forces available from less dynamic sectors, as well as enable national production of otherwise imported goods (CARDOSO, 2012).

It is important to state, regarding the present status of the Prebisch-Singer hypothesis, the 2015 work from Silva et al that demonstrates the validity of the hypothesis by analyzing the terms of exchange between commodities and industrialized goods from 1977 to 2011 and concluded that although prices for commodities have risen led by China and India's economic growth, prices for industrial goods have also risen, leading to the degradation of trade terms.

According to Sanchez-Anochea (2007), the Anglo-Saxon and Latin American branches of structuralist economics share many elements, such as *linkages* and the rejection of *comparative advantages theory*, however the Latin American portion goes a few steps beyond. Firstly, Latin-American structuralism is based on the premise that countries do not follow a similar path in their attempt to reach development. Also, relation between rich and poor countries are not always mutually beneficial and the historic particularities are an essential variable. Furthermore, Anglo-Saxon authors rely heavily on the State's intervention mechanisms disregarding the weaknesses of peripheric country States to do the same. It could also be pointed out that the Anglo-Saxon approach lacks focus on class struggle and how this element may affect the analysis and how the study of isolated economies is more prominent than global economic structures (MISSIO et al, 2012).

Theoretical propositions from the structuralist school state that industrial activities are responsible for greater returns to scale, greater technological innovation, higher productivity, and spillover effects that are responsible for economic growth.

Rodrik (2009) affirms that, when investigating the economic *boom* post World War II, average growth for countries did not exceed 2%. However, Japan, Korea and China were able to reach annual growths of over 8%. These countries became manufacturing superpowers in relatively short periods of time. This is so, according to Rodrik, because these countries invested in industrial development in a rapid manner, moving from less productive activities to higher productive ones. That means, poor countries that began producing what rich countries produce.

## 2.3 The Neo Structural Synthesis

Although the classic development authors contribution to the economic debate exercised great influence in policy during many decades, the results regarding income growth and eventual development of poor countries have been debatable. Many countries took the industrialization path after the second World War where global productive structures suffered a rearrangement allowing for peripherical regions to invest in manufacture. In the Brazilian case, government pushed for industrialization policies from the 1950's on, but according to Arruda (2003), it did so in a dependent manner. The author explains, in consonance with the Latin American structuralist view, that the class relations in Brazil limited and determined the type of industrial development that would occur. Instead of internalizing the process, governmental decision was to externalize production by allowing foreign capital to enter the country and take over the more profitable sectors, such as the automotive industry.

Arruda (2003) explains that the political interests of the agricultural elites – historically dominant in Brazil – worked to maintain policies of their interest. Also, the national industrial elites settled for the non-durable goods sectors, leaving the most profitable and technological areas to be explored by foreign capital. This resulted in a dependent industrialization process.

The process cited above falls into what Silva et al (2015) call the extension effects of the Prebisch-Singer hypothesis which states that deterioration of trade terms occurs not only between manufactured goods and commodities, but also between

technologically low goods versus more advanced ones. When poor countries begin their industrialization process with lower productivity goods, the relation between export and imports of capital denser goods follow the same path observed in the original Prebisch proposition. This is one possible explanation as to why industrialization itself did not deliver the expected effects over income in the long run.

There are many possible explanations as to why nations that implemented an industrial project did not overcome the poverty trap. Aside from the local specific conditions of each one, there are the global movements of capital and its pressures seeking profitability. In accordance with Prebisch proposition of the price cycle explanation, up until the early 70's, productivity rose and alongside it, wages rose as well around most of the globe. This period is called in literature as the *golden age of capitalism* where the social policies were known as *welfare state.* Once profit margins became too short as wages and social benefits rose, especially in central countries, capital, propelled by the robotics revolution of the early 70's, started migrating to the peripherical countries after lower wages and better productive incentives. This is the beginning of the *neoliberal* phase (ANTUNES e POCHMAN, 2007).

This movement resulted in a retraction of structuralist ideas from the 1970's on, with the academic circles being influenced by the neoliberal views that came along the *Washington Consensus* (MISSIO et al, 2012). Also, according to Missio et al (2012) an approach titled *neo structuralism* arose from the neoclassical era merging the classic premises from the previous Latin-American studies such as the concept of center-periphery based on the agricultural vs industrial dichotomy - that correctly implied that poor countries needed to develop their industrial sectors - with insights and methods from neoclassical studies. That is known as the *neo structural synthesis.*

Neo structuralist studies showed that after primary industrial development led by poor countries, the universal dualism proposed by the classic structuralists persists, but within sectors themselves. In industry, this means a dichotomy between the more dynamic and technological sectors put against the less productive sectors. (CIMOLI and PORCILE 2014, MISSIO et al, 2012). Such contribution led way to the proposition that industrial development alone isn't sufficient, although imperative, for economic development, for the kind of industrialization and which sector of the economy is being stimulated is also key for development purposes. According to Missio et al (2012) the technological industrial sector is the main driver for the desired goal.

## 2.4 The Economic Complexity Theory

Contributing to the field of investigating economic development by analyzing productive structures utilizing a mathematical neoclassical approach, Cesar Hidalgo and Ricardo Hausmann (2011) developed an index that tries to capture the productive capabilities of each country by utilizing disaggregated international trade data. According to Hausmann (2009), since Adam Smith, the notion of division of labor has been linked to wealth creation. Specialization leads to increases in productivity. The bigger a given market is, the deeper its participants can specialize in determined areas, creating a complex net of interactivity. Hausmann proposes the following question: If countries are now connected in a global chain of commerce, allowing for greater division of labor and specialization, why hasn't growth domestic product (GDP) risen higher? The answer proposed is that key elements of such improvement cannot be exported along the goods being exchanged. Such key endogenous elements are property rights, infrastructure, skilled labor among others in such a way that they must be locally available.

> "Hence, the productivity of a country resides in the diversity of its available nontradable "capabilities," and therefore, cross-country differences in income can be explained by differences in economic complexity, as measured by the diversity of capabilities present in a country and their interactions." (HAUSMANN, 2009, p. 10570)

This insight can be corroborated by looking at international trade data. Richer countries tend to produce technologically advanced goods that are only produced by a few of them along other less complex products. Poor countries, on the other hand, tend to produce less-complex goods that are produced by many countries. This leads to the conclusion that being able to produce rare and technologically advanced products in a complex and diversified manner is the key element to improving GDP and developing an economy. This idea has consonance to the classic structuralist work cited previously (LADEIRA e CARDOSO, 2020).

Since measuring a country's economic capability is a difficult task due to the high number of variables involved, Hausmann and Hidalgo (2011) utilize the export basket as a proxy to the level of complexity for its productive tissue. Acknowledging the fact that a finished product carries all the information necessary for its production,

comparing the ubiquity and diversity of a country's export basket allows for the understanding of how sophisticated that productive structure is (Gala et al, 2018).

A poor, undiversified country can produce a scarce good, such as diamonds, which could mislead to the interpretation that it is a complex economy. To correct for that, the authors also look at the diversity of such economy's export basket, comparing each product to other countries that can also produce it. For example, if country A is a producer of diamonds but the rest of its export basket is filled by non-technological ubiquitous products, such as bananas and corn, that economy has a limited, undiversified export basket, although it does produce a non-ubiquitous item. For a country to be considered complex, it must be able to produce a wide range of products, including those that few other countries can offer, in a diversified and non-ubiquitous manner. The more products of such caliber a country can produce, the more complex is its productive tissue. Gala et al (2018) utilize the example of x-ray machinery to illustrate a complex economy, which only Japan, the United Stated and Germany produce:

> "[…] these are non-ubiquitous complex products. In this case the export composition of Japan, USA and Germany is extremely diversified, indicating that these countries are highly capable of making many different things. In other words, non-ubiquity with diversity means "economic complexity". (Gala et al, 2018, p. 227).

Being a complex economy means the ability to profit from producing goods with high technological content whose spillover effects are greater than in other sectors. It does not mean a country only produces high-tech goods, but it has a wide and diverse export basket that includes goods from sector with greater returns to scale and productivity per labor unit.

In their methodology, which will be later explained in detail, Hidalgo and Hausmann (2011) utilize international trade classifications such as the Standard International Trade Classification (SITC) and the COMTRADE Harmonized System to identify the products exported by each country. To determined what goods countries efficiently produce and export, they use de *revealed comparative advantage method* (RCA) "the share of product *p* in the export basket of country *c* to the share of product *p* in world trade" (HIDALGO, 2009, 10571). For example, in 2017, according to the Harmonized 4 digit System (SH4 8802), Brazil's export share for helicopters, planes and satellites amounted to 2,58% of its total exports. Worldwide, this share was 1,57%

of total exports. Since 2,58/1,57 is bigger than 1, this means Brazil has revealed comparative advantage in producing those products (code 8802) (HERERRA, 2020).

Using network, computational, and complexity techniques, the complexity authors see the products themselves as packages of information, where one can safely assume that all the abilities necessary to produce such good (technology, institutions, educational levels, empirical know-how, qualified labor etc.) are all embedded. Thus, a countries export basket is a safe indirect measurement of its level of productive sophistication.

> "[...] observing the bipartite network that emerges from the relation between countries and their exports, enables to reconstruct the set of knowledge, institutions, and abilities that allow a determined country to produce and export certain goods in the international markets. This set of capabilities determines a country's economic complexity" (LADEIRA, 2018, p. 16).

The result of such endeavor is the Atlas of Economic Complexity, a compilation of international trade data for over 50 years, from 200 countries and 1000 products (LADEIRA, 2018). The index results are numbers that fluctuate around 0 where the greater positive number means more economic complexity and the negative number means the opposite.

Table 1. 3 highest and 3 lowest ranked countries and Brazil in ECI (2019).

| Rank | Country | ECI |
|---|---|---|
| 1° | Japan | 2.49 |
| 2° | Switzerland | 2.13 |
| 3° | Germany | 2.07 |
| 131° | Liberia | -1.70 |
| 132° | Guinea | -1.75 |
| 133° | Nigeria | -1.77 |
| 53° | Brazil | 0.10 |

Source: Elaborated with data from Atlas of Economic Complexity

Another key contribution made by the economic complexity theory is that looking at how diverse a country's productive system is, it is possible to estimate its future growth potential. Hausmann et al (2011) exemplify this by comparing China and Thailand's income to those of Libya, Oma, and Venezuela which are similar. However, the goods produced by the first two countries are far more diverse and complex than the ones from the latter group. Hence, it is possible to affirm that the productive

structures present in China and Thailand, via ECI, is foretelling of higher growth rates for the future.

### 2.5 Economic growth and convergence patterns

Neoclassical economists have proposed since the 1900's mathematical models to predict whether a poor country could, eventually, catch up to the wealth levels of developed ones. Ramsey (1928), Solow (1956), Swan (1956), Cass (1965) and Koopmans (1965) have proposed that, following certain conditions, in the long run economies tend to reach a similar stationary state of capital accumulation per unit of labor. For that to be a reality, these models presume a certain type of aggregate production function, with constant returns to scale and a positive and decreasing marginal capital productivity moving toward a stationary state (LADEIRA, 2018). Since the marginal returns for capital invested are decreasing, richer countries have smaller and smaller returns per labor unit of invested capital, stimulating capital to migrate to poorer regions. In the long run, technological and institutional advancements lead to greater productivity levels, increasing the wealth of the poorer regions by a faster degree compared to the already developed ones. This would result in a long run stabilization of incomes across different countries in a *catching up* effect. This is known as *absolute convergence*.

Since then, the standard economic growth theory has been modified in different ways, including questions as technological change (Romer, 1990) and human capital accumulation (Lucas, 1988). From an empirical point of view, Mankiw, Romer, and Weil (1992) adapted the standard Solow model to include human capital accumulation in addition to physical capital accumulation. The authors show that convergence patterns aren't universal, as the Solow model predicted, and can reach different equilibrium states for each country according to their own factors of populational growth, physical and human capital accumulation. Thus, convergence shows to be more plausible at conditional levels, where countries with similar characteristics tend to converge to a similar per capita income. (ALMEIDA and MOREIRA, 2019).

Over time, economists have tested different variables by modifying the models to understand which one has greater causality when economic development is the goal. Economic literature is filled with works regarding institutional capabilities, labor

productivity, educational levels and other variables tested to explain economic growth and economic convergence between different regions. The Economic Complexity Theory affirms that a country's structural productivity level, as measured by the ECI, is a key economic *catching up* element as defended by the classical structuralist authors previously discussed [HIDALGO ET AL. (2011); GALA, ROCHA E MAGACHO (2016); ALBEAIK ET AL (2017)].

# 3 LITERATURE REVIEW

## 3.1 Convergence among Brazilian regions

One main aspect of this Thesis' investigation is the premise that convergence is a phenomenon that can be also identified at regional levels. This section does a brief display of recent work done in such direction and the variables mostly associated to these convergent growth patterns.

Literature shows that the convergence hypothesis, both universal and conditional for Brazilian regions, states and municipalities is empirically verifiable. [FERREIRA (1996) and AZZONI (2001)]. Almeida and Moreira, (2019), utilized panel data regression to test for beta convergence among Brazilian states from 2000 to 2014 and found significance for both conditional and universal convergence.

When it comes to control variables, Azzoni et al (1999) show that both human capital and geographical variables are significantly related to the levels of GNI per capita. Lau et al (1993) and Andrade (1997) estimate the impact of human capital in the form of mean years of education of the work force. Results show that 1 extra year of education impacts positively GNI by 20% and 32% respectively.

Nakabashi et al (2010) tested for the influence of human capital for economic growth from 1980 to 2002. Results show an impact of 15% estimated marginal return from education, corroborating the hypothesis of human capital as a main driver of economic growth.

Nakabashi e Salvato (2007) utilized a different proxy for human capital and found out that although less impactful in GNI growth, human capital was more significant in explaining that growth.

In a municipal level, Díaz et al (2017), tested a multilevel model for convergence using human capital as one of the variables. Results show that human capital impact on growth convergence is not independent from spatial distribution.

### 3.2 ECI and convergence patterns

From the contributions made by the ECI authors, literature has applied the *index* as an explanation for economic growth and converge patterns. Although work in this field is still recent and relatively scarce, there has been confirmation of ECI being a relevant variable in explaining convergence patterns between countries as well as regions, given the proper adaptation of ECI to those specific units of measurement.

Özgüzer and Ogus-Binatli (2016) calculated the ECI for 25 European Union (EU) countries and ran a beta-convergence regression to test the correlation between economic growth and convergence patterns using economic complexity as the explanatory variable. They divided the countries into 2 groups with lower and higher ECI. They tested GDP variation against ECI variation for a 1995-2010 time frame. Results show that, for the first set of countries, with higher ECI, economic complexity has a high association to economic growth, supporting Hidalgo and Hausmann (2009) findings that "a group of countries in the EU with higher economic complexity tend to converge to levels of income corresponding to their measured complexity" (ÖZGÜZER and OGUS-BINATLI, 2016, p.102).

For the second group, with lower ECI, economic complexity showed a significant but negative effect, with countries in this group having higher growth rates. The authors propose the explanation that unique EU trade agreements and market access allow for these countries to specialize in low complexity goods. For convergence, the authors show that in the first group of higher economic complexity, convergence happens at a much higher rate than the second group, concluding that economic complexity is important for convergence especially once a certain complexity threshold is met.

Morais (2017) investigated the correlation between economic complexity, growth, and convergence for Latin American countries from 1990 to 2010. The author utilized an econometric spatial weight model incorporating complexity to the matrix. Results show that once complexity is controlled in the spatial weight matrix, there is

corroboration of the literature since complexity shows importance in economic growth and converge among Latin American countries.

Gala et al (2018) utilized a heterogenous regression model to estimate the impact of ECI on the probabilities of convergence and divergence between countries. Utilizing data from the Economic Complexity Atlas, the authors concluded that, among developing countries with similar export baskets, income tends to converge. When compared to countries with poor export baskets, such as Argentina or Nigeria, income tends to diverge. Also, the higher the complexity index for developing countries, the higher is the income convergence probability to high income countries.

Ladeira and Cardoso (2020) used a dynamic data panel analysis with a *System-GMM* estimator. The authors compared data from 39 countries from Latin America, the Caribbean and Asia with population over 1 million people from 1970 to 2010. They tested per capita income variation, physical capital formation, human capital investment and population variation. The control variables were fiscal policy, commercial openness, and economic complexity. Results show that economic complexity has convergence effects on economic growth rates. Looking solely at initial income levels, there is divergence within the sample which is attenuated by the level of economic complexity. For elevated complexity levels, the rate of growth divergence is reduced in function of the structural economic complexity. This corroborates the finding of Gala et al (2018).

## 4 METHODOLOGIES AND DATA

This thesis utilizes Herrera's (2020) economic complexity index calculation for each Brazilian state from 1997 to 2017 as the explanatory variable to understand economic growth and converge patterns between the Brazilian states for the referenced time frame. These indexes are tested in a panel regression beta-convergence model with the variation of per capita income as the dependent variable. The following section displays the original methodology used in the Economic Complexity Atlas for countries. Then, it shows Herrera's adaptation to calculate the ECI for each Brazilian state from 1997 to 2017. Further on, the econometric model, which aims to test the correlation between economic growth and economic complexity for the Brazilian states, is presented.

## 4.1 Economic Complexity Index

### 4.1.1 ECI for countries

Hidalgo and Hausmann (2011) original contribution to the economic development debate utilizes computational science, network concepts and complexity elements to identify how sophisticated a country's productive tissue is. In this context, complexity means the number of connections that a determined point has in relation to the rest of unities observed in a web-like scenario. The authors rely on the conceptual notion that each good produced by a country can be represented as a dot in a web of connections. This dot is the accumulation of all necessary production conditions that an economy must have to compete in international trade markets at an efficient level for that specific good. This is a reliable indirect proxy for the difficult task that is to stablish all the institutional, political, economic structures, as well as many other nuances that influence each country's productive capabilities.

A complex economy is one that produces many different goods, with multi-connectivity between them that show a rich and diverse production system. This means that complex goods, which are the product of many other processes, are available for that specific country. The more complex a good is, the less likely is it to be produced by many competitors. That means a complex good is not ubiquitous, in other words, it is a rare product.

The ECI is a representation of a bipartite export data network where countries are linked to the goods they produce. Mathematically, it corresponds to a $M_{cp}$ adjacency matrix where $M_{cp} = 1$ if country *c* is and efficient exporter of product *p* and $M_{cp} = 0$ when the opposite is true. (LADEIRA, 2018).

To identify which products are efficiently produced by the different countries, the authors examine the export baskets and apply the *revealed comparative advantage* (RCA) proposed by Balassa (1965) which means "the share of product *p* in the export basket of country *c* to the share of product *p* in world trade" (HIDALGO, 2009, 10571).

$$RCA_{cp} = \frac{E_{cp} / \sum_{p' \in P} E_{cp'}}{\sum_{c' \in C} E_{c'p} / \sum_{c' \in C, p' \in P} E_{c'p'}}$$

where ∈ is exports, c and $c'$ are country index, C is set of countries, p and $p'$ are the commodity index and P is the set of commodities. Products with RCA≥1 are competitive in international trade markets. The more products with RCA≥1, the more diverse the economy is.

Product classification follows three different sources. The Standard International Trade Classification (SITC) revision 4 at the 4-digit level, the COMTRADE Harmonized System at the 4-digit level; and the North American Industry Classification System (NAICS) at the 6-digit level. To visualize the relation between products and countries, the authors utilize the *Reflection Method* which consists of "iteratively calculating the average value of the previous-level properties of a node's neighbors and is defined as the set of observables" (HIDALGO and HAUSMANN, 2009, p.1571).

$$(2) \qquad K_{c,N} = \frac{1}{K_{c,0}} \sum_p M_{cp} K_{p,N-1}, \qquad (3) \qquad K_{p,N} = \frac{1}{K_{p,0}} \sum_c M_{cp} K_{c,N-1},$$

for N>1. The initial conditions $K_{c,0}$ and $K_{p,0}$ correspond to the sum of *country-product* connections:

$$(4) \qquad K_{c,0} = \sum_p M_{cp}, \qquad (5) \qquad K_{p,0} K_{p,0} = \sum_c M_{cp},$$

Equations (4) and (5) represent the level of diversification and ubiquity present in each country's export basket. Thus, the Economic Complexity Index is:

$$(6) \qquad \text{ECI} = \frac{\overline{K} - <\overline{K}>}{stdev(\overline{K})}$$

where $\vec{K}$ represents the autovector associated with following the matrix and and $c'$ represents a third country.

$$\widetilde{M}c'c = \frac{1}{K_{c,0}K_{p,0}} \sum_p M_{cp}M_{c'p}$$

As interactions progress, the measurements are of one country's productions related to another). The <> represents the average for the $\overrightarrow{K}$ autovector and *stdev* stands for standard deviation (LADEIRA, 2018).

According to Ladeira (2018), the indicator's variance is time-dependable. However, since it is based on normalization by average, results around zero (0) can be understood as medium productive complexity. Positive results, especially above 2, are considered high productive sophistication. Negative numbers are classified as medium-low and low productive complexity.

### 4.1.2 ECI for regions

In recent years, many papers have been written applying modified versions of the ECI method to other unities of measurement. Pérez-Balsolobre et al (2019), Zaldívar et al (2016), Lee and Lin (2020), Sahasranaman and Jensen (2018), Herrera et al (2020) have investigated complexity in intra-national levels for Spain, Mexico, China, India, and Brazil, respectively. To test the economic complexity hypothesis for economic growth in Brazilian states, this thesis utilizes the ECI calculated by Herrera (2020).

Herrera (2020) utilized Brazil export data from each of its states (DF, the capitol district, was not included) and the ubiquity data for each product in international trade levels but adjusted for the Brazilian export basket:

$$\widetilde{M}_{cc'} = \frac{1}{K_{b,0}} \sum \frac{M_{cp}M_{c'p}}{K_{p,0}}$$

where:

- "c" represents regions
- "p" represents Brazilian export basket

- "$K_{b,o}$" represents worldwide ubiquity adjusted for the Brazilian export basket.

In such approach, the states are compared to each other, with the highest complexity levels hovering around positive 2. It is important to notice the possible methodological flaws when trying to estimate ECI for intra-national levels. ECI, as explained earlier, relies on international trade data, based mainly on revealed comparative advantages (RCA). Thus, the export basket is a proxy for the products being produced at efficient levels and, therefore, competitively when exported across the world. ECI for intra-national levels, could, however, miss out on internal trade routs between states for intermediate goods which aren't necessarily being exported by the respective state. The counter-argument for such problem would be that is a state produces a determined good at high efficiency levels, it would also export that good for the incentives for high demand goods ate international trade levels are worth it.

### 4.2 Growth regressions

This thesis's main objective is to test the correlation between ECI for Brazilian states and its impact on per capita growth variation. To estimate such impact, this thesis utilizes a traditional beta-convergence equation, as in Barro and Sala-i-Martin (1996). Due to the nature of the data, a panel set was chosen, as a tool that merges cross-section and time-series analyses.

As explained earlier, neoclassical theory improved from the classical absolute convergence model such as Solow's (1969) and introduced new variables that allow for different stationary states to be tested for different economies. This shows relevance because the overall conditions are very different from country to country and region to region.

According to Almeida and Moreira (2019), one criticism of the Barro and Sala-i-Martin model is that it may end up neglecting non-observable effects or considering them insignificant. To solve for this, the current thesis uses a fixed-effect regression along with the pooled regression model. The fixed effects setting assumes the existence of correlation between the individual observations and the exogenous variables. The time-span chosen for this regression goes from 1997 to 2017, according to the ECI contributions from Herrera (2020). The panel data set is divided into 4

periods (t=4) – each one being 5 years long. Since the effects of the variables' variations aren't immediate, all of them are tested for their lagged effects. The variables are pushed forward one period to estimate their impact over time.

Economic complexity theory, regarding the utilization of ECI, is a relatively new field, with the index being created in 2011. Yet, studies have shown positive correlation between a country's ECI levels and its growth patterns as well as convergence and divergence patterns. This present study applies that same methodology for Brazil's national states, comparing them to one another. Hence, regression results for ECI are expected to be positive, where the increase of complexity leads to an increase of per capita income.

The growth regression model tests for convergence patterns by regressing initial income data against income variation over time. Literature shows that, under certain circumstances, countries and regions that start off at lower wealth levels grow at a faster pace than regions with higher initial incomes. This leads to a converge pattern to a stationary state, specially among similar unities of measurement. For this, per capita income was collected from the Brazilian Institute of Geography and Statistics (IBGE) at 2010 price levels. Expected regression results for this variable are negative, which mean that poorer regions are growing at faster rates than initially richer ones.

To test for control variables, base convergence literature was used. There is strong evidence for the impacts of human capital in economic growth. Also, there are many different proxies for such variable. For this, mean years of education from the population above 25 years-old – variable *educ* – was collected from IPEADATA. Expected result is a positive correlation between increase in years of education and economic growth. Also, the absolute converge hypothesis was tested.

Table 2. Variables, descriptions, and sources

| Variables | Description | Source |
|---|---|---|
| *Growth* (dependent) | Per capita income variation | IBGE |
| *gdp* (independent)<br>*eci* (independent) | Initial per capita value<br>Economic Complexity Index | IBGE<br>Herrera (2020) |
| *educ (control)* | Average years of education | IPEADATA |

The baseline growth equation is described below:

$$Growth = \ln(\frac{Y_{it+T}}{Y_{it+T-5}}) = \beta_0 + \beta_1 \ln[PIB_{it-5}] + \beta_2 [ECI_{it-5}] + \beta_3 \ln[educ_{it-5}] + \in_{it}$$

Where:

*Growth* - is the dependent variable. It is the average per capita GNI five years ahead of the initial time.

*GDP* - is the initial per capita value. It represents the 1997 per capita income level.

*ECI* - is the economic complexity index at period t-5.

*Educ* - is the average years of education of the total population above 25 years old at t-5.

$\in_{it}$ - is the error term.

### 4.3 Descriptive Statistics

For the comparative descriptive analyses data from SIDRA-IBGE, IPEADATA, PNUD, Herrera (2020) and World Bank were utilized. Basic statistical interventions were utilized with Microsoft Excel and the growth regression model was done via R software.

# 5 RESULTS

## 5.1 Descriptive Statistics

Worldwide economic inequality is measured in different ways. Table 2 shows, utilizing the Human Development Index, the 5 highest placed countries in 2020 and Brazil, highlighting life expectancy at birth, expected years of education, mean yeas of education and GNI per capita.

Table 3. HDI rankings for 5 first place countries and Brazil (2020).

| Rank | Country | HDI value | Life expectancy at birth | Expected years of education | Mean years of education | GNI per capita (PPP $) |
|---|---|---|---|---|---|---|
| **1** | Norway | 0.957 | 82.4 | 18.1 | 12.9 | 66.494 |
| **2** | Ireland | 0.955 | 82.3 | 18.7 | 12.7 | 68.371 |
| **3** | Switzerland | 0.949 | 83.8 | 16.3 | 13.4 | 69.394 |
| **4** | Hong Kong | 0.949 | 84.9 | 16.9 | 12.3 | 62.985 |
| **4** | Iceland | 0.949 | 83.0 | 19.1 | 12.8 | 54.682 |
| **84** | Brazil | 0.765 | 75.9 | 15.4 | 8.0 | 14.263 |

Source: PNUD, 2020.

Different rankings and methodologies, as explained in the introductory section, corroborate the unequal nature of economic development under capitalism. However, one of the main arguments presented is that such unequal nature reproduces itself in every level of comparison.

Brazil is a country of continental dimensions. It is composed of 27 states and over 5000 municipalities. Its current population is estimated at over 213 million people. (IBGE, 2021). Inequality among Brazilian states and regions mirrors that between countries, in a structural reproduction of capitalist characteristics. The comparison shows that very different livelihoods can be attained depending on the region observed. Distrito Federal, the administrative capital, shows a nominal household income per capita over three times greater than Alagoas, the poorest and last place state in both income and the Municipal Human Development Index (MHDI). A person born in Bahia has a life expectancy 4.7 years shorter than a citizen of São Paulo state. Table 4 compares 4 Brazilian states according to their HDIM indexes from 2017. It also

shows life expectancy (2017), total years of education and nominal household income per capita in Brazilian-Real (R$) in 2020:

Table 4. Brazilian states ranking for MHDI (2017) and other variables

| **Rank** | **State** | **MHDI** | **Life expectancy (2017)** | **Income per capita** |
|---|---|---|---|---|
| **1** | DF | 0.850 | 78.4 | 2.475,00 |
| **2** | SP | 0.826 | 78.4 | 1.814,00 |
| **21** | Bahia | 0.714 | 73.7 | 965,00 |
| **26** | Alagoas | 0.683 | 72.0 | 796,00 |
| | Brazil | 0.765 | 75.9 | 1.380,00 |

Source: IBGE, Atlas Br, 2020.

Tables 5 and 6 rank the 5 highest ICE by state in 1997 and 2017. During the 20 year period the only change in position was Rio de Janeiro (RJ) that fell in economic complexity out of the top 5 being replaced by Santa Catarina (SC). São Paulo (SP), as expected due to its history of industrial and economic development, was and remains Brazilian state with the highest ICE:

Table 5. Highest ECI for Brazilian states (1997).

| Rank | State | ECI |
|---|---|---|
| 1° | SP | 2,25 |
| 2° | RJ | 1,44 |
| 3° | AM | 1,02 |
| 4° | PR | 0,91 |
| 5° | RS | 0,87 |

Source: Own elaboration using Herrera (2020)

Table 6. Highest ECI for Brazilian states (2017).

| Rank | State | ECI |
|---|---|---|
| 1° | SP | 1,99 |
| 2° | SC | 1,32 |
| 3° | AM | 1,31 |
| 4° | RS | 1,08 |
| 5° | PR | 0,99 |

Source: Own elaboration using Herrera (2020)

Tables 7 and 8 display the 5 lowest ranked Brazilian states in ICE in 1997 and 2017. Three states figure in both lists: Rio Grande do Norte (RN), Pará (PA) and Amapá (AP). In 1997 Roraima (RO) and Acre (AC) made the ranking being replaced by Tocantins (TO) and Piauí (PI) 20 years later. It is important to stress that the five highest placed states in both lists are mostly from the southeast and south regions, except for Amazonas (AM) for its special position as a tax exception zone for industries. Also, the five lowest ranked states in both tables are in the north and northeast regions:

Table 7. 5 lowest ECI for Brazilian states (1997).

| Rank | State | ECI |
|---|---|---|
| 22° | RO | -0,77 |
| 23° | RN | -1,05 |
| 24° | PA | -1,11 |
| 25° | AP | -1,46 |
| 26° | AC | -1,68 |

Source: Own elaboration using Herrera (2020)

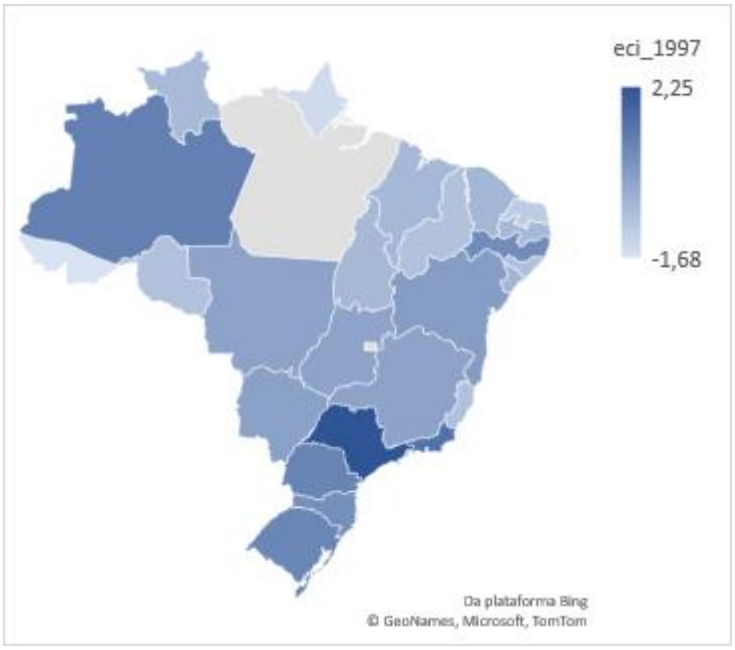
Table 8. 5 lowest ECI for Brazilian states (2017).

| Rank | State | ECI |
|---|---|---|
| 22° | TO | -0,67 |
| 23° | PI | -0,80 |
| 24° | RN | -0,96 |
| 25° | PA | -1,73 |
| 26° | AP | -1,96 |

Source: Own elaboration using Herrera (2020)

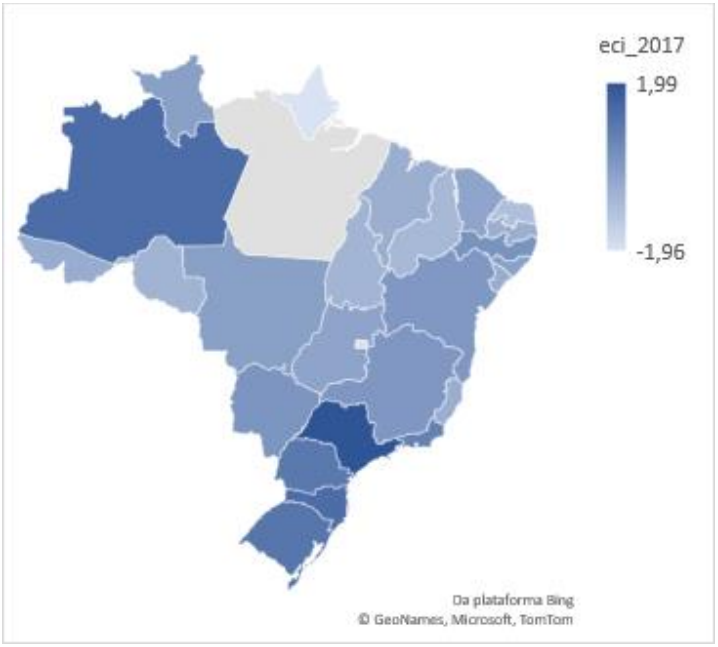
Maps 1 and 2 display a geographical representation of ECI for each state in 1997 and 2017, respectively. The results reinforce the agglomeration tendencies seen in HDMI:

Map 1. ICE per Brazilian State (1997)




Source: Elaborated by the author from Herrera (2020).

Map 2. ECI per Brazilian state (2017)




Source: Elaborated by the author from Herrera (2020).

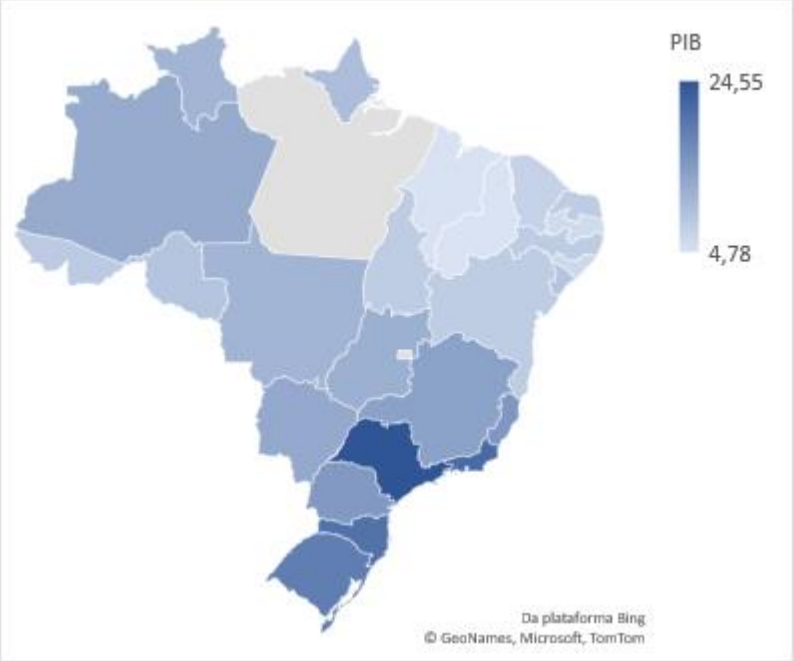
Historically, economic development in Brazil has always been unequal, with the North, Northeast and Midwest regions being significantly less developed than the rest. Results show that, structurally, the overall regional logic of the Brazilian economy has

not changed. When it comes to the complexity of economic production, states that produced more sophisticated goods in 1997 are the same as in 2017. That means Southeast and South region states remain home to more industrial and technological parks, which, in theory, leads to concentration of higher wages and wider supply for services, according to classic agglomeration theories.

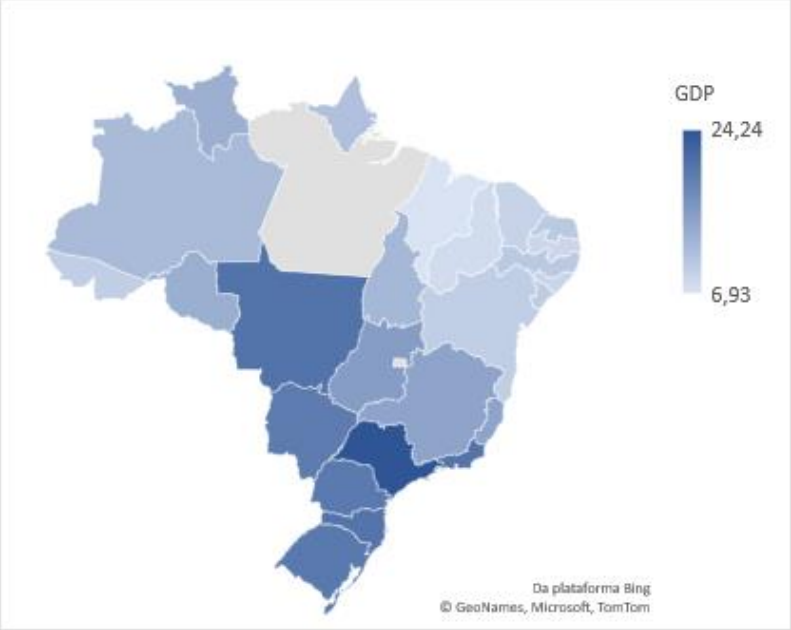
Interesting evidence for such claim is the agribusiness expansion that has taken place in the Midwest region over the past 2 decades. States such as Goiás, Mato Grosso and Mato Grosso do Sul have experienced large investments regarding commodities production such as meat and soy. According to Economic Complexity theorists, such economic endeavor, although high in technological content – international commodity markets are very competitive and costs must be reduced as low as possible – has low spillover effects and low productive connectivity, resulting in low complexity expansion. This is so because agribusiness does not invest in local production of technological goods, such as machinery, instead importing such capital.

Maps 1 and 2 display a geographical visualization of GDP per capita levels for each state in 1997 and 2017:

Map 3. GDP per capita per state (1997)




Map 4. GDP per capita per state (2017)




Source: Elaborated by the author from IPEADATA

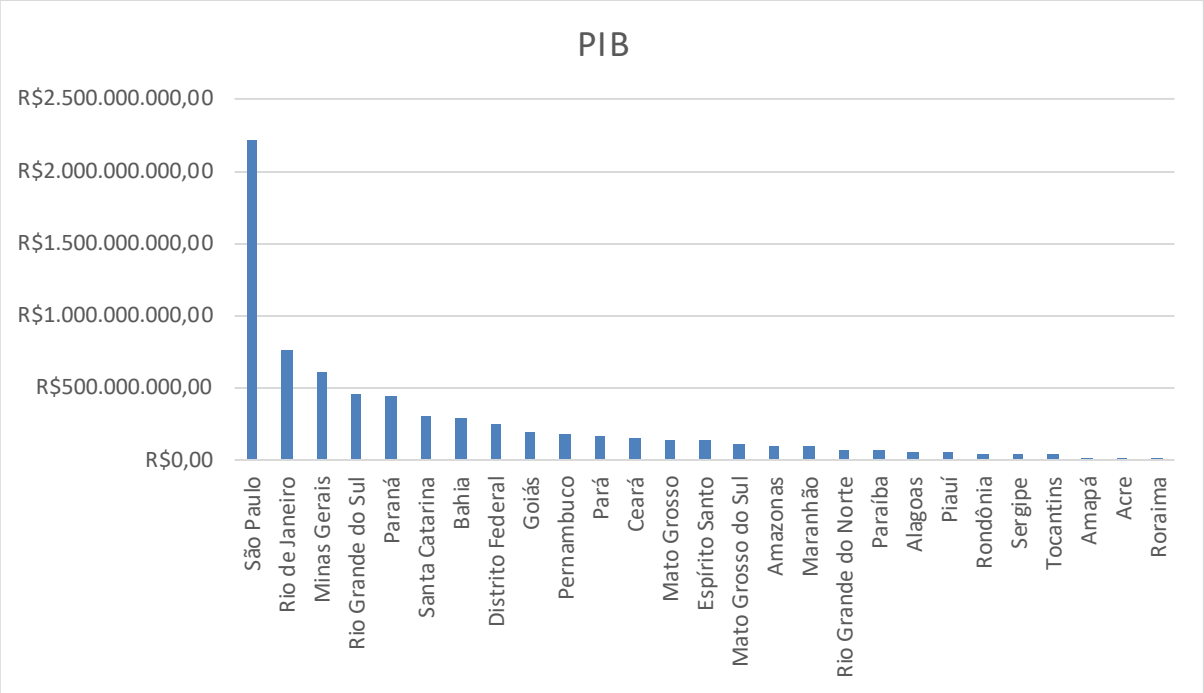
These results show that, although maps 1 and 2 illustrate stagnation when it comes to economic complexity levels, maps 3 and 4 show that per capita income for Midwest States has risen from around R$ 12.000,00 annually in 1997 to around R$ 17.000 in 2017 for the Goiás, Mato Grosso and Mato Grosso do Sul region. This

raises the question: If economic development can be translated as economic growth, isn't agribusiness just as useful as industrial investment? From the structuralist view, no. Because for economic growth to go beyond simple arithmetic, jobs must pay higher wages. If a region produces high income by investing in areas that don't employ many skilled workers, such as agriculture, the results are the creation of a diminished elite with very high purchasing power, whose necessities can be met by importing goods and services. This leads to underdevelopment of local economies even though average per capita income rises. Structuralists defend that income from agribusiness must be converted into other sectors of the economy to promote linkages, production chains, better jobs with higher wages in a sustainable and more spread fashion.

According to the structuralist literature, activities that present more technological innovation, greater increasing returns, greater labor division that generate better linkages and synergies are more efficient at promoting economic development. (REINERT, 2009). Gala et al (2018, p.221) state that "the specialization in agriculture and mining does not allow this type of technological change".

To try in further illustrate such ideas, graphs 1, 2 and 3 are presented. Graph 1 shows the GDP for each Brazilian state in 2018 in Brazilian Reals (thousands). Total national GDP for 2018 was just over R$7 trillion, with São Paulo accounting for R$ 2.2 trillion (31.6%). The 5 richest states combined, São Paulo, Rio de Janeiro, Minas Gerais, Rio Grande do Sul, and Paraná accounted for R$ 4.7 trillion (68.2%). Those five states (plus Espírito Santo) form the Southeast and South axes:

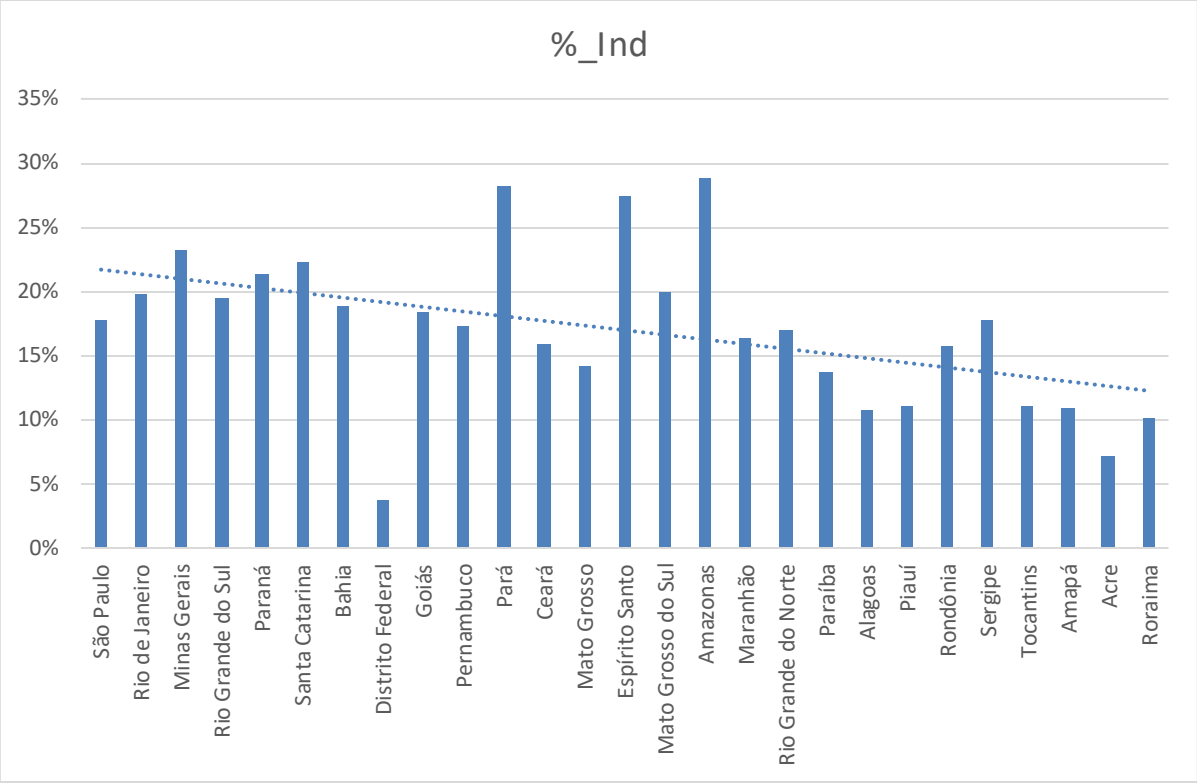
Graph 1. GDP per Brazilian state in Brazilian Real (R$) – thousands (2018).




Source: IBGE

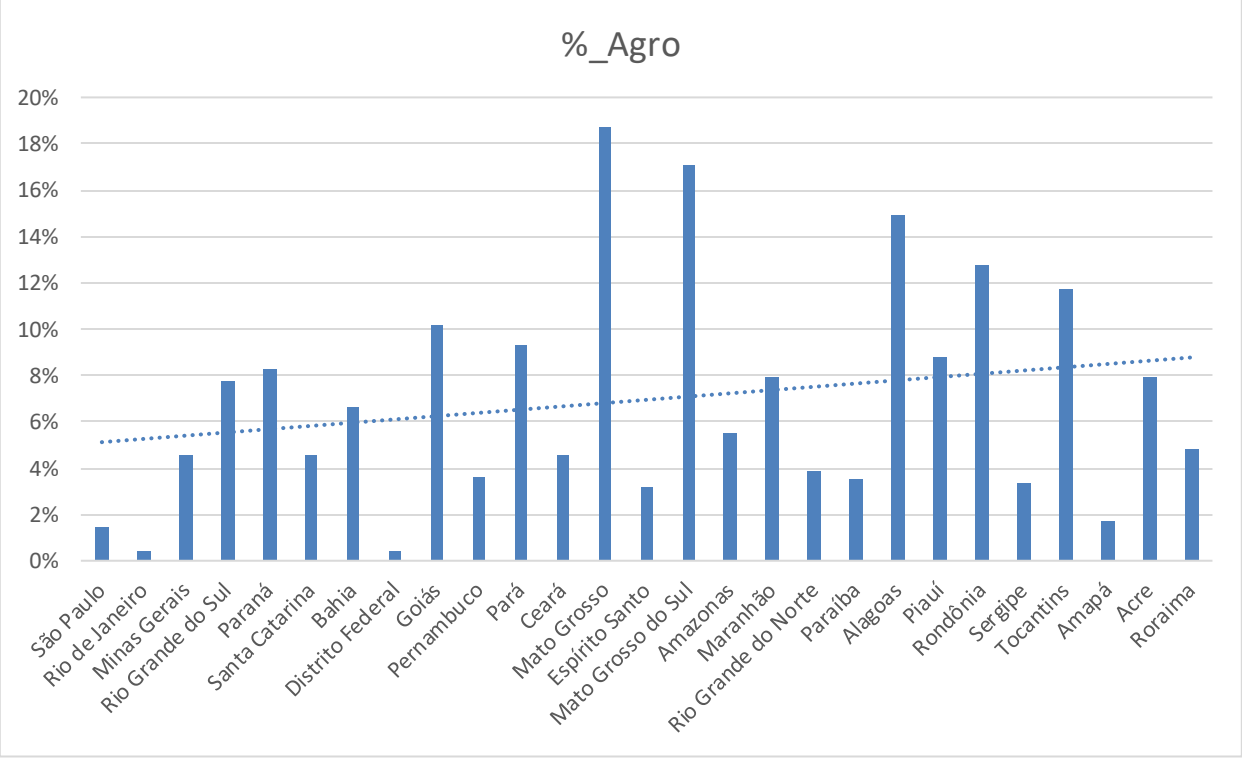
Graphs 2 and 3 display the added value to GDP in percentage for both industry and agriculture. The order of states is maintained equal to graph 1, based on hiher to lower overall GDP.

Graph 2. Participation of industrial activity on overall state GDP (2018) in percentage




Source: IBGE, 2021.

Graph 3. Participation of agricultural activity on overall state GDP (2018) in percentage

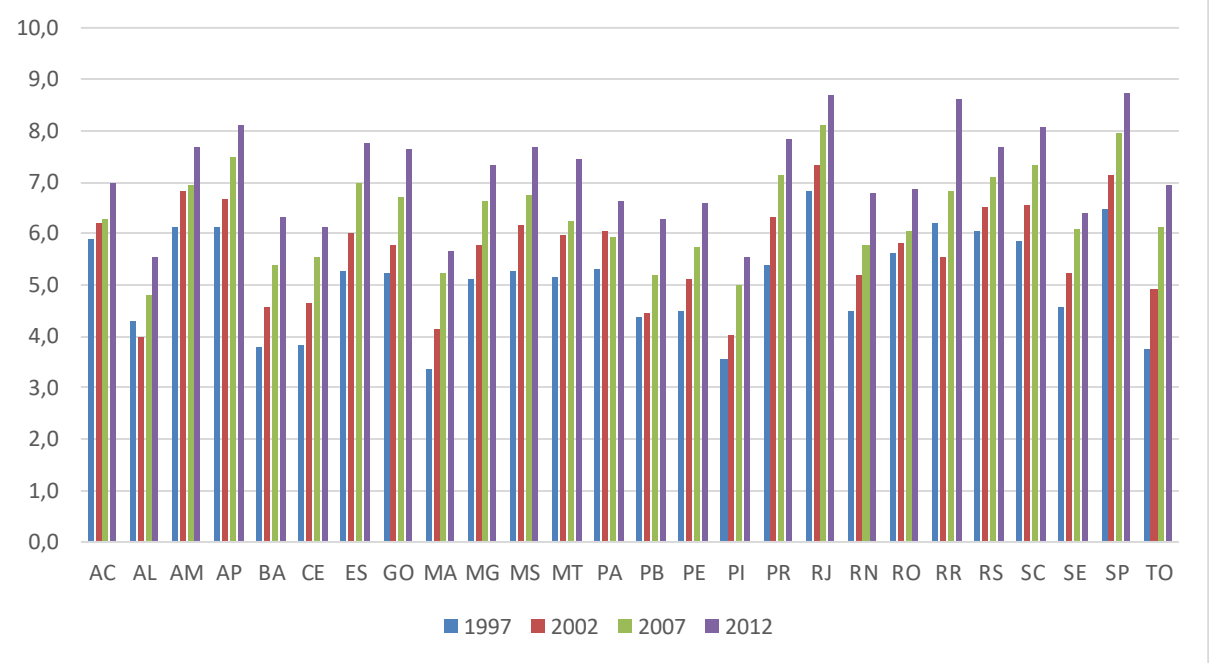



Source: IBGE, 2021.

The tendency lines show that when it comes to the percentage of added value to GDP from industry compared to agriculture, richer states are industry-heavier. Although not an econometric exercise, this observation is corelated to the structuralist premises.

For the human capital proxy, average years of education among population over 25 years of age, from 1997 until 2012, all Brazilian states improved in average years of education:

Graph 4. Average years of education 1997-2012 (population over 25 years old)

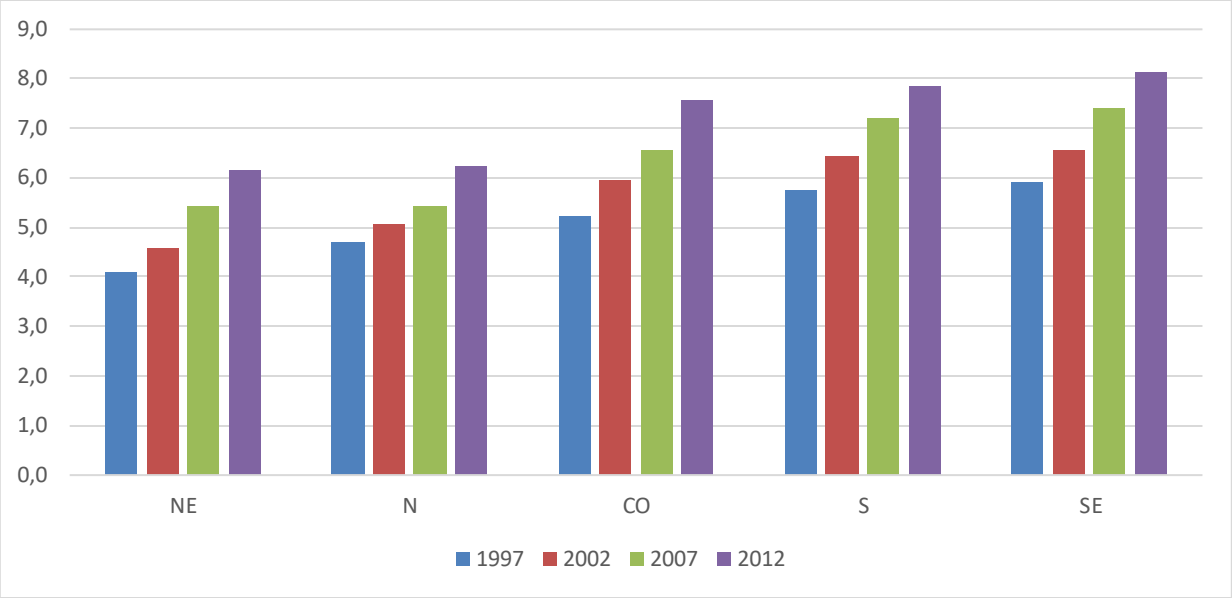



Source: IPEADATA

In 1997, Maranhão was the state with the lowest average number for education, with 3,4 years and Rio de Janeiro was the highest with 6,8. In 2012, Alagoas figured in last place with 5,5 average years of education while Rio tied with São Paulo for the highest at 8,7. In the 15 year interval from 1997 to 2012, Tocantins had the greatest increase, growing from 3,8 to 6,9 average years of education (85%). Meanwhile, Acre had the smallest growth going from 5,9 to 7 average years of education (18%).

When grouped by regions, the traditional unequal characteristic of Brazilian socioeconomic variables repeats itself:

Graph 5. Average years of education by region 1997-2012




Source: IPEADATA

Throughout the time interval, Northeast and North regions show the lowest average years of education, while South and Southeast regions show the highest.

## 5.2 Growth regression results

This thesis' main objective was to test ECI as an argument for economic growth utilizing each Brazilian state as a unity of measurement. Human capital, with average years of education for population above 25 years of age was used as proxy and control variable. Both OLS (pooled) and fixed effect regression models were applied. Results are reported as follows:

Table 9. OLS (pooled-effect) regression including the *ECI*

| Variables | Estimate | Std. Error | t-value | Pr(>\|t\|) |
|---|---|---|---|---|
| Intercept | 1.031987 | 0.049598 | 20.8069 | < 2.2e-16 *** |
| gdp | -0.121967 | 0.023631 | -5.1614 | 0.000001247 *** |
| eci | 0.010280 | 0.007439 | 1.3820 | 0.1700629 |
| educ | 0.161425 | 0.043107 | 3.7447 | 0.0003019 *** |
| R-sq. | 0.22788 | | | |
| R-sq(adjust) | 0.20472 | | | |
| Prob(F-stat) | 0.00000 | | | |

Note: *** coefficient significant at 1% level

The OLS growth regression shows the usual result for the initial gdp level coefficient and the human capital proxy. The initial gdp level coefficient is negative and statistically significant, confirming the conditional convergence hypothesis. The initial level of the human capital coefficient is positive and statistically significant, showing a positive impact of the average years of education on the economic growth process. Last, the ECI does not show a statistically significant impact on economic growth for this data set. One possible reason for that is the presence of an individual-specific effect affecting the error term and, consequently, all the coefficients. The usual way to deal with this is by running a fixed effect estimator. Next, the fixed effect growth regression outcomes are reported.

Table 10. Fixed-effect regression including the *ECI*

| Variables | Estimate | Std. Error | t-value | Pr(>\|t\|) |
|---|---|---|---|---|
| gdp | -0.4633435 | 0.0458853 | -10.0979 | 1.252e-15 *** |
| eci | -0.0092805 | 0.0118349 | -0.7842 | 0.4354 |
| educ | 0.3758383 | 0.0435386 | 8.6323 | 7.458e-13 *** |
| R-sq. | 0.58663 | | | |
| R-sq(adjust) | 0.4323 | | | |
| Prob(F-stat) | 0.00000 | | | |

Note: *** coefficient significant at 1% level

The fixed-effect results corroborate OLS for both gdp and human capital. Coefficient for initial gdp is negative and statistically significant. Coefficient for human capital (*educ*) is positive and statistically significant. This shows that states with lower income per capital levels grow at faster rates than higher ones and shows positive impact on income per capita growth caused by higher educational levels.

The main variable tested, ECI, showed no statistical significance and the correlation between per capita growth and increased ECI was negative even when the fixed-effect regression was used. It is important to notice that there are many possible explanations for such results. ECI is an index meant to account for the complexity of productive capabilities of countries. Export data is the key component for the RCA, and such flow is better measured for countries. Different authors have adapted the index for regional and intranational levels, but that adaptation might cause loss of information when it comes to intranational trade that export data does not capture.

Literature for ECI in general is relatively new and scarce. There are results showing significance for correlation to per capita income growth at national levels and this thesis contribution was to replicate such techniques at intranational levels. The premise that more complex activities generate more externalities, better and more efficient jobs and income is very reasonably sound. However, Brazil has been victim of a phenomenon some scholars, such as José Luis Oreiro and Bresser-Pereira, call a *precocious deindustrialization*. This mean that the economy begins shifting toward services-based activities before fully developing its industrial park in a globally competitive form. Table 10 shows the 20 year span for ECI ranked from highest to lowest from 1997 original order. It shows that many states, such as SP, RJ, PE, BA have lost complexity comparatively:

Table 11. ECI by state from highest to lowest 1997-2017 (1997 rankings).

| UF | 1997 | 2000 | 2005 | 2010 | 2015 | 2017 |
|---|---|---|---|---|---|---|
| SP | 2,25 | 2,08 | 2,01 | 1,81 | 1,73 | 1,99 |
| RJ | 1,44 | 1,28 | 1,44 | 0,95 | 0,80 | 0,73 |
| AM | 1,02 | 1,19 | 0,83 | 1,00 | 1,16 | 1,31 |
| PR | 0,91 | 0,77 | 0,87 | 1,13 | 0,71 | 0,99 |
| RS | 0,87 | 0,79 | 1,14 | 1,35 | 0,93 | 1,08 |
| PE | 0,70 | -0,27 | -0,10 | 0,01 | 0,47 | 0,25 |
| SC | 0,63 | 0,58 | 0,93 | 1,17 | 1,22 | 1,32 |
| BA | 0,25 | -0,25 | -0,43 | -0,18 | -0,20 | 0,12 |
| MS | 0,15 | 0,12 | 0,00 | 0,27 | 0,16 | 0,19 |

| | | | | | | |
|---|---|---|---|---|---|---|
| MG | 0,08 | 0,36 | -0,08 | -0,27 | 0,29 | 0,14 |
| MT | 0,08 | -0,12 | -0,89 | -0,72 | -1,15 | -0,09 |
| GO | 0,05 | 0,18 | -0,35 | -0,32 | -0,70 | -0,21 |
| SE | -0,44 | -0,54 | -0,36 | -0,44 | -0,42 | -0,47 |
| CE | -0,46 | -0,48 | -0,26 | -0,20 | -0,57 | -0,24 |
| MA | -0,51 | -0,50 | -1,21 | -0,86 | -1,24 | -0,52 |
| PB | -0,51 | -0,02 | -0,59 | -0,53 | -1,00 | -0,52 |
| TO | -0,53 | 0,69 | 0,37 | 0,54 | -0,74 | -0,67 |
| RR | -0,56 | -0,84 | 0,34 | -0,98 | 0,29 | -0,09 |
| AL | -0,71 | -1,12 | -0,09 | -0,46 | 1,22 | -0,12 |
| ES | -0,74 | -0,90 | -0,59 | -0,90 | -0,70 | -0,49 |
| PI | -0,76 | -0,45 | -0,81 | -1,27 | -0,04 | -0,80 |
| RO | -0,77 | -0,46 | -0,69 | -0,40 | -0,31 | -0,65 |
| RN | -1,05 | -0,98 | -0,71 | -0,96 | -1,22 | -0,96 |
| PA | -1,11 | -1,23 | -1,21 | -1,56 | -1,51 | -1,73 |
| AP | -1,46 | -2,02 | -1,87 | -1,51 | -1,33 | -1,96 |
| AC | -1,68 | -1,12 | -0,87 | 0,36 | -0,44 | -0,46 |

Source: Made by author from Herrera (2020).

Although some states have gained complexity, such as SC and AM, others have remained almost stationary. The adapted index compares states to one another but utilizing the international trade data and classification from the original Atlas of Complexity, which mean that states such as SP have lost economic complexity.

Socioeconomic analyses show Brazil as a typical unequal country with explicit disparities between regions. Economic complexity index follows that same structural pattern, being higher for states in the South and Southeast regions. Although states often do compete when attracting new business with fiscal incentives and specific laws in a similar way countries do, there might me too many nuances and hidden factors that ECI alone isn't able to grasp when accounting for economic growth at intranational levels. Further investigation with refined modelling and a microeconomic disaggregated approach might be able to further understand the role of economic complexity at intranational levels regarding economic growth.

Utilizing the ECI from Herrera (2020) and testing for income per capita variation for Brazilian states from 1997 to 2017, economic complexity does not show statistical relevance as an explanatory variable.

## 5.3 Growth regression and human capital

In this section, ECI was removed as an explanatory variable and only human capital (*educ*) was included. The sign for beta was expected to be positive, with the increase in average education being directly correlated to higher gdp per capita.

Table 12. OLS (pooled-effect) regression including *educ*

| Variables | Estimate | Std. Error | t-value | Pr(>\|t\|) |
|---|---|---|---|---|
| Intercept | 1.012915 | 0.047854 | 21.1669 | < 2.2e-16 *** |
| gdp | -0.105359 | 0.020438 | -5.1551 | 0.000001264*** |
| educ | 0.149045 | 0.042355 | 3.5189 | 0.0006513 *** |
| R-sq. | 0.21313 | | | |
| R-sq(adjust) | 0.19755 | | | |
| Prob(F-stat) | 0.00000 | | | |

Note: *** coefficient significant at 1% level

OLS model shows expected results for *gdp* and *educ*. Coefficient for initial income (*gdp*) is negative and statistically significant. Coefficient for human capital (educ) is positive and statistically significant. This means states with lower initial per capita income grow at faster rates than higher ones. Also, educational levels have positive impact on economic growth.

Table13. Fixed-effect regression including *educ*

| Variables | Estimate | Std. Error | t-value | Pr(>\|t\|) |
|---|---|---|---|---|
| gdp | -0.462262 | 0.045748 | -10.1045 | 1.053e-15 *** |
| educ | 0.374768 | 0.043407 | 8.6339 | 6.714e-13*** |
| R-sq. | 0.58324 | | | |
| R-sq(adjust) | 0.43518 | | | |
| Prob(F-stat) | 0.00000 | | | |

Note: *** coefficient significant at 1% level

The fixed-effect test corroborates both the literature and OLS testing. Human capital shows statistical significance and positive correlation to economic growth and coefficient for initial per capita income is negative and statistically significant.

## 5.4 Absolute Convergence

Absolute convergence tests for the theoretical premise that units with lower initial income levels grow at faster rates over time than ones with higher initial income levels. With no control or other explanatory variables, beta sign is expected to be negative. Since Brazilian states can be seen as similar units of measurement, absolute convergence is expected to be true.

Table 13. OLS (pooled-effect) regression for absolute convergence

| Variables | Estimate | Std. Error | t-value | Pr(>\|t\|) |
|---|---|---|---|---|
| Intercept | 1.142150 | 0.032345 | 35.3114 | < 2.2e-16 *** |
| gdp | -0.048673 | 0.013261 | -3.6703 | 0.0003875*** |
| R-sq. | 0.11666 | | | |
| R-sq(adjust) | 0.108 | | | |
| Prob(F-stat) | 0.00030 | | | |

Note: *** coefficient significant at 1% level

OLS results show absolute converge between states as coefficient for initial per capita income is negative and statistically significant.

Table14. Fixed-effect regression for absolute convergence

| Variables | Estimate | Std. Error | t-value | Pr(>\|t\|) |
|---|---|---|---|---|
| gdp | -0.181502 | 0.044993 | -4.034 | 0.0001282 *** |
| R-sq. | 0.17446 | | | |
| R-sq(adjust) | -0.10429 | | | |
| Prob(F-stat) | 0.00012 | | | |

Note: *** coefficient significant at 1% level

Fixed-effect results for absolute convergence confirm that states with lower initial income are growing faster than richer ones at statistically significant levels. Results are coherent to the economic convergence literature.

## 6. CLOSING REMARKS

Structuralism is a classical school of thought that has offered many contributions to the economic development debate over the past decades. Its criticism of neoclassical interpretation of social phenomena has led to many advances in both theoretical and practical ways. It is important, when investigating social issues, to account for approaches that incorporate critical thinking and offer multidisciplinary views. The key theorical inquiry that sustains this thesis – inequality of economic development – is a complex topic that can only gain from the conflation of different points of views and methodological approaches.

Brazil, as exemplified by the data collected, figures as a peripherical economy whose productive structure is still heavily based on commodity exports and low complexity goods and services. Although some industrialization progress took place over middle decades of the past century, income has not risen to the developed countries levels. When investigated at intranational levels, inequality between states is also historically strong and has remained so, with clear regional discrepancies that seem to prevail.

Economic complexity theory states the level of productive sophistication and efficiency is the key aspect when going from a peripherical underveloped economy, to a richer central one. Thus, the economic complexity index is a useful tool to understand and intervene in this process - that cannot be attained via market freedom and other liberal values - for inequality is structural. Results in the area are relatively new and mainly focused on countries, but some attempts to adapt the index to regional and intranational levels have taken place.

Results for ECI as an argument for economic growth between Brazilian states did not show significance which leads to many possible explanations. Further investigation, as well as refined modeling, could help understand what the main variables responsible for economic growth for Brazilian states between 1997 and 2017 are, alongside human capital that have led to the convergence patterns observed.

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