Received on March 21, 2018 / **Approved on** July 02, 2019
Responsible Editor: Priscila Rezende da Costa
Evaluation Process: Double Blind Review
e-ISSN: 2318-9975

doi> https://doi.org/105585/iji.v8i1.303

EFFECTS OF INNOVATION AND SOCIAL CAPITAL ON ECONOMIC GROWTH: EMPIRICAL EVIDENCE FOR THE BRAZILIAN CASE

[1]João Gabriel Pio

ABSTRACT

Objective of the study: The main objective of this paper is to analyze the influence of innovative activities on the economic performance of Brazilian states. Given the importance of cooperation and collaborative networks for increasing productivity, the effects of social capital are analyzed in a complementary way.

Methodology/Approach: With a database composed of 297 observations analyzed from 2000 to 2010 for each federation unit, including the Federal District, this work uses the traditional panel and dynamic panel data method to measure the impact of innovation in GDP.

Originality/Relevance: The use of a theoretical model of growth decomposition, which includes variables such as social capital, human capital and natural capital, and the use of data with higher level of disaggregation, at the state level, presents methodological and empirical advances for Brazilian innovation literature.

Main results: The results found point to a significant and positive effect of social capital and to the non-significance of the technological variable. Moreover, as evidenced by the literature, human capital is the main factor of increase of the Brazilian product.

Theoretical/Methodological contributions: Regarding the theoretical aspects, the evidences, mainly, of the social capital show that the cooperation networks exert influence on the performance of the productive activities of the country.

Social/Management contributions: Identifying the results of innovative activities is of paramount importance to policymakers as they can use this information to create new measures and / or to redirect existing technology policies.

Keywords: Economic growth. Innovation. Panel data.

Cite it like this:

Pio, J. (2020). Effects of innovation and social capital on economic growth: empirical evidence for the brazilian case. International Journal Of Innovation, 8(1), 40-58. http://dx.doi.org/10.5585/iji.v8i1.303.

[1]*Mestre em Economia Aplicada pela Universidade Federal de São Carlos; Doutorando em Economia pela Universidade Federal de Juiz de Fora - MG, Brasil. jpiogabriel@gmail.com.*

EFEITOS DA INOVAÇÃO E DO CAPITAL SOCIAL NO CRESCIMENTO ECONÔMICO: EVIDÊNCIAS EMPÍRICAS PARA O CASO BRASILEIRO

RESUMO

Objetivo do estudo: O principal objetivo desse trabalho é analisar a influência das atividades inovativas no desempenho econômico dos estados brasileiros. Dada a importância das cooperações e das redes de colaborações para o aumento da produtividade, de forma complementar, são analisados os efeitos do capital social.

Metodologia/Abordagem: Com uma base de dados composta por 297 observações analisadas no período de 2000 a 2010 para cada unidade da federação, incluindo o Distrito Federal, este trabalho utiliza-se do método de dados em painel tradicional e painel dinâmico para mensurar o impacto da inovação no PIB.

Originalidade/Relevância: A utilização de um modelo teórico de decomposição do crescimento, no qual inclui variáveis como capital social, capital humano e capital natural, e a utilização de dados com maior nível de desagregado, ao nível estadual, apresentam avanços metodológicos e empíricos para literatura brasileira de inovação.

Principais resultados: Os resultados encontrados apontam para um efeito significativo e positivo do capital social e para a não significância da variável tecnológica. Além disso, conforme evidenciado pela literatura, o capital humano constitui-se o principal fator de aumento do produto brasileiro.

Contribuições teóricas/Metodológicas: No que tange aos aspectos teóricos, as evidências, principalmente, do capital social mostram que as redes de cooperação exercem influência no desempenho das atividades produtivas do país.

Contribuições sociais/para gestão: Identificar os resultados das atividades inovativas é de suma importância para os formuladores de políticas públicas, uma vez que podem utilizar essas informações para criação de novas medidas e/ou para o redirecionamento das políticas tecnológicas existentes.

Palavras-chave: Crescimento econômico. Inovação. Dados em painel.

EFECTOS DE LA INNOVACIÓN Y EL CAPITAL SOCIAL SOBRE EL CRECIMIENTO ECONÓMICO: EVIDENCIA EMPÍRICA PARA EL CASO BRASILEÑO

RESUMEN

Objetivo del estudio: El objetivo principal de este trabajo es analizar la influencia de las actividades innovadoras en el desempeño económico de los estados brasileños. Dada la importancia de las cooperaciones y las redes de colaboración para aumentar la productividad, los efectos del capital social se analizan de forma complementaria.

Metodología/Enfoque: Con una base de datos compuesta por 297 observaciones analizadas entre 2000 y 2010 para cada unidad de la federación, incluido el Distrito Federal, este trabajo utiliza el método tradicional de datos de panel y panel dinámico para medir el impacto de la innovación en el PIB.

Originalidad/Relevancia: El uso de un modelo teórico de descomposición del crecimiento, que incluye variables como el capital social, el capital humano y el capital natural, y el uso

de datos con un mayor nivel de desagregación, a nivel estatal, presenta avances metodológicos y empíricos para Literatura brasileña de innovación.

Resultados principales: Los resultados encontrados apuntan a un efecto significativo y positivo del capital social y a la falta de importancia de la variable tecnológica. Además, como lo demuestra la literatura, el capital humano es el principal factor de aumento del producto brasileño.

Contribuciones teóricas/Metodológicas: en cuanto a los aspectos teóricos, las evidencias, principalmente, del capital social muestran que las redes de cooperación ejercen influencia en el desempeño de las actividades productivas del país.

Contribuciones sociales/de gestión: identificar los resultados de las actividades innovadoras es de suma importancia para los responsables políticos, ya que pueden utilizar esta información para crear nuevas medidas y / o redirigir las políticas tecnológicas existentes.

Palabras clave: Crecimiento económico. Innovación. Panel de datos.

1 Introduction

A survey conducted in 2009 by the Organization for Economic Co-operation and Development (OECD) showed that the countries with the best economic performance are those that efficiently develop and manage knowledge. These countries use knowledge to implement innovations, which provide technological advances capable of boosting the economy, generating growth and economic development.

In this sense, the literature on economic growth since Solow (1956) has shown that technological progress is the fundamental element for the performance of nations and for determining different income levels between regions. However, only from the works of Romer (1986) and Lucas (1988) has the effect of technological change been endogenously specified in theoretical and empirical models. In these models, the stock of human capital represents an indicator of accumulated knowledge and learning-by-doing experience, whose externalities result in increasing returns in aggregate economy (Romer, 1986; Lucas, 1988). Thus, authors such as Mankiw, Romer and Weil (1992), Becker, Murphy and Tamura (1990), Rebelo (1991), Lau, Jamison, Liu and Rivkin. (1993), Barro and Lee (1993) and Martín and Herranz (2004) seek to verify the influence of human capital on the economic growth of countries.

It is from this perspective that in the late 1980s works such as those by Reinganum (1989), Romer (1990) and Aghion and Howitt (1992) began to emphasize research, patents and the development of new technologies as drivers of economic growth. that is, greater emphasis is given to the effort to innovate in endogenous growth models.

Thus, recognizing the importance of innovation for growth and development, governments of various countries have been making efforts, through public policies, to intensify the promotion of knowledge and innovation. In Brazil, a number of important legislative measures for technological development were carried out in the early 2000s, such as the Green and Yellow Fund Grant Law (2001), the Innovation Law (2004) and the Good Law (2005), all with the goal of stimulating R&D and promoting innovation. Thus, in the period from 2000 to 2013, national R&D expenditure went from R$ 34.6 billion (1.04% of GDP) to R$ 63.7 billion (1.24% of GDP), placing Brazil as the one of the countries that most conducts R&D through tax incentives, ahead of developed countries like Norway, South Korea and Denmark (OECD, 2017).

Over the past decade, Brazil has made great strides in creating a more suitable institutional apparatus for stimulating innovation. After all, the creation of institutional arrangements capable of supporting different stages of R&D and innovation design has boosted R&D in the country. It now remains to assess whether the innovative effort expended has had an effect on product terms. And it is in this aspect that this research has its greatest contribution to the empirical analysis on the determinants of Brazilian economic growth. Thus, the main objective of this paper is to analyze the influence of innovation on the economic performance of Brazil from 2000 to 2010.

Moreover, another variable that has gained importance as a relevant aspect in explaining economic growth and regional differences is social capital (Bourdieu 1986; Coleman 1994; Putnam 1996). Overall, social capital is an important element that can generate higher levels of productive efficiency through cooperation between individuals. Thus, as a complementary objective, the contribution of social capital in economic performance is also analyzed.

Therefore, the two central hypotheses that are analyzed in this research can be summarized in:

H1: Innovation in Brazil has positive effects on economic performance.

H2: Social capital positively affects Brazilian economic growth.

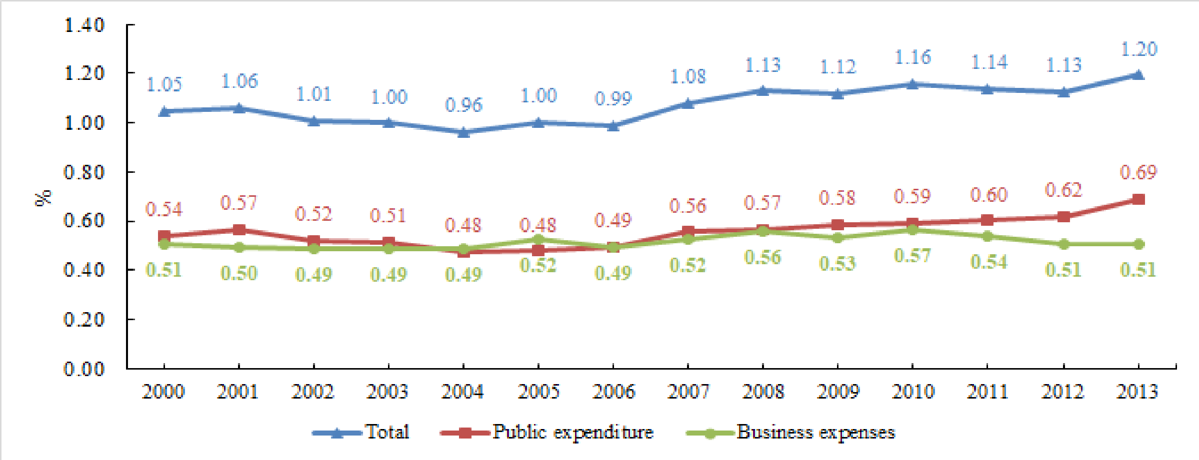
In addition to this introduction, the article contains five more sections. The second section presents the main devices created to expand innovation in Brazil. The third section presents a brief literature review on economic growth. In the fourth section is performed the methodological procedure, the empirical specification of the model and the description of the database. While in the fifth section are presented the results and robustness tests. Finally, in the sixth section the conclusions are drawn.

2 Brazilian innovative environment

Investment in R&D is a key factor in the development of new technologies that generate innovations that leverage long-term economic growth. Incentives for innovation have been improved in Brazil, especially since the 2000s. With this, a series of legislative measures were implemented to boost the Brazilian innovative environment, such as: Green and Yellow Fund Grant Law (2001), Innovation Law (2004) and Lei do Bem (2005), both aimed at stimulating R&D and promoting innovation.

As a result of public incentives, R&D in Brazil has increased over the past decade. Figure 1 shows national R&D expenditure as a proportion of GDP, separated by expenditure by the private sector and the public sector for the period 2000-2013. Total expenditure has been increased from 1.04% of GDP by 2000 to 1.24% in 2013, of which 0.50% and 0.52% respectively were made by the private sector. Public spending as a proportion of GDP was higher than private spending, although both grew at close rates until 2008, when the public surpassed it, reaching 0.71% of GDP in 2013.

Figure 1 - National expenditure on research and development (R&D) in relation to gross domestic product (GDP) by sector, 2000-2013

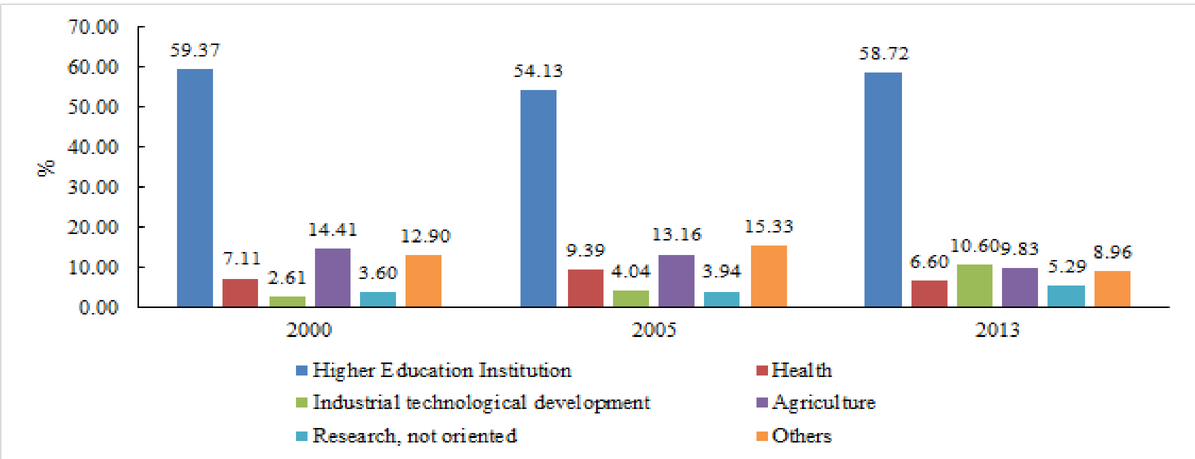


Source: Own elaboration based on data from the Ministry of Science, Technology, Innovations and Communications.

According to Pacheco (2011), the R&D public expenditure indicator expresses a country's effort in the early stages of research and, later, in the stages of technological development. This is because the government is able to make risky investments that have no short-term returns. Thus, these expenditures can create a structure capable of improving the efficiency of private R&D investments.

In this sense, Figure 2 shows the distribution of public R&D expenditure by socioeconomic objective for the years 2000, 2005 and 2013. It is observed that despite the high government spending on R&D, this expenditure is concentrated in a few areas. Most of it goes to higher education institutions, with more than 56% of total spending for all periods analyzed. A significant portion is also earmarked for sectors such as agriculture and non-area-oriented research, both close to 11% for each year examined. These data highlight the government's concern to build an environment that strengthens relations between universities and research institutions with the private sector to create an institutional framework that will allow for greater efficiency in private R&D investments.

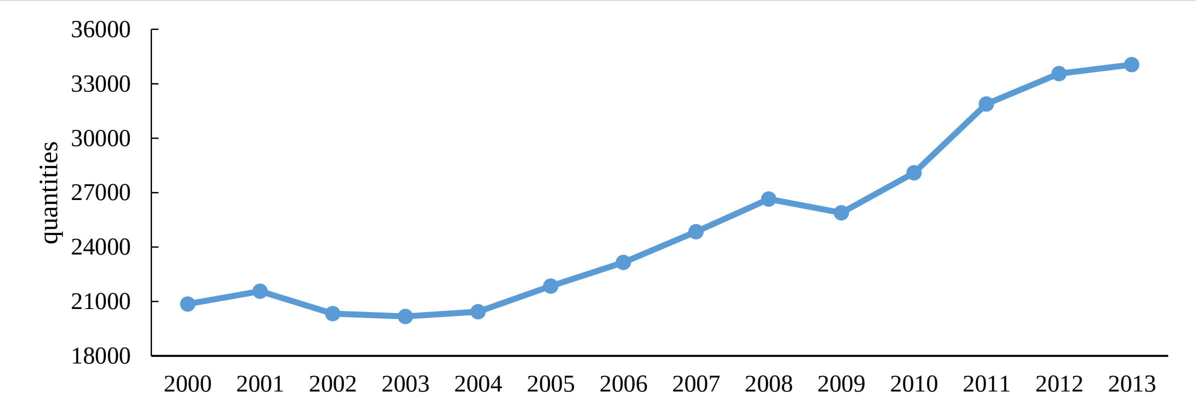
Figure 2 - Distribution of public expenditure on research and development (R&D) by socioeconomic objective (2000, 2005 and 2013)



Source: Own elaboration based on data from the Ministry of Science, Technology, Innovations and Communications.

In addition, as shown in Figure 3, total patent applications filed with the National Institute of Industrial Property (INPI) increased by 68% from 2000 to 2013, from around 20,000 to 34,000 applications. Considering the process of innovation in strict form, the patent is a measure of innovation product and, therefore, a reading of the expansion potential of the production function frontier (GRILICHES, 1998). In this way, the patent can be seen as a demonstration of the successful achievement of R&D.

Figure 3 - Total patent applications filed 2000-2013



Source: Own elaboration based on data from the Ministry of Science, Technology, Innovations and Communications.

Another important aspect for consolidating a thriving environment for innovation is the level of education of the population. There is an intuitive logic between education and innovation, as it is qualified people who are responsible for developing new technologies in the modern economy (Mykhailyshyn, Kondur & Serman, 2018). Thus, the effort for a country to achieve innovation requires a great stimulus for talent development, which can only be done through education. According to data from the Institute of Applied Economic Research (IPEA), the average years of schooling of Brazilians in 2000 was 5.5 and increased to 6.9 in 2010. In addition, expenses with education and culture went from 63 billion reais to 78 billion in the same period.

In the matter specified above, it is worth highlighting, as pointed out by Silva and Dagnino (2008) and Rezende, Corrêa and Daniel (2013), the innovation in Brazil, which results in patent, has its research carried out, mostly, in public universities. Thus, investments in education and training of qualified professionals are important for the Brazilian innovation process. In this sense, since Brazil intensified its efforts to innovate, from 2000 to 2010, it is expected that the product of this effort contributed to the economic performance in the country.

3 Literature review

Until the mid-1950s, the conception of the factors explaining economic growth was consolidated in the classical studies of economics (Smith, 1776; Ricardo, 1817), which considered that growth was due solely to productive factors, such as natural resources. capital and labor in each country or region (Solow, 1956). However, with the evolution of studies related to economic growth, other factors began to be considered as fundamental elements to explain economic performance, such as: human capital, social capital and innovation.

From the works of Romer (1986) and Lucas (1988), endogenous growth models emerge, whose objective is to explain technological progress, giving greater contribution to human capital in determining economic growth. The fundamental interpretation of these models is that technological variation and new knowledge play a central role in the process of capital accumulation and growth.

From this perspective, the central argument contained in endogenous growth models is that investment in physical and human capital generates positive externalities (spillovers) that expand the productive capacity of companies (Marinho & Bittencourt, 2007). That is, investments made by one company can be transferred to another. Thus, physical and human capital stocks represent an indicator of accumulated knowledge and learning-by-doing experience, whose externalities would result in increasing returns in terms of the aggregate economy (Romer, 1986; Lucas, 1988).

In addition, authors such as Mankiw, Romer and Weil (1992), Becker, Murphy and Tamura (1990), Rebelo (1991), Lau *et al*. (1993), Barro and Lee (1993) and Martín and Herranz (2004) seek to verify the influence of human capital on the economic growth of countries. These authors argue that investments should be made not only in physical capital but also in the formation and accumulation of human capital.

Thus, with the increasing advancement of research and development of new technologies, works such as Reinganum (1989), Segerstrom, Anant and Dinopoulos (1990) and Aghion and Howitt (1992) try to incorporate research and innovation as fundamental elements for determine economic growth.

On the other hand, the models developed by Segerstrom, Anant and Dinopoulos (1990), Aghion and Howitt (1992), Aghion, Howitt, Brant-Collett and García-Peñalosa. (1998), Klette and Kortum (2004) and Lentz and Mortensen (2008), also known as Schumpeterian models of endogenous growth, consider technical progress (innovations) in explaining economic growth. In general, these models seek to incorporate innovation as a fundamental element for economic performance and, consequently, to explain the different income levels between countries.

Another variable that has gained importance as a relevant aspect for determining economic growth and explaining regional differences is social capital. This variable affects growth through several ways: i) sustainable network of personal relationships of mutual familiarity (Bourdieu, 1986); ii) socio-structural resources that constitute an asset for the individual, which facilitates the actions of personal and business agents within the structure (Coleman, 1994); iii) civic traditions, effective regional governments and existing forms of social organization (Putnam, 1996). In general, social capital is an important element that can generate higher levels of productive efficiency, as it provides cooperation among individuals, facilitating coordinated actions (Viana & de Lima, 2011).

That said, several factors are important for determining economic growth, such as physical capital, labor, human capital, innovation, and social capital. The literature, in general, has been exploring each of these factors and assessing their importance, both for determining economic performance and for explaining different income levels across countries and regions. Therefore, one of the contributions of this research is to try to explain the economic growth of the Brazilian states, using a methodology that incorporates these elements.

4 Methodological procedure and database

4.1 Empirical model

The methodological procedure adopted in this research starts from the empirical specification approached by Romer (1986, 1990), Lau and Yotopoulos (1989), Aghion and Howitt (1992), Aghion *et al*. (1998), Lau *et al*. (1993) and Lentz and Mortensen (2008). In general, these works seek to analyze the determinants of GDP, making use of the following variables:

$$Y_{it} = F(Y_{it-1}, L_{it}, K_{it}, H_{it}, INO_{it}, CS_{it}, CN_{it}), \quad \text{i, t} = 1, \ldots, \text{n} \qquad (1)$$

On what Y_{it}, $L_{it}, K_{it}, H_{it}, INO_{it}, CS_{it}, CN_{it}$ represent product, labor, physical capital, human capital, innovation, social capital and natural capital, respectively.

As the data set used is a panel, combining time series and cross-section observations over time periods, it is possible to apply the traditional methodology (e.g., fixed or random effect methods). However, traditional procedures for estimating panel data models are well known in the literature because they are not suitable for estimating models involving dynamics, which in this case is corroborated by the empirical specification due to the endogeneity problem (Forbes, 2000; Levine, Loayza & Beck, 2000; Shioji, 2001).

Two methodological procedures have been used to solve the endogeneity problem: 1) The first difference Generalized Moments Method (GMM) proposed by Arellano and Bond (1991); 2) the System - GMM developed by Arellano and Bover (1995) and Blundell and Bond (1998).

In both methods, the main premise regarding the error term is given by;

$$u_{it} = \mu_i + v_{it}$$

$$onde\ \mu_i \sim IID(0, \sigma_\mu^2)\ e\ v_{it} \sim IID(0, \sigma_v^2)$$

Where *i* refers to the states and *t* to the time period. The term μ_i is the individual, time-invariant fixed effects, while v_{it} represents the state-specific shocks that vary over time, being heteroscedastic and time-correlated among individuals, but not between individuals. Thus, it is assumed that

$$E(\mu_i) = E(v_{it}) = E(\mu_i v_{it})$$

$$E(v_{it} v_{i's}) = 0\ \forall\ i, i', t, s\ com\ \ i \neq i'$$

These assumptions would imply momentary constraints that are sufficient to consistently identify and estimate DPD models (Blundell & Bond, 1998).

The difference between the methods occurs since the first difference GMM estimator instrumentalizes the difference explanatory variables that are not strictly exogenous with their available level lags. However, in this estimator, lags in available levels may be weak instruments for non-strictly exogenous variables (Arellano & Bover, 1995).

In this sense, Arellano and Bover (1995) and Blundell and Bond (1998), aiming to solve the problem of weak instrumentalization, developed the System GMM, which adds to the GMM in difference the original level equation, thus increasing the efficiency due to the presence of more instruments.

Based on the specification of the DPD model and the general purpose of this research, two models are estimated;

$$lny_{it} = \beta_k lnk_{it} + \beta_h lnh_{it} + \beta_{ino} lnino_{it} + \beta_{cs} lncs_{it} + c_i + \delta_i + \mu_{it} \qquad (2)$$

$$lny_{it} = \beta_k lnk_{it} + \beta_h lnh_{it} + \beta_{ino} lnino_{it} + \beta_{cs} lncs_{it} + c_i + \delta_i + lny_{it-1} + \mu_{it} \qquad (3)$$

Equation 2 refers to models estimated by the traditional method (pooled OLS (OLS), fixed effect (FE) and random (RE)). On the other hand, Equation 3 uses the GMM System/First Difference method. c_i, μ_{it} and δ_i which are the unobserved effects, the error term and the time *dummy* respectively. The fixed time effect, δ_i, was included in the model to capture the measurement errors associated with the data used.

The hypotheses tested in this research refer to the verification of significance and signs of the parameters β_{ino} and β_{cs}.. If the hypotheses raised are valid, it is expected that $\beta_{ino} > 0$ and $\beta_{cs} > 0$.

4.2 Database

The work database is composed of 297 observations analyzed from 2000 to 2010 for each Federation Unit (UF), including the Federal District. The reason for choosing the series in such a period was due to lack of data with a longer periodicity that retained the information structure. Table 1 summarizes the specification of the database and the variables used.

Table 1 - Description of variables and data source.

Variable	Description	Data source	Works that used
PIB	Gross Domestic Product (R$ million at 2010 prices).	IPEA	Lau and Yotopoulos (1989) and Lau *et al*. (1993)
LAB	Number of persons engaged.	IPEA	Lau *et al*. (1993)
CF	Industrial electricity consumption (annual MWh).	IPEA	Souza (1999), Nakabashi and Figueiredo (2008)
CH	Average years of schooling of persons 25 years of age and over.	IPEA	Barro and Sala-i-Martin (1992) and Cohen and Soto (2007)
INO	(Number of patents filed by residents / R&D expenditure) per 100,000 inhabitants.	INPI/MCTIC	Scherer (1982), Griliches (1998) and Bell and Pavitt (1997).
CS	Sum of the number of cooperatives and other forms of nonprofit organizations per 100,000 inhabitants.	(MTE-RAIS)	Knack and Keefer (1997) and Viana and de Lima (2011)
CN	Added Value of agriculture.	IPEA	Viana and de Lima (2011) and Kurecic and Kokotovic (2017)

Source: Own elaboration.

As a measure of state labor (LAB) the number of persons engaged is used. These data are available from the Institute of Applied Economic Research (IPEA). The Gross Domestic Product (GDP) of each FU is used as a measure of state output, being measured in millions of R$ at constant 2010 prices.

Industrial electricity consumption, measured in megawatt hours per year, is used as a proxy to capture the effects of physical capital stock (CF) on the economic growth of each Brazilian state. This data is part of the IPEA database. This variable was also used by Souza (1999) and Nakabashi and Figueiredo (2008).

The proxy for social capital (CS) is the sum of the number of cooperatives and other forms of nonprofit organizations per 100,000 inhabitants. Such information was obtained from the Ministry of Labor and Employment (MTE-RAIS).

In addition, the present study uses the average years of study of people 25 years of age or older as a proxy for human capital (CH). Barro and Sala-i-Martin (1992) and Cohen and Soto (2007) also made use of this specification.

For natural capital (CN), the value added of the agricultural sector was used as a proxy. The purpose of including this variable is to capture state-specific aspects that ultimately contribute to R&D performance. After all, since Brazil is a country that intensively exploits agribusiness, the use of this variable is justified. Hinterberger, Luks and Schmidt-bleek (1997), Viana and Lima (2011) and Kurecic and Kokotovic (2017) also used similar specification.

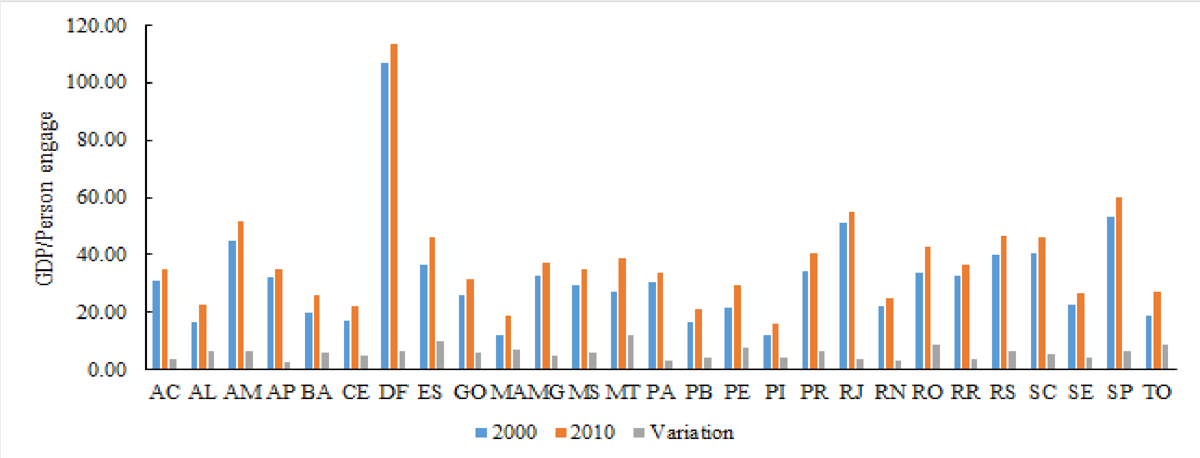
Finally, the innovation proxy (INO) is the number of patents filed by residents in each FU divided by total R&D expenditure per 100,000 inhabitants. These data are available on the website of the National Institute of Industrial Property (INPI). Scherer (1982), Griliches (1998) and Bell and Pavitt (1997) also used patents as a measure of innovation.

It is noteworthy that the use of the number of patents filed as an indicator of innovation is the subject of long debate (e.g., Pavitt, 1988; Griliches, 1998). The variation in the economic significance of inventions and the identical weight attributed to non-patented product and invention patents constitute complications in the use of this variable as an indicator of innovation. However, despite all these limitations, patents are generally accepted by much of the literature as a good indicator of innovation outcomes (e.g., Griliches, 1998; Ernst, 2001).

4.3 Descriptive data analysis

The analysis of Figure 4 allows us to see the different levels of output by persons employed in the different states. It is worth mentioning some values, the state of Mato Grosso was the one that gained the highest position from 2000 to 2010, being the state that obtained the largest growth in the indicator in the analyzed period. In general, in the Northeast there were the largest growths of output per work in the period, and among the ten states with the highest performance, seven belong to the Northeast (Maranhão, Pernambuco, Piaui, Bahia, Paraiba, Alagoas and Ceará).

Figure 4 - GDP performance indicator by employed person: 2000-2010*



Source: Own elaboration.

*AC-Acre, AL-Alagoas, AM-Amazonas, AP-Amapá, BA-Bahia, CE-Ceará, DF-Distrito Federal, ES-Espírito Santo, GO-Goiás, MA-Maranhão, MG-Minas Gerais, MS-Mato Grosso do Sul, Mato Grosso, PA-Pará, PB-Paraíba, PE-Pernambuco, PI-Piaúi, PR-Paraná, RJ-Rio de Janeiro, RN-Rio Grande do Norte, RO-Rondônia, RR-Roraima, RS-Rio Grande do Sul, SC-Santa Catariana, SE-Sergipe, SP-São Paulo, TO-Tocantins.

Table 2 presents the descriptive statistics for the variables of labor, physical capital, human capital, social capital, natural capital and innovation for each Brazilian state from 2000 to 2010. As expected, the state of São Paulo leads in terms of labor and physical capital, followed by Minas Gerais and Rio de Janeiro. For human capital, measured in schooling averages, the Federal District has the highest average. Although the states of the North and Northeast of the country have the last places for these variables, in absolute terms, when observed the average growth rate in the period from 2000 to 2010 are the regions that have the highest values, especially Roraima and Amapá, with respect to work, Pernambuco and Bahia for physical capital, and Rondônia and Tocantins for human capital.

Table 2 - Descriptive Statistics, Average and Growth Rate (Labor, Physical Capital, Human Capital, Social Capital, Natural Capital and Innovation)

Variable	Labor		Physical capital		Human capital		Social capital		Natural capital		Innovation	
	Mean	Growth rate*	Mean	Growth rate *	Mean	Growth rate *	Mean	Growth rate *	Mean	Growth rate *	Mean	Growth rate *
AC	0.192	0.052	0.024	0.05	6.012	0.009	33.598	0.04	0.562	0.25	0.089	0.355
AL	1.083	0.007	1.804	0.234	4.483	0.025	41.295	0.032	1.082	-0.075	0.018	0.087
AM	0.959	0.046	1.263	0.053	6.941	0.012	25.858	0.048	1.225	0.082	0.029	-0.003
AP	0.193	0.057	0.023	0.042	7.217	0.018	75.066	0.006	0.138	-0.044	0.252	0.306
BA	5.767	0.01	8.879	0.253	5.092	0.035	55.65	0.029	6.905	-0.083	0.006	-0.023
CE	3.383	0.015	1.933	0.02	5.14	0.034	56.613	0.011	2.217	-0.063	0.006	-0.021
DF	1.082	0.041	0.388	0.025	8.987	0.017	191.104	-0.005	0.264	0.026	0.016	-0.037
ES	1.581	0.024	4.036	0.038	6.596	0.025	156.363	0.011	2.642	-0.046	0.065	-0.126
GO	2.638	0.032	2.733	0.084	6.348	0.027	100.061	0.012	6.466	-0.015	0.029	-0.08
MA	2.43	0.001	6.858	0.023	4.731	0.037	21.357	0.041	3.416	-0.032	0.008	0.113
MG	8.639	0.022	25.345	0.03	6.267	0.024	126.358	0.02	15.192	-0.064	0.005	-0.041
MS	1.08	0.032	0.804	0.04	6.454	0.022	101.397	0.031	4.1	-0.095	0.026	0.023
MT	1.326	0.028	1.143	0.082	6.253	0.027	79.797	0.022	7.623	0.011	0.056	-0.162
PA	1.954	0.046	9.321	0.053	5.914	0.01	31.179	0.033	4.622	-0.151	0.004	0.082
PB	1.41	0.018	1.042	0.03	4.974	0.026	73.423	0.031	1.206	-0.105	0.007	0.144
PE	3.243	0.007	2.926	0.306	5.547	0.026	77.259	0.021	2.605	-0.107	0.007	0.396
PI	1.325	0.015	0.181	0.057	4.535	0.033	30.353	0.038	1.035	-0.021	0.022	-0.106
PR	4.884	0.022	8.738	0.042	6.808	0.024	163.828	0.018	10.693	-0.109	0.023	-0.057
RJ	6.682	0.023	7.706	-0.008	7.769	0.017	218.5	0.011	1.108	-0.083	0.004	-0.036
RN	1.184	0.022	1.022	0.039	5.511	0.025	60.356	0.032	0.837	0.12	0.007	0.182
RO	0.459	0.041	0.211	0.063	5.935	0.011	59.831	0.101	2.011	0.028	0.37	0.167
RR	0.128	0.059	0.014	0.04	6.535	0.025	28.752	-0.018	0.196	0.188	0.673	-0.178
RS	5.161	0.012	8.963	0.038	6.922	0.017	189.81	0.009	13.818	-0.064	0.016	-0.027
SC	3.027	0.025	7.033	0.045	7.079	0.025	189.084	0.026	7.292	-0.096	0.035	0.015
SE	0.824	0.025	1.145	0.031	5.701	0.028	58.952	0.03	0.615	-0.042	0.039	-0.061
SP	18.489	0.026	48.692	0.038	7.608	0.02	146.863	0.013	15.262	-0.073	0.002	-0.031
TO	0.567	0.022	0.103	0.052	5.654	0.041	50.219	0.041	1.376	0.1	0.18	0.155

Source: Own elaboration.

* Average growth rate between 2000 and 2010.

For the variable's social capital and natural capital, the states of the Southeast and South have the highest averages, with Rio de Janeiro and the Federal District the highlights in the first case, and São Paulo and Minas Gerais in the second.

Regarding innovation, unlike expected, the northern region of the country has the highest averages, especially Roraima, Rondônia and Amapá with the first three positions, respectively. One possible explanation is that part of the filed patents is strongly related to technology development based on research conducted in the Brazilian Amazon. In addition, the innovation indicator built in this research takes into account the population relationship.

5 Results

5. 1 Results and statistical tests [1]

Table 3 presents the results of the estimates. In the first part of the table, the results for pooled OLS (OLS), random effect (RE), and fixed effect (FE) are considered. In the second part, the results are presented for the DPD model, considering the estimation by First Difference GMM (DIF-GMM) and System GMM (SYS-GMM).

Table 3 - Results for estimated models

Variable	M1	M2	M3	M4	M5
	OLS	RE	FE	DIF - GMM	SYS - GMM
y_{t-1}	-	-	-	0.869***	0.885***
lab	0.898***	0.628***	0.229***	0.082**	0.058*
cf	0.060***	0.074***	0.035***	0.017**	0.021***
ch	2.047***	0.357***	0.06	0.122*	0.119**
ino	0.031**	-0.003	-0.016***	0.004	0.004
cs	0.056*	0.200***	0.089***	0.046**	0.035**
cn	0.01	0.045***	0.047***	0.012	0.013*
r2	0.975	-	0.965	-	-
Breusch Pagan test p > chi2		0.000		-	-
Hausman Test p > chi2		0.000		-	-
AR(1) test Pr > z	-	-	-	0.000	0.000
AR(2) test Pr > z	-	-	-	0.384	0.374
Hansen- Sargan test	-	-	-	1.000	1.000

Source: Own elaboration.

The first estimating model was pooled OLS. The Breusch Pagan test rejected the null hypothesis of no unobserved effect, χ^2 (1) = 697.81. This indicates that other estimators should be used to control unobserved effects.

Hausman's test, χ^2 (16) = 284.90, points out that the most efficient estimator is the FE. When considering the FE, the coefficient of social capital reduces and that of human capital loses significance. This may be an indication that when unobserved effects are not controlled, the estimated coefficients may not be consistent due to the endogeneity problem.

Regarding the DPD models, to validate the assumptions underlying the proposed method, it is important to analyze the results of the AR (1), AR (2) and Hansen-Sargan tests. The first two refer to the AR tests for waste autocorrelation. By construction, the residuals of the deferred equation must have serial correlation, AR (1), and the differentiated residues, AR (2), should not exhibit significant behavior. That is, if the errors of the proposed models are not serially correlated, there must be evidence of first-order serial correlation, captured by the AR (1) test, and no evidence of second-order serial correlation, AR (2). Both tests have as null hypothesis the absence of autocorrelation of the residues. The Hansen-Sargan test, in turn, is a test of overidentification constraints. The joint null hypothesis is that the instruments are valid, ie not correlated with the error term, and that the instruments not included were correctly removed from the estimated equation.

As can be seen in Table 3, the AR (1) test was statistically significant in both models, indicating the presence of serial correlation in the residues. On the other

[1] O *software* utilizado para as estimações foi STATA 2012.

hand, the AR (2) test rejected the null hypothesis of serial correlation in the differentiated residues for both DIF-GMM and SYS-GMM. As expected, these results show that for the estimated models, there is no significant evidence of serial autocorrelation in the residues. Finally, the Hansen-Sargan test did not have its null hypothesis rejected, with a high level of significance for both models. This indicates that the instrumentation process was adequate, that is, the instruments used are valid.

The inclusion of the time-lagged dependent variable as an explanatory and, consequently applying the GMM method, has impacts on the magnitude of the other explanatory variables of the model, especially with respect to work and human capital, which suffered reductions. This result was expected, since GDP depends heavily on its past values, which ultimately affects the contribution of variables with the most direct impact on production, such as labor.

Finally, it should be noted that although the two DPD models (DIF-GMM and SYS-GMM) were adequate according to the statistical tests, the following results analysis will be performed considering the M4 model (SYS-GMM), once that the instrumentalization process is considered more robust, as pointed out by Blundell and Bond (1998).

5.2 Discussion and comparison with the literature

This paper relates more strictly to the work of Lau *et al*. (1993) and Cangussu, Salvato and Nakabashi (2010), in which a similar functional specification is used to capture the effects of labor, physical capital and human capital on GDP. The methodology used by Lau *et al*. (1993) was that of traditional panel data (fixed and random effect), analyzed from 1970 to 1990. On the other hand, Cangussu, Salvato and Nakabashi (2010) made use of the dynamic panel, evaluated from 1980 to 2002. In contrast to these, two additional variables were used in the model, innovation and social capital, analyzed from 2000 to 2010.

From this perspective, Lau *et al*. (1993) and Cangussu, Salvato and Nakabashi (2010) find that human capital (CH) is the most important factor in explaining state GDP. Specifically, the contribution found was 0.21 for the first, and 1.74 for the second. Although different, the result obtained in this article (0.12) indicates that this factor is the most important.

It is evident that the differences in the results reflect the period considered in each research. In the case of the research by Cangussu, Salvato and Nakabashi (2010), the increase in schooling of the Brazilian population generated large increases in labor productivity, since there were changes in the structure during this period. Already the period considered in this research has some stability of human capital, but still remains a predominant factor.

For physical capital (CF), the results are in accordance with the literature. Specifically, a significant and positive value of 0.02 was found. For Lau *et al*. (1993), the value was 0.09, and for Cangussu, Salvato and Nakabashi (2010) around 0.11. Unlike these, the results of this research point to a smaller contribution of physical capital in the explanation of GDP.

The labor (lab), in turn, was significant and positive, being its representation the second most important in modeling, with about 0.06. Cangussu, Salvato and Nakabashi (2010) found 0.017, but not significant, and Lau *et al*. (1993) 0.41. The difference between the results obtained by Lau *et al*. (1993) can be explained by the period analyzed, and also by the methodology employed, which as previously observed, the non-inclusion of the lagged dependent variable overestimates the impact of labor on GDP.

Overall, the results show that human capital is an important factor in determining GDP and explaining differentials between Brazilian states. In addition, the results corroborate the empirical evidence obtained for Brazil in other studies, as indicated.

It now remains to evaluate the results for the other variables, which configure the methodological effort and the main contribution of this work. The first point to be highlighted is the contribution of social capital (CS), measured as the sum of the number of cooperatives and other forms of nonprofit organizations per 100,000 inhabitants in explaining the product. This variable was statistically significant and presented one of the highest magnitudes among the variables (0.035). The result found is in agreement with the literature (Bourdieu, 1986; Coleman, 1994; Putnam, 1996). In addition, empirical works applied in Brazil, such as Arraes, Barreto and Teles (2004), Bonamino, Alves, Franco and Cazelli. (2010) and Abbade (2014) highlight social capital as a fundamental element for the strengthening of economic relations and formation of a set of values capable of improving economic performance.

Finally, the variable of interest, innovation (INO), was not statistically significant. This result shows that while efforts to innovate through laws and programs that stimulate R&D spending have intensified over the past decade, the effects on production levels have not yet been achieved.

Innovation literature constantly shows the strong relationship between innovation and economic performance of nations (eg, Lentz & Mortensen, 2008; Zalewski & Skawińska, 2009; Acemoglu, Akcigit, Alp, Bloom & Kerr, 2018), however, the effects of The effort to innovate depends on time, as long-term results depend on the economic environment and technological absorption capacity.

5.3 Robustness Test

As this work proposed an alternative model, which includes two explanatory variables not previously considered empirically for Brazil, it is necessary to perform robustness tests to assess how valid these are for determining state GDP.

Table 4 presents the results of the estimation by System-GMM, following the specification of the previous section. However, the population growth rate (pop), **M1**; government spending on education and culture (i_cs), M2; government expenditure on capital (gov), **M3**; and finally, all are included together, **M4**. These variables are commonly used in the literature as possible determinants of GDP (eg, Nakabashi & Figueiredo, 2008; Viana & de Lima, 2011; Resende & Figueirêdo, 2017). Moreover, the objective with this modeling is to evaluate the consistency and sensitivities of the previously estimated parameters.

The addition of the variables does not cause major changes in the magnitude and significance of the estimated parameters in relation to the main model. Therefore, this result shows that the chosen model and the method used were adequate.

Table 4 - Robustness Test

Variable	(main model)	M1	M2	M3	M4
y_{t-1}	0.885***	0.886***	0.890***	0.881***	0.882***
lab	0.058*	0.062*	0.058*	0.057*	0.060*
cf	0.021***	0.020***	0.020***	0.022***	0.020***
ch	0.119**	0.114**	0.117**	0.117**	0.112**
ino	0.004	0.004	0.004	0.003	0.004
cs	0.035**	0.034**	0.035**	0.037**	0.036**
cn	0.013*	0.014*	0.013*	0.013*	0.014*
pop	-	0.009***	-	-	0.009***
i_cs	-	-	-0.004	-	-0.002

gov	-	-	-	0.009	0.009
AR(1) test Pr > z	0.000	0.000	0.000	0.000	0.000
AR(2) test Pr > z	0.374	0.316	0.391	0.361	0.309
Hansen- Sargan test	1.000	1.000	1.000	1.000	1.000

Source: Own elaboration.

In addition to the above specification, two more robustness tests are commonly used to assess the consistency of estimated parameters when using growth models (e.g., Levine & Renelt, 1992; Doppelhofer & Miller, 2004; Resende & Figueirêdo, 2017). The first is proposed by Leamer (1985), who builds a sensitivity analysis, *the extreme bounds analysis* (EBA), to identify robust empirical relationships. As a second test, in response to the perceived rigor of the EBA, Sala-i-Martin (1997) proposes an alternative method for robustness sensitivity analysis, known as *Sala-i-Martin test*.

In the EBA test *M* models are estimated for all possible combinations between explanatory variables. For any variable, the extreme lower and upper limits are defined as maximum and minimum values of the estimated M models. Thus, if the upper and lower extreme limits have the same sign, the variable in question is robust, otherwise it is declared fragile. On the other hand, the Sala-i-Martin test (1997) analyzes the entire distribution of the estimated variable coefficients, considering the t-test to evaluate the significance of the estimated parameter (Hlavac, 2016; Resende & Figueirêdo, 2017).

Table 5 presents the results. For the EBA test, the coefficient of the two extreme limits (lower and upper) of the regressions is exposed, as previously discussed. For this test, human capital, natural capital and innovation were considered fragile, that is, they cannot explain GDP.

Table 5 - Robustness test, EBA and Sala-i-Martin

Variable	Leaner test (EBA)			Sala-i-Martin test			
	Inferior limit	Upper limit	Conclusion	$\bar{\beta}_v$	$\bar{\sigma}_v$	T test	Conclusion
lab	0.837	1.337	robust	1.002	0.020	50.100	robust
cf	0.338	0.605	robust	0.479	0.017	28.176	robust
ch	-0.950	3.590	fragile	2.140	0.119	17.983	robust
ino	-0.653	0.186	fragile	-0.039	0.020	-1.950	fragile
cs	0.004	1.513	robust	0.410	0.042	9.762	robust
cn	-0.223	0.752	fragile	0.084	0.028	3.000	robust
Nº de Combinators: 17							
Nº de Regressors: 17							

Source: Own elaboration.

There is no theoretical and empirical support to justify the lack of robustness of human capital. However, according to Brock, Durlauf and West (2003), the biggest criticism of the EBA method is its insensitivity to different models, that is, poor specifications may be harming the test result.

In this sense, the Sala-i-Martin test, which considers the entire distribution of the explanatory variable, is also presented in Table 4. The results are derived from the mean coefficient estimating the mean standard deviation, and the conclusion of significance was performed using statistics. t. Unlike the previous test, human and natural capital are now considered robust. However, innovation remains non-robust.

Overall, as expected, labor, human capital, physical capital, social capital, and natural capital are robust in explaining the product. This shows which specification used was appropriate.

Moreover, corroborating with the previous specification, the innovation is not significant for robustness testing, indicating that the state product is not yet affected by this variable.

6 Conclusion

The importance of innovation and social capital as strategic factors for economic performance and for explaining different income levels across regions and countries has been studied with greater emphasis since the late 1980s. For this reason, a number of government incentives were created in Brazil in the first decade of the 2000s with the aim of creating an innovative environment. It is specifically at this point that the present work intends to make its contribution to the empirical analysis.

The first point to highlight is the result obtained for human capital. This variable is one of the most important in explaining Brazil's economic growth. Although analyzed at different periods, Lau *et al*. (1993) and Cangussu, Salvato and Nakabashi (2010) also obtained similar results. This shows that the increase in average schooling in Brazil is still the fundamental element for the increase of productivity and production.

Another important result was obtained for social capital, which shows that cooperatives and other forms of nonprofit organizations are essential for determining GDP. This result is also as expected, as evidenced by the literature. The result points out that personal relationship networks are important channels for increased efficiency, which ultimately contribute to the increase in GDP.

Finally, according to the results described in the previous section, the variable of interest, innovation (INO), was not significant. Although efforts to innovate have intensified in the last decade, mainly through increases in R&D expenditure, the effects on the level of production have not yet been achieved. This is because innovation is a factor that depends on the formation of technological absorption capacity and, in general, on the integration of society in order to promote technological development. Such issues are long-term acquired as a result of past efforts to innovate. Thus, it is expected that greater efforts to innovate and higher levels of investment in R&D will produce long-term results and thus contribute to increased productivity and production.

The importance of the present work is to determine the effects of innovation and social capital, as well as other variables, on production performance. Although innovation is not significant, the results on human capital show that higher knowledge is fundamental for increasing productivity and production. Therefore, investments in innovation must be maintained and intensified to achieve technological advances in the future.

The main limitations of the work are associated with the construction of the innovation variables, about which the literature has long discussion about the theme, and social capital, which although a usual proxy has been used, there are still some limitations to capture the cooperative relations, civic behavior, among others. Thus, it will be relevant to address these issues in future work.

Finally, the statistical results point to the rejection of hypothesis **H1**, indicating that innovation in the analyzed period was not a determining factor in explaining GDP growth. On the other hand, the results point to the support of hypothesis **H2**, indicating that social capital affects the product.

References

Abbade, E. B. (2014). Inovatividade e Performances Social, Ambiental e Econômica em MPMES: Uma Investigação Empírica. *Revista Ibero-Americana de Estratégia*, 13(3), 35.

Acemoglu, D., Akcigit, U., Alp, H., Bloom, N., & Kerr, W. (2018). Innovation, reallocation, and growth. *American Economic Review*, 108(11), 3450-91.

Smith, A. (1776). A riqueza das nações–investigação sobre sua natureza e causas. *Tradução de Norberto de Paula Lima*. São Paulo: Abril, 1983.

Aghion, P., & Howitt, P. (1992). A model of growth through creative destruction. *Econometrica*, *60,* 323-351.

Aghion, P., Howitt, P., Howitt, P. W., Brant-Collett, M., & García-Peñalosa, C. (1998). *Endogenous growth theory*. MIT press.

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The review of economic studies*, *58*(2), 277-297.

Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of econometrics*, *68*(1), 29-51.

Arraes, R. A., Barreto, R. C. S., & Teles, V. K. (2004). Efeitos do capital social e do capital político no desenvolvimento econômico: simulações para países e estados brasileiros. *Análise Econômica*, *22*(41).

Barro, R. J., & Lee, J. W. (1993). International comparisons of educational attainment. *Journal of monetary economics*, *32*(3), 363-394.

Barro, R. J., & Sala-i-Martin, X. (1992). Convergence. *Journal of political Economy*, 100(2), 223-251.

Becker, G. S., Murphy, K. M., & Tamura, R. (1990). Human capital, fertility, and economic growth. *Journal of political economy*, *98*(5, Part 2), S12-S37.

Bell, M., & Pavitt, K. (1997). Technological accumulation and industrial growth: contrasts between developed and developing countries. *Technology, globalisation and economic performance*, *83137*, 83-137.

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of econometrics*, 87(1), 115-143.

Bonamino, A., Alves, F., Franco, C., & Cazelli, S. (2010). Os efeitos das diferentes formas de capital no desempenho escolar: um estudo à luz de Bourdieu e de Coleman. *Revista Brasileira de Educação*, *15*(45).

Bourdieu, P. (1986). *The forms of capital*. In J. G. Richardson (Ed.), Handbook of theory and research for the sociology of education: 241-258. New York: Greenwood.

Brasil. (2017, Abril 20). Lei nº 10.332, de 19 de dezembro de 2001- Subvenção do Fundo Verde Amarelo. Institui mecanismo de financiamento para o programa de ciência e tecnologia para o agronegócio, para o programa de fomento à pesquisa em saúde, para o programa biotecnologia e recursos genéticos - genoma, para o programa de ciência e tecnologia para o setor aeronáutico e para o programa de inovação para competitividade, e dá outras providências. http://www.mct.gov.br.

Brasil. (2017, Abril 20). Lei nº 10.973, de 2 de dezembro de 2004 – Lei da Inovação. Dispõe sobre incentivos à inovação e à pesquisa científica e tecnológica no ambiente produtivo e dá outras providências. http://www.mct.gov.br. Acesso em: 20 abr. 2017.

Brasil. (2017, Abril 20). Lei nº 11.196, de 21 de novembro de 2005 – Lei do Bem. Dispõe sobre os incentivos fiscais que as pessoas jurídicas podem usufruir de forma automática desde que realizem pesquisa tecnológica e desenvolvimento de inovação tecnológica. http://www.mct.gov.br. Acesso em: 20 abr. 2017.

Brock, W. A., Durlauf, S. N., & West, K. D. (2003). Policy Evaluation in Uncertain Economic Environments. *Brookings Papers on Economic Activity*, *1*, 235-322.

Cangussu, R. C., Salvato, M. A., & Nakabashi, L. (2010). Uma análise do capital humano sobre o nível de renda dos estados brasileiros: MRW versus Mincer. *Estudos Econômicos (São Paulo)*, *40*(1), 153-183.

Cohen, D., & Soto, M. (2007). Growth and human capital: good data, good results. *Journal of economic growth*, *12*(1), 51-76.

Coleman, J, S. (1994). *Foundations of social theory*. Harvard university press.

Doppelhofer, G., & Miller, R. I. (2004). Determinants of long-term growth: A Bayesian averaging of classical estimates (BACE) approach. *American economic review*, 94(4), 813-835.

Ernst, H. (2001). Patent applications and subsequent changes of performance: evidence from time-series cross-section analyses on the firm level. *Research Policy*, 30(1), 143-157.

Forbes, K. J. (2000). A Reassessment of the Relationship between Inequality and Growth. *American economic review*, 90(4), 869-887.

Griliches, Z. (1998). Patent statistics as economic indicators: a survey. In *R&D and productivity: the econometric evidence* (pp. 287-343). University of Chicago Press.

Hinterberger, F., Luks, F., & Schmidt-Bleek, F. (1997). Material flows vs.natural capital': What makes an economy sustainable?. *Ecological economics*, 23(1), 1-14.

Hlavac, M. (2016). Extreme Bounds: Extreme Bounds Analysis in R. *Journal of Statistical Software*, 72(9), 1-22. doi:10.18637/jss.v072.i09.

INPI. (2017, Abril 5). Instituto Nacional da Propriedade Industrial. http://www.inpi.gov.br/.

IPEA. (2017, Abril 5). Instituto de Pesquisa Econômica Aplicada. Disponível em: http:www.ipeadata.gov.br.

Klette, T. J., & Kortum, S. (2004). Innovating firms and aggregate innovation. *Journal of political economy*, *112*(5), 986-1018.

Lau, L. J., Jamison, D. T., Liu, S. C., & Rivkin, S. (1993). Education and economic growth Some cross-sectional evidence from Brazil. *Journal of development economics*, 41(1), 45-70.

Lau, L. J., & Yotopoulos, P. A. (1989). The meta-production function approach to technological change in world agriculture. *Journal of Development Economics*, *31*(2), 241-269.

Leamer, E. E. (1985). Sensitivity analyses would help. *The American Economic Review*, *75*(3), 308-313.

Lentz, R., & Mortensen, D. T. (2008). An empirical model of growth through product innovation. *Econometrica*, *76*(6), 1317-1373.

Levine, R., & Renelt, D. (1992). A sensitivity analysis of cross-country growth regressions. *The American economic review*, 942-963.

Levine, R., Loayza, N., & Beck, T. (2000). Financial intermediation and growth: Causality and causes. *Journal of monetary Economics*, 46(1), 31-77.

Lucas Jr, R. E. (1988). On the mechanics of economic development. *Journal of monetary economics*, 22(1), 3-42.

Knack, S., & Keefer, P. (1997). Does social capital have an economic payoff? A cross-country investigation. *The Quarterly journal of economics*, 112(4), 1251-1288.

Kurecic, P., & Kokotovic, F. (2017). Examining the ''Natural Resource Curse''and the Impact of Various Forms of Capital in Small Tourism and Natural Resource-Dependent Economies. *Economies*, 5(1), 6.

Mankiw, N. G., Romer, D., & Weil, D. N. (1992). A contribution to the empirics of economic growth. *The quarterly journal of economics*, *107*(2), 407-437.

Marinho, E., & Bittencourt, A. (2007). Produtividade e crescimento econômico na América Latina: a abordagem da fronteira de produção estocástica. *Estudos Econômicos (São Paulo)*, *37*(1), 5-33.

Martín, M. A. G., & Herranz, A. Á. (2004). Human capital and economic growth in Spanish regions. *International Advances in Economic Research*, *10*(4), 257-264.

Mykhailyshyn, H., Kondur, O., & Serman, L. (2018). Innovation of Education and Educational Innovations in Conditions of Modern Higher Education Institution. *Journal of Vasyl Stefanyk Precarpathian National University*, 5(1), 9-16.

Nakabashi, L., & Figueiredo, L. D. (2008). Mensurando os impactos diretos e indiretos do capital humano sobre o crescimento. *Economia aplicada*, *12*(1), 151-171.

OCDE. (1996). The knowledge-based economy. *Organisation for economic co operation and development*, OECD, OECD, 2, 1-46.

OECD. (2017, Outubro 10). Compendium of R&D tax incentive schemes: OECD countries and selected economies, 2017, http://oe.cd/rdtax.

Pacheco, C. A. (2011). O financiamento do gasto em P&D do setor privado no Brasil e o perfil dos incentivos governamentais para P&D. *Revista USP*, (89), 256-276.

Pavitt, K. (1988). Uses and abuses of patent statistics. *Handbook of Quantitative Studies of Science and Technology*, 509-536.

Putnam, R. D. (1996). *Comunidade e democracia: a experiência da Itália moderna*. FGV Editora.

Rebelo, S. (1991). Long-run policy analysis and long-run growth. *Journal of political Economy*, *99*(3), 500-521.

Reinganum, J. F. (1989). The timing of innovation: Research, development, and diffusion. *Handbook of industrial organization*, *1*, 849-908.

Rezende, A. A., Corrêa, C. R., & Daniel, L. P. (2013). Os impactos da política de inovação tecnológica nas universidades federais-uma análise das instituições mineiras. *Revista de Economia e Administração*, 12(1).

Resende, G. M., & de Figueirêdo, L. (2017). Testes de robustez: Uma aplicação para os determinantes do crescimento econômico estadual brasileiro entre 1960 e 2000. *Revista Econômica do Nordeste*, *41*(1), 9-40.

Ricardo, D. (1817). *On the Principles of Political Economy and Taxation*. (3 ed) Batoche Books.

Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of political economy*, *94*(5), 1002-1037.

Romer, P. M. (1990). Endogenous technological change. *Journal of political Economy*, *98*(5, Part 2), S71-S102.

Sala-i-Martin, X. X. (1997). I just ran two million regressions. *The American Economic Review*, 178-183.

Shioji, E. (2001). Public capital and economic growth: a convergence approach. *Journal of economic growth*, 6(3), 205-227.

Scherer, F. M. (1982). Inter-industry technology flows and productivity growth. *The review of economics and statistics*, 627-634.

Segerstrom, P. S., Anant, T. C., & Dinopoulos, E. (1990). A Schumpeterian model of the product life cycle. *The American Economic Review*, 1077-1091.

Silva, R. B., & Dagnino, R. (2009). Universidades públicas brasileiras produzem mais patentes que empresas: isso deve ser comemorado?. *Revista Economia & Tecnologia*, 5(2).

Solow, R. M. (1956). A contribution to the theory of economic growth. *The quarterly journal of economics*, *70*(1), 65-94.

Souza, M. R. P. (1999). Análise da variável escolaridade como fator determinante do crescimento econômico. *Revista da FAE*, *2*(3).

Viana, G., & de Lima, J. F. (2011). Capital humano e crescimento econômico: o caso da economia paranaense no início do século XXI. *Revista Paranaense de Desenvolvimento-RPD*, (116), 139-167.

Zalewski, R. I., & Skawińska, E. (2009). Impact of technological innovations on economic growth of nations. *J. System. Cybern. Inform*, *7*(6), 35-40.