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REVISTA BRASILEIRA DE ECONOMIA
DOI 10.5935/0034-7140.20200011
ISSN 1806-9134 (online)
FGV
FUNDAÇÃO GETULIO VARGAS

Evidence on the Determinants of Productivity in Brazil, 2004–2014

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Contents

Keywords
Labor productivity, determinants, economic growth, infrastructure

JEL Codes
047 J24 043

Abstract · Resumo

In Brazil, productivity has been underperforming since the 1980s. Thus, considering its importance for economic growth, it is important to verify ways to stimulate its performance. Therefore, this study aims to verify how some determinants influenced the productivity, being used the methodology of structural autoregressive vectors. It was verified that effects of the improvements in the determinants would only occur in a longer time horizon, also that the infrastructure had a greater effect on productivity, both in the short and the long run. Therefore, improvements in terms of infrastructure have a greater effect on productivity, and consequently on economic growth.

1. Introduction

Since the 1980s Brazil has been characterized by low productivity, with some years of stagnation and even some growth, but low and soon reversed. At the beginning of the 2000s there was an increase in the growth of Brazilian production, accompanied by an increase in productivity in the country, but with the advent of the international crisis of 2008, this situation ended. Following the recovery of the international crisis, Brazil has followed a scenario of low productivity growth that has persisted, stagnating according to De Negri and Cavalcante (2014).

As mentioned in the literature, the short-run growth in the early 2000s was sustained by the improvement of the terms of trade, which benefited Brazil's situation on the international scenario by stimulating the production of agricultural products and their exports, and investments in this sector, leaving aside the industry sector, according to Cavalcante and De Negri (2014). In the same period, there was an increase in employment in the country, due to the growth of production, reaching levels close to full employment, thus, with the exhaustion of available labor, future growth could

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Received on Feb 1st, 2019
Final Acceptance on Aug 30th, 2019

no longer support this variable, there being a limitation to demographic increase, due to the aging of the population, according to Bonelli (2014). As well as much discussed in the literature, the level of investment in the country historically has not been able to stimulate desirable economic growth, being insufficient in this objective. Thus, considering the low growth, the depletion of future labor and the insufficient level of investment, it is necessary to look for an alternative as a way to stimulate production. In this way, the focus turns to the study of productivity, as a way to increase the efficiency of production and make it return to having the desired performance.

However, according to Mation (2014), comparing with other countries, it is possible to see that Brazilian productivity performance is not satisfactory, reaching among the countries with the worst productivity when compared to other nations with similar productive structure. It is therefore important to make an analysis in order to identify how certain determinants may be responsible for our low productivity. Thus, it is important to discuss methods that can help the country to follow the growth path of these other countries, among the methods that can help the country in this task is the stimulus of productivity. However, productivity has followed a downward trajectory or stagnation in the country in recent years, so, first, it would be necessary to improve its performance. For this purpose, it is important to verify what can stimulate the improvement in productivity.

Thus, the objective of this study is to make an analysis of some determinants of productivity, verifying the influence on its performance and if these influences can help to understand why the Brazilian productivity has performed so below of what is presented by the economies that have a similar scenario. It is expected that all the determinants analyzed (human capital, innovation, infrastructure, institutional quality, trade openness, and business environment) will have positive effects on productivity. For this purpose, the present study uses the econometric instruments for time series, more specifically the methodology of structural autoregressive vectors (S-VAR), in order to verify improvements in which of the variables would have the greatest effect on productivity performance.

This paper is divided into three sections besides this introduction and the final considerations, in the first section a theoretical and empirical review is made on the relations between productivity and the determinants studied here. The second section describes the methodology used in this study as well as the method of calculating the indicators and the proxies used for each determinant. Finally, in the third section, we present the analysis of the trends of the variables in the period, as well as the results of the model.

2. Theoretical and empirical review

Initially, the determinants of productivity included human capital, which was associated with both labor productivity and total factor productivity. This concept was introduced by Mincer (1958), Schultz (1961), and Becker (1962), who stated that investment in human capital would be investments in education, training in new skills in new jobs, and health, Becker (1962), and Schultz (1961) also included food expenditures on investment in human capital, especially in jobs that required brute force. The authors agreed that these expenditures would tend to lower wages early in life, but were intended to increase labor earnings over the years. There was agreement that jobs that required more schooling and more experience were also more productive jobs. However, as Becker (1962) stated, considering that a job required specific skills, if the worker quit and sought employment in another activity, as a result, it would not be as productive as the previous one.

Regarding the costs of investing in human capital, Schultz (1961) stated that an apprentice would continue working and learning a new profession until his productivity exceeded the cost of learning, when this happened, he would seek another job that was more convenient, which would leave the employer without recovering his expenses. Therefore, he concluded that training expenses should be paid by employees, that is, the increase in wage earnings would be postponed. However, Becker (1962) also agreed that the costs of training should be paid by employees, but argued this because workers owned property rights over newly acquired skills, which gave them returns on these skills.

With respect to productivity, Schultz (1961), and Becker (1962) affirmed the existence of a wage life cycle. When the worker began his professional life, he would have a low wage, little experience and training, that is, he would have to invest to improve his skills, considering that he would also have low productivity in consequence, as Becker (1962) stated. The more the worker acquired skills, the more his productivity would increase, giving him greater wage gain, enough to compensate for the expenses and the time delayed at the beginning of his professional life.

However, according to Mincer (1958) when the worker reached a certain age his productivity would begin to decrease, which would also lower his wage, and this would occur mainly in activities involving physical effort. So the higher wage during the years of higher productivity would need to be sufficient to supply the wages of the low productivity years both at the beginning and at the end of the wage life cycle. Still on the role of human capital in production, Schultz (1961) related it to productivity through a production function, concluding that during the period from 1900 to 1956, the distance between production and use of inputs increased. This fact suggested that the difference was an increase in productivity. However, as the author pointed out, productivity would be a residual factor, that is, it could not be very large, so Schultz (1961) suggested that human capital would also be responsible for increasing the distance between production and productive inputs.

As with human capital, another highly commented relationship was between productivity and innovation. Griliches's (1979) article, seminal on this subject, using as a tool a production function explained that much of the growth of total factor productivity (TFP) in the United States was due to research and development (R&D) spending, not only those considered at the time of analysis, as well as those from previous years. In fact, Griliches (1979) stated that R&D levels did not always influence TFP, but that this effect would have a lag of three to five years. He also argued that the best approach in the study of this relationship would be through the production function since the econometric approach could have problems that could not be solved at the time.

Still on productivity and innovation, Pakes and Griliches (1984) also related this spending on R&D with the number of patents and found that this relationship also existed and had an effect on productivity.[1] In order to confirm the existence of the relations, Griliches (1980) carried out a study to verify if a fall in the expenses with research and development had relation or affected the fall of the productivity that occurred in the United States between the decades of 1970 and 1980. Among his results, he concluded that these two falls were related. However, he could not verify the causality between the two movements, besides observing that there was no fall in the TFP, only in the labor productivity. This method of analysis was later adopted by Crepón, Duguet, and Mairesse (1998), who managed to verify the relationship between productivity, research, and innovation at the firm level. Through the study of Griliches (1979), Crepón et al. (1998) managed to sketch a theory relating productivity and innovation, which consisted of some equations, two on research and development, one for innovation and one for productivity, they affirmed that research and development generated innovation that generated productivity, indicating an order of causality between variables. However, Crepón et al. (1998) concluded that research and development did not always generate patents. In summary, it was possible to conclude from these studies that innovation influences productivity.

In turn, infrastructure also contributed greatly to productivity gains. Aschauer (1989), in his seminal paper, showed that infrastructure could be related to productivity, stating that infrastructure in transports would play a primary role in ensuring productivity, just as innovation did. In addition, he considered the fall in investments in infrastructure as one of those responsible for the fall of productivity in the 1970s in the United States, as well as Griliches (1980) stated with spending on R&D. Aschauer (1989) considered investments in infrastructure as government investments, due to the existence of some assets difficult to be offered by the private sector, because they were difficult to price. In addition, the author also sought to verify the role of government in long-run productivity. In the study, he said that the role of government would be very important in the production and concluded that productivity would be moved according to the movements of public capital.

As for Aschauer (1989), Munnel (1990) and Barro (1990) identified that there was a relationship between productivity and government, however, that causality would be from productivity to the definition of the role that the government played in production. Munnel (1990) also focused its analysis on the same period as Aschauer (1989), a period of the 1980s, but the author conducted a regional analysis of the United States stating that states that invested more in public capital obtained greater productivity in the private sector, indicating a correlation between the private and public sectors. And just like Aschauer (1989), Munnel (1990) concluded that investments in basic infrastructure (including transports) would be the ones with the greatest return on private productivity. In analyzing the relationship between public sector and private sector investments, Aschauer (1989), and Barro (1990) concluded that they were complementary, while Munnel (1990) concluded that they would be substitutes.

Another important determinant to explain the behavior and the difference of productivity between different places would be the institutions. North (1990) was one

[1]The methodology was through the inclusion of the variable patents and R&D expenditures in the production function. The period analyzed was mainly from 1968 to 1975 for the industrial firms of the United States.

of the firsts to analyze this relationship. And he said that institutions could be of two kinds, informal (customs, traditions) or formal (laws, property rights). Institutions would be what defined the interactions in a society, so a good institutional environment, formed by both political and economic institutions, would be fundamental to induce an increase in productivity. However, as North (1991) stated, institutions would be intrinsic to each society and would take a long time to change, some even taking a thousand years to change. The author then analyzed the evolution of institutions from the time that production and trade of products were made in the same village when the bourgeoisie emerged. North (1990) observed how the institutional environment evolved, lowering transaction costs, and having a growing impact on the level of productivity.

Also on the institutions, Hall and Jones (1999) resumed the period of colonization and showed that the countries that were colonized by different countries acquired the institutional characteristics of these and that this influenced the institutional environment of the colonized countries until the 20th century. North (1990) further stated that the institutions were intended to ensure the protection of private property rights, and that, if this right were not guaranteed, there would be less incentive for producers to invest in production and that it would be necessary to invest in security expenditures, damaging productivity. In relation to the guarantee of private property rights, Hall and Jones (1999) observed that the institutions were managed by the Government and that at times there could be a divergence in the interests of the latter, so the property right was not fully guaranteed.

With this, the productive differences between certain locations could be explained, because of places with social infrastructure[2] (institutional environment and government policies), more favorable to productive activities would have a higher level of productivity, because there would be less space for corruption, production interferences and impediments to trade. Hall and Jones (1999) concluded that countries with greater social infrastructure had higher labor productivity.Therefore, it was possible to conclude that, although institutions were difficult to change and intrinsic to each society, they would also be responsible for much of the differences in productivity of countries. Considering that better institutions would inhibit practices that deviate from the objective of improving productive activities and guaranteeing the private property rights.

Regarding the relationship between trade openness and productivity, Grossman and Helpman (1990) constructed a theory of growth and trade for two countries considering that the endogenous technological progress resulted from the maximizing profit behavior of the entrepreneurs. The authors related economic growth to trade openness and other international economic conditions. Just as Romer (1990), they divided production between the R&D sector, the goods sector, and the consumer sector, as well as assuming differences for the countries, which would be comparative advantages. In the model, the world was composed of two countries, each engaged in three activities, the production of final goods, the production of a variety of differentiated intermediary goods and research and development.

[2]Measure of institutions used by Hall and Jones (1999).

Grossman and Helpman (1990) stated that the model had constant returns to the scale, however, in the sector of differentiated intermediate goods the existence of increasing returns led to increased productivity, this was done through specialization. Therefore, an increase in the degree of specialization generated gains in technological efficiency. In addition, in order to have greater specialization, innovations in the R&D sector needed to occur. And from this, they considered that the effect of tariffs, export subsidies, and research and development subsidies led to greater specialization, which influenced productivity, and consequently growth. Therefore, it was through the effect of trade openness in the R&D sector that there were improvements in productivity.

Finally, the last relationship to be observed occurs between productivity and the business environment, recently introduced through the study of Djankov, La Porta, de Silanes, and Shleifer (2002). The authors, when conducting a comparative study among countries using regulatory theories, came to the conclusion that the business environment influenced economic growth because, through greater regulation, bureaucracy, procedures, among others, the country could hide some illness, such as corruption, which would negatively impact the growth of the country. Therefore, a greater bureaucratization could discourage companies with considerable productive efficiency to enter the country. They concluded that countries with greater regulatory freedom would tend to grow more and be richer, and the opposite would also be true. Thus, greater regulation and bureaucracy would discourage the opening of productive enterprises and also hide corruption, which would go against the objectives of economic growth, meeting the personal goals of certain groups. In general, considering the literature on the subject, the relations between productivity and its determinants can be represented by Figure 1.

In addition to the causality of the variables for productivity, according to the literature, the productive efficiency also influences innovation. Also, innovation was influenced by all other variables. Being that the institutional quality influences all others too. Finally, evidence of bidirectional causality was found between the business environment and the infrastructure. The same is true of innovation and trade openness.

Considering the importance of the performance of the determinants to the productivity trajectory in theory, it is interesting to see how these relations behaved in different periods, observing if in the course of time they have maintained or if

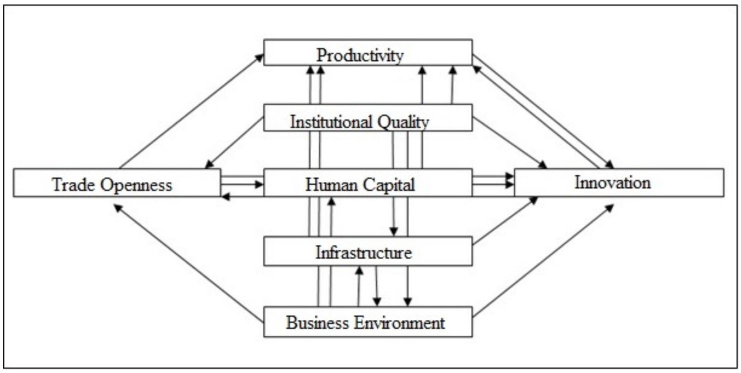


Figure 1. Diagram of Relations between Determinants and Productivity.

there have been changes in their trajectories in the country. Thus, several studies have addressed the relationship between productivity and human capital. Some studies have analyzed how this relationship developed in the second half of the 20th century, such as Ferreira and Veloso (2013), and Barbosa and Pessôa (2008), as well as comparing with the United States, showing how the relationship between human capital and productivity behaved in the period. The studies concluded that Brazil was close to the limit of the possibility of human capital growth and that if this happened it would be necessary to face the real problem in the country, which was the poor quality of education.

Still considering the long run, Jacinto (2015) also verified a long-run relationship between human capital and productivity in the country, in addition to doing an analysis at the level of companies affirming that this relationship was not very divergent between different companies. According to Barbosa, Pessôa, and Veloso (2010), some authors, when measuring human capital, could only take into consideration the years of study and this could jeopardize the analysis. Therefore, when using a methodology that also considered professional experience and income, they concluded that in Brazil, even that human capital increased in the 2000s, this growth was not accompanied by an increase in the earnings of qualified labor, considering that there was an increase in the supply of this labor force, which could have effects on productivity.

Some studies have focused on verifying empirically the positive relationship between innovation and productivity. In Brazil, Catela and Porcile (2013), Steingraber and Gonçalves (2010), Cavalcante, Jacinto, and De Negri (2015), among others, studied this behavior. The studies in Brazil have focused mainly on the industrial sector, observing that it was considered the most innovative sector by Kaldor (1978). However, Lavopa (2011) stated that the innovation process in developing countries would have lower technological sophistication when compared to developed ones, which could explain why the low innovative degree would have impacts on low productivity in developing countries. Therefore, different innovation capacities would be needed in these countries to achieve the same results.

Catela and Porcile (2013), as well as Steingraber and Gonçalves (2010) affirmed that there was no clear causality between innovation and productivity, only that they had a positive relationship. Still on this correlation, Steingraber and Gonçalves (2010), and Silva, da Silveira, Paranhos, Hasenclever, and Miranda (2015) stated that other factors were also included on this relation, besides productivity and innovation. These include social capital, the role of institutions and the business environment, the later affecting negatively, being observed its stagnation in the country.

Among the studies that focused on the relationship between productivity, innovation and investment in research and development are Cavalcante et al. (2015), and Silva et al. (2015). The first ones came to the conclusion that firms that innovated and invested in R&D were more productive, and that when these innovations occurred targeting the world market, gains in productivity were even greater. Silva et al. (2015) studied the relationship between productivity, innovation, and market power, concluding that the greater the market power, the less incentive the company would have to innovate since deficiencies would be absorbed by other sectors.

In turn, the relationship between productivity and infrastructure was also empirically addressed, with infrastructure having great importance in productivity due to the generation of positive externalities, as pointed by Campos, Conceição, and Romminger (2015), and Velloso, Matos, Mendes, and de Freitas (2012), mainly in the transports infrastructure. The authors agreed that when there was poor quality infrastructure there was a generation of negative externalities, through increased costs, rigidity and inefficiency throughout the economy, considering that there would be a need to use transportation both to move inputs and production, which could also cause negative impacts even on foreign trade. On the other hand, when there was a good quality infrastructure, returns to the economy improved their efficiency, since, for example, through good roads and railways, companies could carry out their productions far from the center of their consumers, being able to worry about install in a place that would provide better labor force, technological diffusion, among others.

Campos et al. (2015), Velloso et al. (2012), and Schettini and Azzoni (2015) analyzed the role of government and private companies in providing adequate infrastructure. The authors noted that both types of investment were not substitutes, but complementary, that is, government investment did not discourage private companies from competing. Based on this assertion, Mussolini and Teles (2010) studied the ratio between public and private capital as a measure of the degree of infrastructure and its relation to productivity for the second half of the twentieth century in Brazil, confirming that there was a long-run relationship between infrastructure and total factor productivity.

There are also studies that aimed to analyze the role of regional infrastructure on productivity, among them were Benitez (1999) and, more recently, Schettini and Azzoni (2015). Thus, like the other studies, they showed a positive relation between infrastructure and productivity, and Schettini and Azzoni (2015) focused their study on the industrial sector. In both studies, they confirmed that there was a greater impact of infrastructure on productivity in the Southeast region, which was explained by the greater degree of infrastructure in this region.

Regarding the relationship between productivity and the institutional environment, for Gonçalves (2008), countries would need to maintain institutions that were efficient in defending private property rights, so that producers and entrepreneurs would be encouraged to invest in production. In addition, efficient institutions would also generate lower transaction costs.

As institutions take a long time to change, some papers have sought to relate their performance to productivity in Brazil in the twentieth century. Among them were Alston, Mueller, Melo, and Pereira (2010), and Yano and Monteiro (2008), the first made an analysis from 1930 until the most recent periods, Governments Fernando Henrique Cardoso and Lula. While the second related some institutional reforms in the 1990s with productivity, reaching the conclusion that greater trade openness and financial reform had a positive effect on productivity. Some other papers also related institutions to productivity through other relationships, among them were Steingraber and Gonçalves (2010), and Dias and Tebaldi (2012), the former related the institutions to innovation, and thus allowed it to affect productivity. The latter showed that institutions influenced human capital, and this, in turn, influenced productivity.

Several studies in Brazil have tried to verify how the trade openness affected productivity performance, mainly the industrial one. Among them were Rossi and Ferreira (1999), Ferreira and Rossi (2003), Ferreira and Guillén (2004), and Fraga (2016), among others. In considering the impact of trade openness on productivity, Rossi and Ferreira (1999) analyzed the role of trade openness in both labor productivity and total factor productivity in the Brazilian manufacturing industry from 1985 to 1997. They affirmed that until 1990 there was stagnation of productivity and that from that year until 1997 there was significant growth.

Rossi and Ferreira (1999) also stated that trade openness had a significant impact on productive efficiency, and concluded that trade barriers caused productivity rates to fall, that is, more economically open countries had more stimulus to grow, however, trade barriers measures could be adopted with the aim of protecting industry from the countries. Ferreira and Rossi (2003) verified the relationship of the positive effects of international trade on the productivity of Brazilian industry from 1988 to 1990. Among the results, they found that trade barriers had decreased and that this led to increased productivity. Ferreira and Guillén (2004) also studied the relationship between industrial productivity and trade openness and concluded that there was an increase in average productivity in the industry after reductions in trade barriers.

Fraga (2016) analyzed the relationship between foreign direct investment, labor productivity, and total factor productivity and trade openness from 1996 to 2007, considering twenty-two sectors of the manufacturing industry through a dynamic panel analysis. Among the results, it was concluded that trade openness influenced productivity, in addition to the import penetration coefficient. Considering TFP, the trade openness was one of the variables that influenced it the most. Therefore, what was possible to conclude is that given the evidence presented by Brazil, trade openness had positive effects on improving Brazilian productivity, especially in the manufacturing industry.

Regarding the business environment and productivity, in countries where there is a precarious business environment, productivity performance may suffer. Some papers have emphasized how the ease of opening a business and the very ease of maintaining this business have affected labor productivity, however, there are still few studies analyzing this relationship. Mation (2014), and Cavalcante et al. (2015) analyzed the Brazilian business environment and its relationship with productivity, while Bah and Fang (2011) studied the African continent and Diagne (2013) studied Senegal. What all these studies had in common was that they were made in places where the business environment was not desirable.

Cavalcante et al. (2015), and Diagne (2013) related productivity to the business environment through investment. Diagne (2013) concluded that if there was an improvement in this environment, in addition to growth in TFP, there would also be a 79% product and a 94% investment growth. In addition, Mation (2014), and Bah and Fang (2011) also agreed that improvements in the business environment could have positive effects on productivity. Mation (2014) even concluded that most of the poor countries with poor business environment indexes had a positive evolution in the period, however, Brazil dissociated from this movement, leaving its business environment practically stagnant, which did not contribute to improving productivity performance. Although there was a strong correlation between the variables, this was mainly due to factors invariant in time.

Thus the empirical relations to Brazil between productivity and its determinants are in line with what is expected in theory. Therefore, it was assumed that improving the performance of these determinants could improve productivity performance and thus contribute to continued economic growth in the long run. Considering these facts, this paper seeks to verify how these variables, together, affect productivity in Brazil in the recent period. That is, the assumptions made are that the variables human capital, innovation, infrastructure, institutional quality, trade openness, and business environment all positively affect labor productivity. And the objective is to verify which determinant have the greatest impact on productivity performance.

3. Methodological Procedures

3.1 Database

The empirical analysis based on the use of the time series econometric technique seeks to analyze the variables that, considering the theoretical and empirical literature, affect the performance of labor productivity, considered as a measure of productive efficiency. The objective was to identify which determinant variable most influenced productivity in the period. On the basis of its identification, measures can be adopted for its growth, which also seeks to boost productivity growth, and consequently economic growth. This study used as determinants the variables suggested by De Negri and Cavalcante (2014), namely, human capital, innovation, infrastructure, institutional quality, and business environment, plus trade openness.

GDP was used as a production measure, being deflated by the implicit GDP deflator, taken from the Contas Nacionais Trimestrais (IBGE, n.d.). Regarding the income information, occupation status, the weight of the person, calculated age and number of hours worked, used to measure the average number of hours worked in the economy per quarter, they were taken from the Pesquisa Mensal de Emprego (PME, n.d.). All these variables were used to construct the indicator of labor productivity.

The variables average years of study, the weight of the person, age, income, and occupation condition were used to calculate the institutional quality, human capital, and business environment indexes, and were taken from the Pesquisa Mensal de Emprego (PME, n.d.). In relation to the variable electric power generation, it was obtained the proxy for the infrastructure variable from Ipeadata (n.d.). Regarding exports, imports and GDP, the variable of trade openness was obtained, and, finally, GDP in dollars and FDI were used to measure the innovation index, and the variables were taken from the Banco Central do Brasil (BCB, n.d.) and Contas Nacionais Trimestrais (IBGE, n.d.).

3.2 Methods

3.2.1 Measurement of Variables

The analysis was made for the period from 2004 to 2014, being carried out by quarters. Therefore, it was necessary to calculate the proxies for the unit of time established. First, the methodology used for the calculation of labor productivity followed the method of

Barbosa and Pessôa (2014). Therefore, the methodology obtained was:

$$LP_t = \frac{Y_t}{L_t}, \tag{1}$$

in which t refers to each quarter, Y_t refers to total production, and L_t refers to the number of total hours worked in the economy. The real production was obtained using the implicit GDP deflator based on the year 2010. The measure of labor used in the estimation was based on the methodology of Barbosa and Pessôa (2014):

$$L_{i,j} = \sum_{\substack{i=1 \\ j=1}}^{N} p_{i,j} WH_{i,j}, \tag{2}$$

where $L_{i,j}$ is the average number of hours worked in the week of all workers, $WH_{i,j}$ is the average number of hours worked per worker, and $p_{i,j}$ is the weight of the person in the sample. The average number of hours for the month was calculated by multiplying it by the number of weeks per month and then summed to complete the quarter. Regarding the weight of the person, the weight of the last month referring to each quarter was used.

The measurement of human capital followed the methodology of Caselli (2005), being estimated through the function

$$HC_{i,j} = e_{i,j}^{\varphi_{i,j}(s_{i,j})}, \tag{3}$$

with $HC_{i,j}$ being the stock of human capital per person, $\varphi_{i,j}$ representing the returns to education and $s_{i,j}$ the average schooling. The estimation of returns to education followed the wage equation of Mincer (1974),[3] in which

$$\ln(w_{i,j}) = \beta_0 + \beta_1 s_{i,j} + \beta_2 exp_{i,j} + \beta_3 exp_{i,j}^2 + \varepsilon_{i,j}, \tag{4}$$

where $\ln(w_{i,j})$ is the natural logarithm of workers' income and $exp_{i,j}$ is equal to experience. The return to education assumed the value of β_1 in the income equation. Age above 10 years was considered as the minimum age for the estimation of total average hours worked and human capital, according to IBGE (n.d.). With regard to the institutional quality index, we chose to use the methodology proposed by Dias and Tebaldi (2012):

$$inst = \frac{\varphi\beta\gamma}{r}, \tag{5}$$

in that $\varphi\beta\gamma$ referred to people with post-secondary education, therefore, above 11 years of schooling, and r referred to uneducated people, individuals over 25 were considered in the estimation. This variable was used because, according to Dias and Tebaldi (2012), in countries where there is better institutional quality, people have more incentives to invest in education and human capital, since in the future they will obtain a return for these studies. Therefore, the higher the ratio between people with higher education and uneducated, the better the performance of institutions. Both human capital and

[3] The calculation of the income equation was done using Stata software.

institutional quality obtained monthly results, so an average was made between the months of each quarter in order to present a quarterly result.

Regarding the business environment, Fontes and Pero (2012) affirmed that a good business environment would be related to formalization conditions in the labor market, and Djankov et al. (2002) stated that the higher cost and time spent opening a new business would be associated with an increase in informality. In addition, in the Doing Business Report, World Bank (n.d.), which measures the business environment for several countries, has an index that records labor market regulation. Therefore, the formality in the labor market was treated as a proxy for the business environment, following the methodology of Barbosa and Moura (2015),[4] in which

$$BUS_t = \frac{Formality_t}{Formality_t + Informality_t}, \tag{6}$$

where BUS means business environment. Considering the proxy for infrastructure, the sum of the generation of thermal, conventional, nuclear thermal and emergency thermal power was used, then, as the variables were presented per month, these were added in order to complete the quarter. In relation to the trade openness index, according to Magalhães, Branco, and Cavalcanti (2007), the ratio between the sum of exports and imports and GDP was used:

$$TRAD = \frac{X + M}{GDP}, \tag{7}$$

where $TRAD$ means trade openness, X refers to exports and M to imports. Finally, the innovation index followed the methodology of Araujo, Araujo, Durlo, and Santos (2015), the ratio between foreign direct investment inflows and GDP:

$$INOV = \frac{FDI}{GDP}, \tag{8}$$

with $INOV$ referring to the index of innovation, and FDI referring to foreign direct investment. Regarding the variable innovation, was obtained the sum of the months to compose the index of the quarter.

3.2.2 Methodology

Before entering the econometric analysis, first, the study sought to perform a growth decomposition to verify the importance of productivity in terms of economic growth in Brazil, in the period analyzed. Thus, growth decomposition was also performed to measure how labor productivity measured by the number of average hours worked contributed to the total production, following Barbosa and Pessôa (2014), using this equation:

$$\frac{1}{N}\ln\left(\frac{GDP_{t+N}}{GDP_t}\right) = \frac{1}{N}\ln\left(\frac{LP_{t+N}}{LP_t}\right) + \frac{1}{N}\ln\left(\frac{WH_{t+N}}{WH_t}\right) + \frac{1}{N}\ln\left(\frac{OP_{t+N}}{OP_t}\right), \tag{9}$$

in which WH is the worked hours or the ratio between total hours worked and people occupied, with $N = 1, \dots, 44$, the number of observations or number of quarters.

[4]The formality proxy was used to measure the business environment due to the unavailability of monthly data for Brazil.

Then, regarding econometric analysis, time series econometric techniques were adopted, as suggested by Enders (2010), and it is considered as a unit of time the quarter in the period from 2004 to 2014 in Brazil, therefore, totaled 44 observations. First, it was necessary to verify if the analyzed variables were stationary, being analyzed by the unit root test of Augmented Dickey–Fuller (ADF), Dickey–Fuller GLS, Phillips–Perron (PP) e Kwiatkowski–Phillips–Schmidt–Shin (KPSS). As the variables were stationary at the level, the methodology of structural autoregressive vectors (S-VAR) would be used. However, if the variables presented stationarity in the differences, it would be necessary to test the existence of cointegration, and being detected the cointegration, the model would be estimated through the methodology of Vector Error Correction (VEC), however, not being detected the cointegration, the methodology would be of Structural Autoregressive Vectors (S-VAR) in the differences. The stationarity of the analyzed series is necessary so that spurious regression results cannot be generated, according to Enders (2010), so if variables with roots are presented, they must be differentiated until they become stationary. The estimated model, according to the theory, uses the following order of exogeneity:

$$lprod = \alpha_1 linov + \alpha_2 ltrad + \alpha_3 lbus + \alpha_4 lhc + \alpha_5 linfr + \alpha_6 linst + \varepsilon\,, \qquad (10)$$

in that *lprod* is the logarithm of labor productivity, *linov* is the logarithm of innovation, *ltrad* is the logarithm of the trade openness, *lbus* is the logarithm of the business environment, *linfr* is the logarithm of the infrastructure, *lhc* is the logarithm of human capital and *linst* is the logarithm of institutional quality. It was decided to estimate the model in logarithms to be analyzed in elasticities and the order of presentation of the variables was also made considering the exogeneity of the variables found according to the literature review. It is expected that all variables will have a positive impact on productivity. The S-VAR methodology denotes y as a vector $(n\times 1)$ containing the value of n variables, in the case, 7 variables, assumed in the period. According to Hamilton (1994), the dynamics of y is presumably governed by a Gaussian autoregressive vector of order p:

$$y_t = c + \Phi_1 y_{t-1} + \Phi_2 y_{t-2} + \cdots + \Phi_p y_{t-p} + \varepsilon_t\,. \qquad (11)$$

The methodology employed in the study was the S-VAR, considering the results of the unit root tests results in the variables being stationary in level, and if any variable had root, the variable in difference would be used. The S-VAR is a methodology considered as atheoretical since it does not distinguish between endogenous or exogenous variables in the estimation, which could lead to bilateral causality. Therefore the importance of defining the number of lags to be used, since the ideal would be to use few lags in the model so that many degrees of freedom would not be consumed or there would be multicollinearity or specification bias, according to Enders (2010).

Therefore, after the estimation of S-VAR, autocorrelation, heteroscedasticity and normality tests were performed in order to verify if the errors were white noise, a necessary condition for the model to present consistent results. In addition, the lag length criteria were also applied in order to specify the best lag to be used in the model. After the specification of the lag criterion, the stability of the S-VAR was verified. Finally, we obtained the results of the estimation, the impulse response function and the variance decomposition, demonstrating the impact of each independent variable on the dependent variable over time when exposed to shocks.

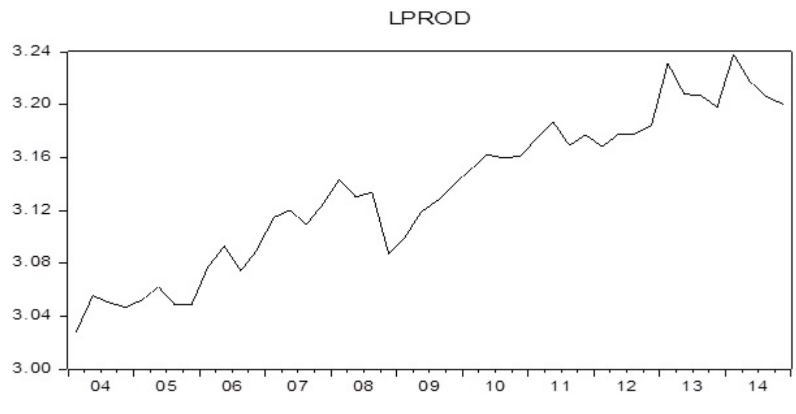
4. Results and Discussions

In analyzing the model, first of all, it is interesting to observe the productivity performance in the period. Figure 2 presents the evolution of the variable. The trend was growth in the period, the same performance obtained by Bonelli (2014), De Negri and Cavalcante (2014), Barbosa and Pessôa (2014), Bonelli and Bacha (2013), among others.

The performance of the series of the determinants was verified in Figure 3, and it was possible to observe that all the determinants presented a trajectory of growth in the period, as well as the productivity. The variables that obtained the greatest growth trajectory were stock of human capital and institutional quality, which are important not only for productivity growth but also for improvement in several other indicators of the country, such as economic growth and development. They were also the variables that were less impacted with the 2008 Crisis.

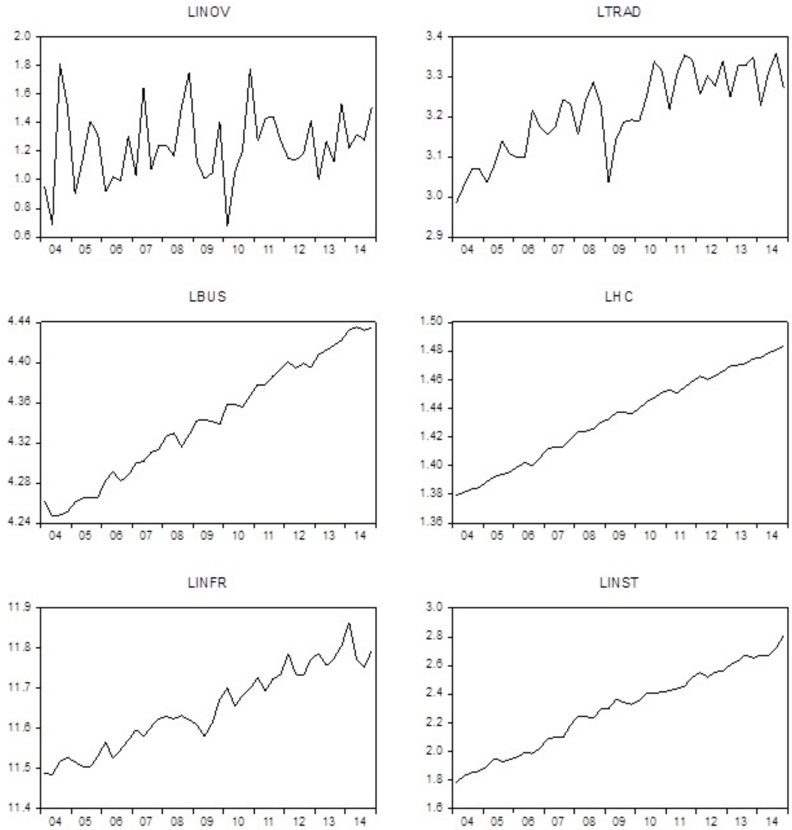
Among the variables that obtained greater volatility, there were found the logarithm of innovation and the logarithm of trade openness. In the series of trade openness, it is possible to identify a certain cycle of growth and fall of the indicator, being the exception in the period 2008–2009, which may have been due to the Economic Crisis of 2008, since it is a variable highly influenced by external movements to the country. The variable innovation obtained a significant oscillation during the analyzed period, not going unnoticed in 2008, however, on average, its growth trend was lower compared to the other determinants. The variables business environment and infrastructure, as well as human capital and institutions, tended to grow in the period, but more sustained than the last ones.

Following, Table 1 shows the contributions of the factors for Brazilian economic growth during the period from 2004 to 2014. First, it can be seen that economic growth was positive throughout the period, however, it has tended to fall over time. In addition, it can be verified that the contribution of labor productivity to growth during the period



Source: Own elaboration from the software Eviews 7 (2017).

Figure 2. Performance of the Logarithm of Brazilian Labor Productivity 2004–2014 (per quarter).



Source: Own elaboration from the software Eviews 7 (2017).

Figure 3. Graphical Analysis of the Independent Variables 2004–2014 (per quarter).

Table 1. Growth Decomposition 2004–2014 (% per quarter).

Period	GDP	LP	WH	OP
2004Q1–2004Q4	1.92	0.46 (23.87)	0.27 (14.32)	1.19 (61.80)
2005Q1–2005Q4	1.43	−0.10 (-6.83)	0.72 (50.35)	0.81 (56.49)
2006Q1–2006Q4	1.55	0.33 (21.38)	0.25 (15.97)	0.97 (62.65)
2007Q1–2007Q4	1.89	0.25 (13.17)	0.73 (38.68)	0.91 (48.15)
2008Q1–2008Q4	0.65	−1.40 (−214.89)	1.16 (177.11)	0.90 (137.77)
2009Q1–2009Q4	2.56	1.00 (39.14)	0.53 (20.57)	1.03 (40.29)
2010Q1–2010Q4	1.74	0.26 (14.77)	0.67 (38.59)	0.81 (46.63)
2011Q1–2011Q4	1.11	0.08 (7.13)	0.52 (47.02)	0.51 (45.86)
2012Q1–2012Q4	1.3	0.40 (30.50)	0.03 (2.06)	0.88 (67.44)
2013Q1–2013Q4	1.26	−0.83 (−65.89)	1.64 (130.04)	0.45 (35.85)
2014Q1–2014Q4	0.32	−0.94 (−294.08)	0.94 (292.98)	0.32 (101.10)
2004Q1–2014Q4	0.91	0.39 (43.23)	−0.01 (−0.91)	0.52 (57.69)

Note: Between parentheses, there are the percentage contributions of each input factor to economic growth, the ratio between the growth of the factor of production and the growth of production.

Source: Own elaboration based on the data of IBGE (n.d.), PME (n.d.), and Ipeadata (n.d.).

had some changes, and in some years became negative, including the last two years of the analysis. In relation to the working hours and the occupied population, it is verified that there was a positive contribution during the whole period. Thus, it is verified that the Brazilian economic growth reached during the period of analysis was not based on productivity gains, that is, there is room for improvements in productivity to lead to increases in the growth of Brazilian production.

After verifying the trends of the variables, the results of the stationarity tests are presented in Table 2, and more than one stationarity test was performed due to differences in its parameters. It was concluded that all variables were stationary in level, with the exception of human capital. Thus, the variable *lhc* was differentiated, allowing for the adoption of the structural Autoregressive Vectors methodology, which requires the stationarity of the series.

As estimated by the S-VAR model, the Lag Length Criteria test suggested the use of 3 lags by the Akaike criterion and 1 lag by the other criteria. We chose to use 1 lag in the model due to the results of the tests, also due to the limited number of observations obtained in the period, and with this option, no autocorrelation or heteroscedasticity was detected. In addition, the residues were considered normal. Thus, it was possible to verify the results of the estimation of S-VAR in Table 3.

First, with respect to the results, it can be verified that, with the exception of innovation, all other determinants contributed positively to labor productivity in the analyzed period. In addition, it was verified that among the determinants, considering the long run, according to the model, the variables trade openness, infrastructure, and institutional quality not only presented positive parameters but were also statistically significant for the estimated model. Finally, among the determinants analyzed, the one that contributed most in terms of elasticity to productivity was the institutional quality.

In the following, the results obtained from the analysis of the impulse response function are presented in Figure 4. As with the results of the econometric estimation, it is verified that innovation was the only determinant that presented a negative response of the productivity to the shocks caused in the innovation.

In the other variables, it is seen that there is a positive response of productivity to shocks occurring, with the greatest shock occurring through infrastructure, followed by business environment, institutional quality and human capital. However, it is also important to remember that only in two of these variables there was a long-run statistical significance. Thus, both institutional quality and infrastructure provide positive impacts on the performance of long-run labor productivity.

The decomposition of the variance shows how productivity decomposes itself in terms of the analyzed variables, it is possible to verify its results in Table 4. It is interesting to note that in the very short run the productivity variable is fully explained by itself, and the other variables were not representative. However, as the periods progressed, productivity began to depend on other determinants, although not much, because after ten quarters it is seen that it was still responsible for 76.58% of its variations.

Considering the short period of two quarters, not counting productivity itself, the variable that most caused variations was infrastructure, with 8.15%, followed by innovation with 2.97%, but it is necessary to remember that according to the

Table 2. Results of the Unit Root Tests.

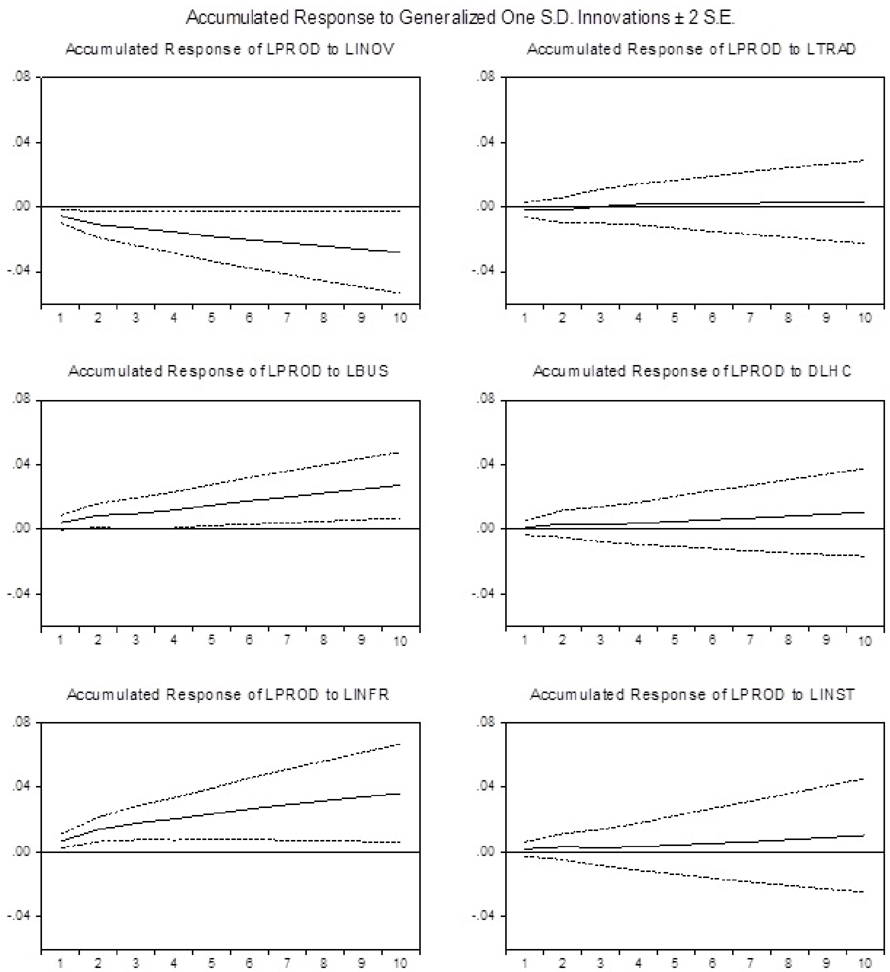
Variables	Statistic t	1% Critic Value	5% Critic Value	10% Critic Value
ADF – Level				
lprod	−3.9956	−4.186481	−3.51809	−3.189732
linov	−6.567211	−4.186481	−3.51809	−3.189732
ltrad	−2.551058	−4.211868	−3.529758	−3.196411
lbus	−5.694939	−4.192337	−3.520787	−3.191277
lhc	−2.978318	−4.186481	−3.51809	−3.189732
linfr	−3.353767	−4.211868	−3.529758	−3.196411
linst	−3.282199	−4.186481	−3.51809	−3.189732
ADF – 1 Difference				
ltrad	−3.090306	−4.211868	−3.529758	−3.196411
lhc	−7.359523	−4.205004	−3.526609	−3.194611
ADF – 2 Difference				
ltrad	−13.61044	−4.211868	−3.529758	−3.196411
GLS – Level				
lprod	−4.006257	−3.77	−3.19	−2.89
linov	−6.39185	−3.77	−3.19	−2.89
ltrad	−2.107448	−3.77	−3.19	−2.89
lbus	−4.130388	−3.77	−3.19	−2.89
lhc	−3.070016	−3.77	−3.19	−2.89
linfr	−3.127182	−3.77	−3.19	−2.89
linst	−3.217647	−3.77	−3.19	−2.89
GLS – 1 Difference				
ltrad	−2.640952	−3.77	−3.19	−2.89
GLS – 2 Difference				
ltrad	−1.708917	−3.77	−3.19	−2.89
PP – Level				
lprod	−3.976022	−4.186481	−3.51809	−3.189732
linov	−9.054699	−4.186481	−3.51809	−3.189732
ltrad	−4.684137	−4.186481	−3.51809	−3.189732
lbus	−6.31507	−4.186481	−3.51809	−3.189732
lhc	−2.876072	−4.186481	−3.51809	−3.189732
linfr	−5.128272	−4.186481	−3.51809	−3.189732
linst	−3.192639	−4.186481	−3.51809	−3.189732
PP – 1 Difference				
lhc	−12.51271	−4.192337	−3.520787	−3.191277
KPSS – Level				
lprod	0.073056	0.216	0.146	0.119
linov	0.201673	0.216	0.146	0.119
ltrad	0.124716	0.216	0.146	0.119
lbus	0.071478	0.216	0.146	0.119
lhc	0.223768	0.216	0.146	0.119
linfr	0.075149	0.216	0.146	0.119
linst	0.1583	0.216	0.146	0.119
KPSS – 1 Difference				
lhc	0.15985	0.216	0.146	0.119

Source: Own elaboration from the software Eviews 7 (2017).

Table 3. Estimates for the Model, 2004–2014.

Variables	Coefficients	Standard-error	Statistic z	Prob.
lprod	0.010426	0.001138	9.165151	0.000000
linov	−0.000017	0.001609	−0.010580	0.991600
ltrad	0.007211	0.001791	4.026215	0.000100
lbus	0.000764	0.001958	0.390428	0.696200
lhc	0.000938	0.001962	0.478258	0.632500
linfr	0.033524	0.004152	8.073896	0.000000
linst	0.346630	0.038223	9.068600	0.000000

Source: Own elaboration from the software Eviews 7 (2017).



Source: Own elaboration from the software Eviews 7 (2017).

Figure 4. Impulse-Response Function.

Table 4. Decomposition of Variance.

Period	S.E.	LPROD	LINOV	LTRAD	LBUS	DLHC	LINFR	LINST
1	0.014684	100	0	0	0	0	0	0
2	0.017424	86.83745	2.972981	0.182771	1.625818	0.226698	8.153096	0.001189
3	0.018285	82.11693	2.867828	2.263976	2.016969	0.551795	10.12671	0.055791
4	0.019003	81.30535	2.854395	2.926662	2.751554	0.579937	9.507707	0.074395
5	0.019721	80.54826	3.012158	2.813462	3.777733	0.540428	9.225496	0.082467
6	0.02024	79.41267	3.032252	2.767676	4.636341	0.519634	9.505024	0.126398
7	0.020659	78.54303	3.024177	2.823037	5.338405	0.504163	9.558958	0.208226
8	0.021069	77.87828	3.056118	2.828229	6.014356	0.484851	9.447907	0.290264
9	0.021461	77.22491	3.100408	2.791249	6.671733	0.467592	9.374984	0.369123
10	0.021817	76.58262	3.130257	2.759612	7.276473	0.452794	9.344648	0.453594
Cholesky Order: LPROD LINOV LTRAD LBUS DLHC LINFR LINST								

Source: Own elaboration from the software Eviews 7 (2017).

previous analysis, this contribution is negative, moreover, initially, the determinant that contributed least was institutional quality. Within ten quarters, infrastructure continued to be the determinant that caused most changes in productivity, followed by the business environment, innovation, trade openness, human capital and institutional quality, which remained the determinant that caused the least changes in productivity. This may happen due to the resilience of institutions to change in the short run. Therefore, both short-run and long-run policies that aim to stimulate productivity could stimulate improvements in infrastructure for this purpose. When verifying how much each determinant responds for the variations in the productivity, it was possible to verify some productivity rigidity in the short run, that is, the majority of the explanations of its variances were explained by itself. This left little space for the performance of the other variables, at least in a short period, as analyzed by the model. Therefore, when comparing the results of Table 4 with the increasing productivity performance in Figure 1 and the increasing performance of the determinants in Figure 3, it was possible to verify that, although the determinants are growing in the period, their effects have not yet been enough so that productivity has sufficient effect to contribute positively and sustainably to long-run growth.

Therefore, according to the results of the econometric analysis together with the results described in the empirical evidence, it was verified that in fact, the determinant variables analyzed influence the Brazilian productivity performance in the period. The variable that presented the greatest influence on productivity was the infrastructure since it has great importance for generating positive externalities, as Campos et al. (2015), and Velloso et al. (2012) pointed out, mainly highlighting the transports infrastructure. This is because if there is poor quality infrastructure there is a generation of negative externalities, through increased costs, rigidity, and inefficiency throughout the economy, considering that it would be necessary to use transport both to move inputs and production, which could also cause negative impacts even in foreign trade. Thus, good quality infrastructure generates returns to the economy that improves its efficiency, since companies could conduct their productions far from the center of their consumers, being able to worry about settling in a place that would provide a better labor force, technological diffusion, among others.

5. Final Considerations

The objective of the present study was to verify the impact of some determinants, together, on the performance of Brazilian labor productivity in the period from 2004 to 2014, considering the trend of low growth that this variable has been suffering in the last decades and its importance for the country's economic growth. What has been verified is that the literature review, both theoretical and empirical, recognizes the importance of the impact of these selected determinants on productivity performance.

From the analysis of the trend of these variables in logarithms in the period covered, it was verified that the determinants had a tendency of growth in the period, some of which grew more than the others. It was verified that human capital and institutions were the determinants that obtained the highest increase, and that were less affected by the Crisis of 2008, whereas the innovation and the trade openness were the determinants that had more oscillation during the period, being that the first had more modest growth compared to the other determinants, despite the oscillations, and the last was the determinant that was most affected by the 2008 Crisis.

Then, when analyzing the impacts of the determinants together on productivity, it was possible to verify that, although these determinants increased during the period, this was not enough for productivity to grow uniformly and positively, and sustainably influence economic growth. Therefore, even greater improvements are needed with a longer time horizon in the determinants so that they can positively influence productivity, being that this is a variable that in the short term is more influenced by its own past behavior, that is, the low efficient past performance. Thus, it is necessary to aim for the long term to achieve changes in productivity behavior. Regarding the effects of the determinants analyzed, through the analysis of time series, it was verified that improvements in infrastructure, but also in institutional quality, tend to have a greater impact on productivity in both the short and long periods.

Therefore, it would be important to consider the impacts of exogenous determinants on the production process for productivity analysis. In doing so, it was found that infrastructure had a greater effect on productivity performance, however, it must be remembered that the analysis was based on the short run, and the effect of the determinants was low, accounting for less than 25% of the variances productivity. Thus, it is concluded that a longer period would be necessary for the variables to influence and stimulate productivity growth, given its resilience in the short run.

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