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EFFECTS OF INVESTMENTS IN TRANSPORTATION INFRASTRUCTURE ON ECONOMIC GROWTH IN BRAZIL

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ABSTRACT

This paper investigates the effect of investments in transportation infrastructure on Brazilian economic growth over the period from 2000-2016. The theoretical approach is based on the Solow Growth model.This model explains that economic growth is decomposed into capital, education, and technology investment shocks.The estimation of the effect of these shocks on GDP growth in Brazil was using the Error Correction Mechanism Vector Model (VECM).The econometric results show a bidirectional relationship between investment in transportation infrastructure and economic growth.This endogeneity among the time series was verified by the Granger test.In general, the shocks of transportation investments in Brazil are statistically significant and persist in GDP growth for up to 6 years.

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INTRODUCTION

Investments in infrastructure, technological progress and education are some of the factors capable of promoting economic growth, according to the theoretical model proposed by Solow (1956). Decomposing these investment shocks into an economy is the starting point of Solow's growth model, whose main objective is to study the determinants of a country's economic progress (Romer, 2006). In the specific case of this study, the focus will be investments in transportation infrastructure. In the economic literature it is a consensus that investments in infrastructure, including those with transportation , are capable of increasing total factor productivity, reducing production costs, increasing incomes and generating increases in production levels (Krugman, 1991, Fourie, 2006). The effects of building new roads and even spending on urban mobility impact the economy at various levels, both regionally and nationally (Littman, 2010). In Brazil, the Institute for Economic and Applied Research (IPEA, 2010) found that problems related to transportation infrastructure affect the economic growth of the country. According to this study, the history of Brazilian investments in the modernization of transportation infrastructure began in the 90's, but it is still very precarious due to the high dependence on road transportation and its high costs. According to the National Land Transportation Agency (ANTT, 2018), Brazilian transportation modes correspond to 59% of highways, 24% of railroads, 13% of waterways, 3.7% of pipelines and only 0.3% the airport.The impact on the growth of economic activities is direct, due to the loss of competitiveness both in the domestic market and in the international market. A substantial literature has evaluated the impact of transportation investment on the growth of countries.All studies have found that the effect is positive and statistically significant. However, the magnitude of this effect varies with the degree of development of the countries.All studies estimate the effect of transportation investment shocks through econometric procedures.Most of the studies use econometric procedures of multivariate time series and regression models in panel without correction of endogeneity. The average impact of transportation investments on GDP in Brazil varies from 0.01 to 0.5% (Bertussi and Elery Jr., 2011, Maia, 2015, Castro, 2016,Queiroz and Fernandez, 2017).While in countries like India the effect is progressive with time, reaching up to 1.81% (Pradhan and Bagchi, 2013). In this context, the objective of this paper was to verify the intensity with which investments in transportation infrastructure affect the economic growth of Brazil, from 2000 to 2016. In particular, it was still evaluated whether there is any degree of endogeneity between the series of investments in transportation and economic growth, in order to test whether economic progress promotes even more transportation investments in Brazil. The contribution of this study is to reveal to what extent transportation investments are capable of influencing the growth of Brazilian production, as well as to study the intensity and duration of these shocks over time. In addition to this introduction, the paper contains a literature review on economic growth and transportation investments. The methodological section presents the Solow economic growth model and the econometric procedures of multivariate time series adopted.The fourth section contains the results estimated using a model of Error Correction Mechanism Vectors. Finally, the last section presents some conclusions and economic notes.

TRANSPORTATION INFRASTRUCTURE INVESTMENTS AND ECONOMIC GROWTH

The impact of transportation investment in the economic growth of the countries has been the focus of several studies.These papers identify the relationship and impact of these investments in the economic development of the nation.The magnitude of investment shocks in transportation infrastructure in GDP growth depends on the econometric methodology used and the degree of development of the country analyzed. Overall, all authors point out that the impact is positive and statistically significant. See Table 1 for more specific details. Several studies have noted the importance of capital invested in transportation for the development of countries (Boopen, 2006, Aboset, 2016, Peter, Rita and Edith, 2015).

Table 1. Bibliographic Review on Economic Growth and Investments in Transportation

Author	Country	Method	Endogeneitytest	Impact
PradhanandBagchi (2013)	India	Vector ErrorCorrection Modelo (VECM)	No	(0.58%) in the short time, to (1.77%) in the medium time and (1.81%) in the long time.
Silva, Bertonciniand Silva (2017)	Brazil	Panel (fixedeffect)	No	Positive (0.044%) [inelastic]
Boopen (2006)	Africa	Dinamic Panel (GMM Arellano Bond)	Yes	Positive (0.43%) [inelastic]
Farias and Teixeira	Brazil	Panel	No	Positive (0.01%) [inelastic]
Queiroz and Fernandes (2017)	Brazil	Panel	No	Positive (0.5%) [inelastic]
Castro (2016)	Brazil	Spatial Difference-in-difference	No	Positive
Maia (2015)	Brazil	Panel	No	Positive (0.02%) [inelastic]
BertussiandEllery Jr. (2011)	Brazil	Panel (fixed effect) and quantile regression	No	Positive (0.34%) [inelastic]
Peter, Rita and Edith (2015)	Nigeria	Probit Model and multivariate model	No	Positive (0.21) [inelastic]
Alder (2015)	Indiaand China	General Equilibriummodel	No	Positive
Badalyan, HerzfeldandRajcaniova (2014)	Armenia, GeorgiaandTurkey	Panel cointegration analysis and panel causality analysis	No	Positive
Aboset (2016)	Ethiopia	Multivariate Time Series	No	Positive

Note: elaborated by the authors.

This relationship was analyzed for African countries, identifying positive, inelastic and statistically significant impacts. Similarly, the study of Pradhan and Bagchi (2013) noted the two-way effect between the transportation economy and economic growth in India. After all, road transportation is one of the basic inputs in the production process. The authors also verified that investments in road infrastructure promote economic growth at different intensities over time. In the long term the impact can reach 1.8%, the only elastic result of the literature. The same studies carried out in several countries were also made for a Brazilian economy (Bertussi and Ellery Jr., 2011, Maia, 2015, Queiroz and Fernandes, 2017).Araújo Jr. (2006) points out in his study that an increase promoted in infrastructure investments generates higher rates of economic growth in the long term. Differently from the other studies, the authors developed a dynamic computable general equilibrium model calibrated for the Brazilian economy. Bertussi and Ellery Jr. (2006) analyzed the relationship between economic growth and transportation investments locally. They analyzed the expenses of the Brazilian states and their effects on the growth of the country, from 1986 to 2007.In their study the authors concluded that the positive relationship between public spending in the transportation sector and the economic growth rate of the Brazilian states is a local phenomenon, not a global experience.

METHODOLOGY

In this section, both a basic model of economic growth and an econometric estimation of the effects of transportation investments will be presented.The theoretical model is based on the Solow Economic Growth Model (Solow, 1956), whose main purpose is to explain the determinants of a country's economic progress. All the econometric procedures fall on multivariate time series models, such as Autoregressives Vectors and Error Correction Models.

Basic Model: At any point in time, when capital (k_t), technology (a_t) and labor (l_t) levels are combined, there will be the determination of the product y_t. Thus, equation 1 is specified.

$$y_t = f(k_t, a_t, l_t) \tag{1}$$

According to Solow (1957), the importance of equation 1 is to note that marginal changes in k_t and l_t, over time, may be able to promote variations in y_t. The model does not ignore the technological progress, in these circumstances, it will occur when increases occur in a_t (Romer, 2006). Thus, the growth of y_t can be specified as follows.

$$\dot{y}_t = \frac{dy_t}{dk_t}.\frac{dk_t}{dt} + \frac{dy_t}{dl_t}.\frac{dl_t}{dt} + \frac{dy_t}{da_t}.\frac{da_t}{dt} \tag{2}$$

on what $\frac{dk_t}{dt} = \dot{k}_t$specifies changes of capital over time, $\frac{dl_t}{dt} = \dot{l}_t$represents changes in work levels, and$\frac{da_t}{dt} = \dot{a}_t$considers technological progress. Thus, from mathematical manipulations, the equation 3 is specified.

$$\frac{\dot{y}_t}{y_t} = \frac{dy_t}{dk_t}.\frac{\dot{k}_t}{k_t}.\frac{k_t}{y_t} + \frac{dy_t}{dl_t}.\frac{\dot{l}_t}{l_t}.\frac{l_t}{y_t} + \frac{dy_t}{da_t}.\frac{\dot{a}_t}{a_t}.\frac{a_t}{y_t} \quad (3)$$

According to Romer (2006), the following coefficients can be interpreted as elasticities. Since $\alpha_k = \frac{dy_t}{dk_t}.\frac{k_t}{y_t}$is the elasticity of economic growth relative to capital, $\alpha_l = \frac{dy_t}{dl_t}.\frac{l_t}{y_t}$is the elasticity of growth relative to labor, and$\alpha_a = \frac{dy_t}{da_t}.\frac{a_t}{y_t}$is the elasticity of growth relative to technological progress. In this context, equation 4 specifies a way of measuring the contribution of investments in capital (transportation) to economic growth, emphasizing that one of the likely consequences of y_t growth would be economic development. Therefore, the final equation to be estimated is 4.

$$\frac{\dot{y}_t}{y_t} = \alpha_k.\frac{\dot{k}_t}{k_t} + \alpha_l.\frac{\dot{l}_t}{l_t} + \alpha_a.\frac{\dot{a}_t}{a_t} \quad (4)$$

Econometric Procedures: In order to evaluate the effects of investments in Transportation (INVT) on the series of annual variation of the Gross Domestic Product (GDP) - proxy for economic growth, we used multivariate time series models. The Autoregressive Vector Model (VAR) approach allows the analysis of the dynamic effects of changes in variables included in a multiequation model, with the advantage of considering all variables as endogenous (Greene, 2006).

Thus, the following model is specified:

$$GDP_t = \alpha_{01} + \alpha_{11}INVT_t + \alpha_{21}INVT_{t-1} + \cdots + \alpha_{k1}INVT_{t-k} + \beta_{11}GDP_t + \beta_{21}GDP_{t-2} + \cdots + \beta_{l1}GDP_{t-l} + \varepsilon_{1t} \quad (5)$$

$$INVT_t = \gamma_{02} + \gamma_{12}GDP_t + \gamma_{22}GDP_{t-1} + \cdots + \gamma_{k2}GDP_{t-m} + \delta_{11}INVT_t + \delta_{21}INVT_{t-2} + \cdots + \delta_{l1}INVT_{t-n} + \varepsilon_{2t} \quad (6)$$

where α, β, γ and δ are sets of parameters to be estimated,k, l, m and n are the final time lags of the time series, and ε_{1t} and ε_{2t} are random errors of the respective equations.The option was a logarithm model, after all its estimates are elasticities in relation to the regressor variables. According to Greene (2006), the first procedure to estimate multivariate time series models is the stationarity tests. The tests used were the Dickey-Fuller Augmented Test (ADF) and the Phillips-Perron Test. Although the former is parametric and the latter non-parametric, its null hypotheses are non-stationarity. If the GDP_t and $INVT_t$series are integrated first order processes $I(1)$, the partial difference between them may be stable and around a fixed average (Greene, 2006). Thus, the series would fluctuate together at similar rates.If the two series meet these requirements, they are considered as cointegrated.To check a pattern of cointegration between the series we use the Johansen Test, whose advantage is to verify the presence of more than one cointegration vector (Johansen, 1998, Johansen, 1991). If there is cointegration between GDP and INVT, it means that there is a long-term relationship between the variables. In circumstances of some short-term imbalance, an error vector is in charge of correcting. Thus, instead of the VAR model, an Error Mechanism Vector Model (VECM) is specified (Pradhan and Bagchi, 2013).By means of the VEC model it is possible to obtain two procedures, the Decomposition of the Variance (DV) of the variable of interest and Impulse-Response Functions (IRF).DV reports the proportion of prediction error variance that results from each endogenous variable, over the forecast horizon. The IRF measures the reaction time of the responses to shocks in the variables of interest.The importance of IRF analysis is to verify the direction, pattern and duration of responses from shocks. In addition, the Granger Causality Test (GCT) was implemented. This test reveals whether variations in the INVT precede time variances in GDP. If so, we do not reject the hypothesis that INVT causes in Granger's sense economic growth. This test checks the direction of causality, whether it is unidirectional or bidirectional. When bidirectional, the test reveals that variations in GDP also precede variances in INVT, that is, the fact that the Brazilian economy grows GDP also requires investments in transportation .

Data and Data Source: Data were extracted from the World Bank (WB, 2018). The selected variables were Investment in Transportation (INVT), Time Series of GDP Variations, Science and Technology (CTI) and Education (EI) series. The period of analysis was from 2000 to 2016. In order to test the robustness of the VECM or VAR models, structural breakpoint tests were evaluated in government transitions, specifically in the years 2002 and 2008.

The variables used are specified below:

- *Transportation Investment (INVT)* - Investment in transportation projects with private participation covers infrastructure projects in transportation that have reached financial closure and directly or indirectly serve the public. Data are in current U.S. dollars.
- *Gross Domestic Product (GDP)* - Annual percentage growth rate of GDP at market prices based on constant local currency. Aggregates are based on constant 2010 U.S. dollars.
- *Information and Communication Technology Investment (ICT)* - Investment in ICT with private participation is the value of commitments to information and communications technology backbone infrastructure projects (including land based and submarine cables) that have an active government component (eg, the government is a contracting authority).
- *Government Expenditure on Education (EI)* - General government expenditure on education (current, capital, and transfers) is expressed as a percentage of GDP. It includes expenditure funded by transfers from international sources to government.

Some data show that the investment in transportation in Brazil is about 5.5 billion a year. The average growth of Brazilian GDP was 2.3% in the period studied. In percentage terms of GDP, transportation investment in Brazil does not total 1%. In relation to the advanced countries, Brazil is in relative delay to Germany, France and the United States. However, the average annual growth of the Brazilian GDP exceeded almost all the countries listed in Table 1. It is interesting to note that transportation investments are related to the degree of development of the countries. Nevertheless, Transportation Investments in Brazil surpasses almost all underdeveloped countries, for example in India and Russia, but is far behind the United States. All of this information is shown in Table 2.

Table 2. Brazilian Investment in Transportation Relating to the Rest of the World - 1990/2016

Brazilian Investment in Transportation Relating to the Rest of the World - 1990/2016							
Country	RelativeInvestment	Relative GDP growth	% GDP invested in transport	Country	RelativeInvestment	Relative GDP growth	% GDP invested in transport
India	1,29	0,35	0,18	Mozambique	38,29	0,31	1,24
Turkey	1,38	0,49	0,45	Ukraine	41,9	-1,35	0,13
China	2	0,24	0,20	Venezuela	54,2	0,74	0,20
Russia	3,87	3,65	0,10	Uruguay	84,72	0,73	0,12
Mexico	3,89	0,81	0,13	Bolivia	88,2	0,55	0,18
Colombia	4	0,63	0,47	Paraguay	99,32	0,68	0,21
Peru	6,14	0,52	0,46	Angola	102,78	0,47	0,06
Brazil	-	-	0,31	Romania	114,2	1,17	0,03
Argentina	4,56	0,72	0,13	Somalia	544,1	-1,55	0,90
South Africa	7,56	0,97	0,23	United States	0,007	0,95	1,20
Chile	9,58	0,48	0,23	Germany	0,02	1,40	1,04
Iraq	10,89	0,25	0,29	France	0,9	1,47	0,95

Source: World Bank, 2018. Elaboration of the authors.

ECONOMETRIC RESULTS

This section presents the estimated results of the proposed model in equations 5 and 6. At first, the order of integration of the series was verified, by means of the Dickey Fuller and Philips Perron Tests for unit root detection. The next step was to verify the endogeneity and cointegration properties of the series, through the Granger Causality Test and the Johansen Cointegration Test. By means of these statistics, we opted for a vector model of error correction mechanism. Finally, we estimated the post-estimation procedures, such as the Decomposition of Variance and the Impulse and Response Functions.

Stationarity tests: According to the Dickey-Fuller Augmented (ADF) and Phillips-Perron (PP) tests, at the established levels of significance, it is not possible to reject the hypothesis that the time series of Transportation Investment (TINV) and GDP variation are processes non-stationary with presence of 1 unit root (Elliot, Rothenberg and Stock, 1996).All results are shown in Table 3. Still as verified in the stationarity tests, only one difference is sufficient to make the respective series in stationary processes. In order to verify if the series are endogenous and cointegrated, the Granger test and the Johansen test are recommended. The Johansen test estimate is indispensable for deciding between an Auto Regressive Vector (ARV) and an Error Correction Mechanism Vector (ECMV).

Table 3. Estimates of stationarity tests Dick-Fuller Augmented and Phillips-Perron

Unit Root Test									
Variables	ADF Test	Phillips Perron Test	ADF Test lags(1)	Phillips Perron Test lags(1)	ADF Test lags(2)	Phillips Perron Test lags(2)	ADF Test lags(3)	Phillips Perron Test lags(3)	Unit Root Number
Investiment Transport	-2,899* [0,0455]	-2,916* [0,0435]	-1,704*** [0,4290]	-2,867* [0,0494]	-1,741*** [0,4100]	-2,916* [0,0435]	-1,545*** [0,5115]	-2,921* [0,0429]	1
GDP	-2,876* [0,0482]	-2,876* [0,0482]	-1,159*** [0,6911]	-2,870* [0,0489]	-0,178*** [0,9400]	-2,944* [0,0405]	0,553*** [0,9804]	-3,081* [0,0280]	1
d1_Investment Transport	-6,341 [0,0000]	-6,341 [0,0000]	6,686 [0,000]	-6,382. [0,0000]	6,520. [0,0000]	-6,493 [0,0000]	-3,610. [0,0056]	-6,760 [0,0000]	0
d1_GDP	-6,582 [0,0000]	-6,582 [0,0000]	-4,495 [0,0000]	-7,162 [0,0000]	-4,337 [0,0000]	-8,346 [0,0000]	-4,005 [0,0000]	-7,759 [0,0000]	0

Note: The variables "d1_Investment Transport" and "d1_GDP" correspond to the first difference of the respective time series.***, ** and * denote those statistically significant variables at the 1%, 5% and 10% levels.
Source: Search results.

Endogeneity and Cointegration Tests: Testing the properties of endogeneity is important to verify if temporal variations in a respective time series precede in time the variations in another series (Granger, 1981). If this hypothesis can not be rejected, it considers that the series can be part of an endogenous system and modeled by an ARV. The results of the Granger Causality test are shown in Table 4. According to the Granger Test estimates, the stochastic processes analyzed are endogenous. This means that the Variations of Transportation Investment precede the variations presented by GDP in Brazil. These results probably show that transportation infrastructure investments are able to promote economic growth. In addition, this study sought to determine whether the investments in transportation in Brazil and GDP growth have a common trend. When this occurs, it is stated that these time series have long-term equilibria.

However, to verify if there are possible short-term equilibria, the Johansen Cointegration test is estimated. The results of the Johansen Cointegration test were shown in Table 5. In the above estimates, one does not strongly reject a hypothesis of non-cointegration and does not reject a hypothesis in the cointegration equation. Thus, it is accepted that there is at least one cointegration equation in the multivariate model. In this way the specified model was a Vector of Error Correction Mechanisms (VECM) (Ramanathan, 2001). The estimation of the VECM model was presented in Table 6, although in the specialized literature it is not necessary, after all the important are the post-estimation procedures, such as the impulse response functions and the variance decomposition. According to the information criteria of Akaike, Schwarz and Hanna-Quinn, the estimated VECM model is the first order (Paulsen, 1984).

Table 4– Granger Endogeneity Test Estimates

Unit Root Test									
Variables	ADF Test	Phillips Perron Test	ADF Test lags(1)	Phillips Perron Test lags(1)	ADF Test lags(2)	Phillips Perron Test lags(2)	ADF Test lags(3)	Phillips Perron Test lags(3)	Unit Root Number
InvestimentTransport	-2,899* [0,0455]	-2,916* [0,0435]	-1,704*** [0,4290]	-2,867* [0,0494]	-1,741*** [0,4100]	-2,916* [0,0435]	-1,545*** [0,5115]	-2,921* [0,0429]	1
GDP	-2,876* [0,0482]	-2,876* [0,0482]	-1,159*** [0,6911]	-2,870* [0,0489]	-0,178*** [0,9400]	-2,944* [0,0405]	0,553*** [0,9804]	-3,081* [0,0280]	1
d1_Investment Transport	-6,341 [0,0000]	-6,341 [0,0000]	6,686 [0,000]	-6,382. [0,0000]	6,520. [0,0000]	-6,493 [0,0000]	-3,610. [0,0056]	-6,760 [0,0000]	0
d1_GDP	-6,582 [0,0000]	-6,582 [0,0000]	-4,495 [0,0000]	-7,162 [0,0000]	-4,337 [0,0000]	-8,346 [0,0000]	-4,005 [0,0000]	-7,759 [0,0000]	0

Note: ***, ** and * denote that the Wald statistic is statistically significant and the non-causality hypothesis is rejected. Source: Search results.

Table 5. Estimates of the Johansen Cointegration Test

Johansentests for cointegration				
NullHypotesis	Lambda_max	CriticalValue (5%)	Lambda_trace	CriticalValue (5%)
r=0	12,3052	10,07	17,5663	15,41
r<=1	5,2611**	3,76	5,2611**	3,76
r<=2	4,8910**	1,890	-	-

Note: ***, ** and * denote significant statistics at significance levels of 1%, 5% and 10%, respectively.When they are significant, a hypothesis of non-cointegration is not strongly rejected. Source: Search results.

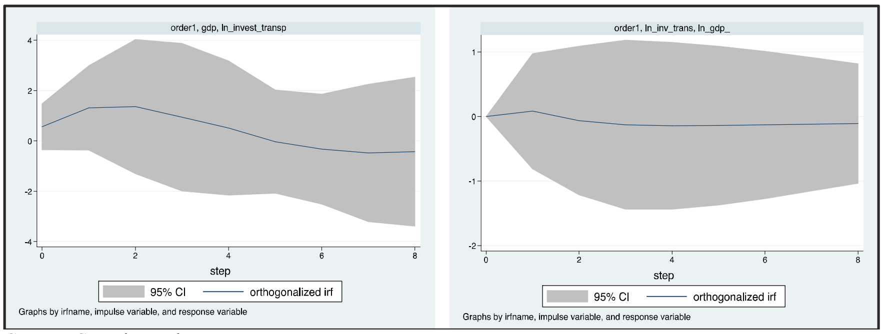
The first part of estimation table contains the estimates of the short-run parameters. The second part of estimation table contains the estimated parameters of the cointegrating vector for this model. In general, the estimates of the model are statistically adequate and significant. The coefficient of the variable "Investment in Transport" in the cointegration equation is statistically significant, as well as the adjustment parameters. In addition, the adjustment parameters are easy to interpret and provide estimates with the correct signals, implying a rapid adjustment towards equilibrium. When the predictions of the cointegration equation are negative, the transportation investment is above its equilibrium value, because its coefficient in the cointegration equation is negative. Thus, when transportation investment in Brazil is very high, it rapidly increases GDP growth levels.

Table 6. Estimates of the VECM model

Vector Error-correctionModel		
Variables	d_GDP	d_Invest_Transp
CorrectionErrorMechanism	-1,2858** [0,6076]	0,00507** [0,000215]
GDP_ld	0,0929 [0,3866]	-0,00022*** [0,000137]
Invest_transp_ld	0,00016* [0,00073]	-0,88898*** [0,2732]
Constant	-0,3913 [0,7177]	92,3436 [254,01]
Cointegratingequations		
ln_gdp	1,0000 [.]	
ln_invest_transp	-0,3095 [0,0203]	
Constant	6,8421 [.]	

Note: ***, ** and * denote the statistical significance of the variables and their lags.Source: Search results.

Impulse and Response Functions: From a statistically suitable model, we estimate the Impulse-Response Functions (IRF).Unlike a stationary ARV, the lagged variables in the VECM model are not reversible to the average and this implies that the effects of the Transportation Investment shocks in Brazil will not disappear over time. The graphs of the IRFs can be analyzed in Figure 1.



Source: Search results.

Figure 1. Estimates of Impulse-Response Functions

The graphs indicate that an orthogonalized shock in the Transportation Investment has a long effect on the Brazilian GDP growth, but that an orthogonalised shock on GDP has a transient effect.According to this model, a shock in Transportation Investment persists in the series of GDP growth in up to 6 years. The same effect is not observed in the influence of the GDP in the investments in Transports. However, it is important to mention that the endogeneity of these time series means that Investment in Transportation Infrastructure is capable of promoting economic growth, as well as economic growth is capable of promoting more investments in Transportation.

Forecast-error Variance Decompositions: From the historical decomposition of the prediction error it is possible to analyze the participation of each variable in changes occurred in the others. The objective is to verify the magnitude of transportation shocks contribute to the growth of Brazilian GDB. According to the Solow Growth model, GDP growth can be decomposed into investment shocks in technology, education and capital (investment in transportation infrastructure). Thus, a new VECM model was estimated with variables related to investments in technology, education and infrastructure. Thus, a new VECM model was estimated with variables related to investments in technology (ICT), education (EI) and infrastructure (INVT). Decomposition of the variance of the prediction errors of the GDP with the inclusion of EI and ICT variables are shown in Table 7.

Table 7. Decomposition of the variance of the GDP forecast errors

Portion of GDP variation explained (%)				
Time Course (years)	INVT	EI	ICT	GDP
1	7,08	7,17	4,71	81,04
2	7,45	7,64	4,82	80,09
3	5,89	9,04	5,73	79,34
4	3,29	10,94	6,67	79,10
5	2,87	12,29	6,73	78,11
6	0,20	14,89	6,84	78,07
7	0,19	15,82	6,94	77,05
8	0,19	15,85	6,97	76,99
9	0,17	16,51	7,15	76,17
10	0,16	16,52	7,39	75,93

Source: Search results.

The results presented in Table 7 show the decomposition of shocks in the GDP variance, according to the EI, ICT and INVT variables. It is important to note that transportation investments in Brazil lasted for up to 6 years in GDP growth. Another interesting aspect is that investments in transportation have decreasing returns to scale. In the first two years the three types of investments presented the same magnitude of shock in the GDP growth. owever investments in education are increasing in the long term. Other aspects are evident, such as the growth of GDP itself and the need for reinvestments in transportation infrastructure. Note that 75% of GDP growth is explained by itself or by other factors that this research does not consider. In addition, investments in transportation infrastructure have persistent effects on the GDP series for up to 6 years. From six years or during this period, there is a need for reinvestments.

CONCLUSION

The objective of this paper was to analyze the long-term relationship between economic growth and investments in transport infrastructure in Brazil.The results show the difficult decision of the Brazilian government to invest in the medium and long term. The opportunity cost of not investing in education is very high and unrecoverable in up to 1 decade. However, investments in transportation are essential to explain growth in the short and medium term. This fact becomes even more worrying when one considers that the Brazilian economy is totally dependent on the road infrastructure. The Brazilian economic growth depends strictly on investments in transportation , as well as needs reinvestments in the already existing structure. From the results of this research, the endogenous aspect of transportation investment shocks is the key to growth. After all, the evolution of spending on transportation infrastructure promotes GDP growth, and this GDP growth promotes even more investments in transportation. For future research, it is recommended a more detailed analysis of the relation between investments in transportation and economic growth in Brazil. It is recommended the study of the shocks of investments in transportation infrastructure in the Brazilian states, because a great part of these investments are state. In addition, it is recommended to test the spatial overflow effects of these investments, because the Brazilian production is still transported by several States from the point of origin. It is believed that investments made in certain localities of Brazil generate economic growth in their vicinity.

REFERENCES

Aboset, T. A. 2016. The effects of government transportation infrastructure expenditure on economic growth in Ethiopia. Addis Ababa University, Ethiopia.

Alder, S. 2015. Chinese Roads in India: The Effect of Transportation Infrastructure on Economic Development. University of North Carolina at Chapel Hill, 2015.

ANTT – Agência Nacional de Transportes Terrestres. Disponível em: <http://www. antt.gov.br/index.php /content/view/4744/Publicacoes.html>. Acess: jan.

Araújo Jr., I. T. 2006. Investimentos em Infraestrutura e Crescimento Econômico no Brasil. Economia e Desenvolvimento, Recife (PE), v. 5, n. 2, p. 161-188.

Badalyan, G., Herzfeld, T. and Rajcaniova, M. 2014. Transportation infrastructure and economic growth: Panel data approach for Armenia, Georgia and Turkey. 142nd EAAE Seminar Growing Success? Agriculture and rural development in an enlarged EU,.

Bertussi, G. L. e Ellery Jr. R. 2011. Gastos públicos com infraestrutura de transporte e crescimento econômico: uma análise para os estados brasileiros. IPEA, Boletim Regional, Urbano e Ambiental.

Boopen, Seetanah. Transportation Infrastructure and Economic Growth: Evidence from Africa Using Dynamic Panel Estimates. The EmpiricalEconomicsLetters, 2006.

Castro. L. S. 2016. Crescimento Econômico e Infraestrutura: o impacto do PROACESSO em Minas Gerais. Universidade Federal de Viçosa, Viçosa, Brazil.

Elliot, G., Rothenberg, T. J., & Stock, J. H. 1996. Efficient tests for an autoregressive time series with unit root. Econometrica. V. 64, p. 813-836.

Fourie, J. 2006. Economic Infrastructure: A review of definitions, theory and empirics. South African Journal of Economics. Economic Society of South Africa, v. 74, n. 3, p. 530-556.

Granger, C. W. J. 1981. Some properties of time series data and their use in econometric model specification. Journal of Econometrics.V. 16, p. 121–130.

Greene, W. H. 2000. Econometric Analysis.Prince Hall, 4 ed.

IPEA – Instituto DE Pesquisa EconôMICA Aplicada. Infraestrutura Econômica no Brasil: Diagnósticos e Perspectivas para 2025. Brasília, 2010.

Johansen, S. Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models. Econometrica, V. 59, n. 6, p. 1551-1580.

Johansen, S.. Statistical Analysis of Cointegration Vectors.Journal of Economic Dynamics and Control, V. 12, N. 2–3, p. 231–254.

Krugman, P. 1991.Increasing Returns and Economic Geography. Journal of Political Economy, v. 99, n. 3, 1991.

Littman, T. Evaluating Transportation Economic Development Impacts. Victoria TransportationPolicyInstitute, 2010.

Maia, M. S. Efeitos da infraestrutura de transporte sobre o crescimento econômico brasileiro de 2001 a 2012.Universidade Federal de Viçosa, Viçosa, Brazil, 2015.

Munnell. A. H. 1992. *Infrastructure Investment and Economic Growth.* Journal of Economic Perspectives.V. 6, N. 4, P. 189–198.

Paulsen, J.1984. Order determination of multivariate autoregressive time series with unit roots. Journal of Time Series Analysis. v. 5, p. 115–127.

Peter, S., Rita, E. e Edith, M. 2015. The Impact of Road Transportation Infrastructure on Economic Growth in Nigeria. International Journal of Management and Commerce Innovations, Vol. 3, Issue 1, pp: 673-680.

Pradhan, Rudra P. e Bagchi, Tapan P. Effect of transportation infrastructure on economic growth in India: The VECM approach. Research in TransportationEconomics, Elsevier, 2013.

Queiroz, S. L. e Fernandes, E. A. 2017. A Infraestrutura de Transporte Rodoviário e o Crescimento Econômico Brasileiro.Anais do 45° Encontro Nacional de Economia.

Queiroz, S. L. e Fernandes, E. A. 2017. A Infraestrutura de Transporte Rodoviário e o Crescimento Econômico Brasileiro.Anais do 45° Encontro Nacional de Economia, ANPEC.

Ramanathan, R. 2001. The long-run behavior of transportation performance in India: a cointegration approach. Transportation Research Part A. V. 35, p. 309-320.

Romer, D.Advanced Macroeconomics. Nova York, McGraw-Hill, 736 p., 2006.

Silva, E. V. A,Bertoncini, B. V. e Silva, F. G. F. 2017. Infraestrutura de transporte e desenvolvimento económico: Uma análise a partir da construção da ferrovia Transnordestina. Espacios, v. 28, n. 47, pág. 38.

Solow, R. M. 1956. A Contribution to the Theory of Economic Growth. The Quarterly Journal of Economics, v. 70, I. 1, p. 65-94.

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