Productivity in Brazil in the period 1996-2016: the technology impact for economic growth

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Abstract: Empirical studies regarding the productivity in developing countries, including Brazil, have demonstrated the negative impact of high inflation rates on the economic performance. However, the recent Brazilian experience clearly shows that stabilization, in and of itself, is not capable of recovering the investment rates. With this in mind, this study's goal is to answer, with the help of econometric simulation models, the questions: (i) what are the key-drivers to assess the Brazilian economy?; and (ii) what are the key-factors to be considered when investments are made, particulary in technology to impact the productivity growth? To answer the questions we evaluated the impacts of macro-economic variables on private investments, using a strategic bias and a long term vision plan. The estimates demonstrate empirical crowding-in evidence of public investments over private investments as a real impact to productivity, considering technology as a key driver for growth. As for public invetsments we suggest that the crowding-in impact dislocates private investments. All these indicators were obtained as presented in the therory, with the exception of the real interest rates variable (r), in which we observed that the coefficient is positive and insignificant in the estimated equation.

Key-words: econometric models, private investment, productivity, technology impact.

1 Introduction

Several studies show the necessity of developing econometric models, using reliable information, related to productivity in Brazil, especially since the period related to the implementation of the Real Plan until now. The econometric model is only possible by taking into account the advances in the theories regarding simulation and the national macro-economic principles. Consequently, we have an interesting combination of information, simulation models and analysis that enable decision-making processes, which can be seen in [6], [7], [10], [12] and [17].

Over the last few years several organizations have been making efforts to apply simulation models in their businesses. Thus, the objective of this article is to elaborate an econometric simulation model, focused on productivity and technology impact and with true possibilities of economic growth during the coming years, due to increases in internal consumption. The econometric models presented can be used for macro-economic analysis, as well as for investment decisions, and especially for the analysis of the scenarios hereby presented.

It is noteworthy that the data used refers to the period between 1996-2016, due to the implementation of the Real Plan, and the unfolding of the ongoing international economic crisis of 2007.

According to [19] the econometric model presented does not take into account the variables related to imports and exports, which justifies this methodological option, due to the fact that any analyses will be directed towards the internal market, with a high percentage of consumption and service sales, thus increasing the economy's need of profound adjustments in order to achieve sustained and long term growth. We presume that private investment is a function of the GDP growth, however, we will not evaluate the impact of international economies on the Brazilian economy.

However, we will use the real exchange rate as a proxy for the existence of external restrictions,

represented by the external debt/GDP rate, in order to investigate the impact of external conditions on private investments in Brazil.

The performance of the proposed econometric model is the result of the variables utilized, of their restrictions, of the temporal series, and of the long-term estimates of associated risk. However, the suggested evaluations are subject to further studies, which may determine the impact of technology on productivity in the economy. The results achieved by the proposed model are consistent, according to the proposed theory, as well as the results generated with empirical evidence for the decision makers.

This study is divided in five sections: the first is the introduction; Section 2 revising the literature related to private investments in Brazil. Section 3 presents the methodology that describes the Cross-Section model, which is proposed to assess the impacts of macro-economic variables on productivity and the technology effect in Brazil. Section 4 presents the results of the econometric simulation for the period 1996-2016 and lastly, section 5 presents our conclusions.

1.1 Revising the literature

The goal of the econometric model in question is to test the hypothesis that the series of private investments, governmental investments, the GDP, interest rates, inflation, among other factors, are correlated, which enables the modelling of long term behavior of productivity and the technology impact. Using empirical studies, we will try to identify if there is an inhibiting factor for private investments derived from the macro-economic instability and from governmental investments.

The vital role of capital formation in sustainable economic growth is widely recognized. However, in Brazil and in many other developing countries the investment rates were reduced until the mid 1990's, a fact which was a result mainly of the external debt crises and of lack of inflationary control.

The gross formation of fixed capital in relation to the Brazilian GDP, measured at constant prices, had an average decrease of 23% in the 1970's, of 18.5% in the 1980's and of 15.2% in the 1990-1995 period, [4].

In 1998 Brazil's economy felt the impacts of the so-called Asian crises, and in 2008 the great international financial crises happened. Due to the deceleration of the GDP in 2011 it is quite possible that other fiscal measures will be adopted by the government, in an attempt to stimulate the level of economic activity, especially those related to the increase in credit for 2012 and the years ahead.

The econometric results obtained in other studies related to investments themes, and its determinants in Brazil and in other countries are presented in Table [1]. They summarize the works used as a foundation for the empirical research of this article.

The study of investment behavior, specifically in the private sector, results from the fact that this is a typically endogenous variable and from the observation that the adoption of specific economic actions in the market will increase the relative importance of productivity and the technology impact in the creation of aggregated capital. Particularly important dimensions of this problem are related to measuring the effects of macro-economic instability on the levels of investments in the private sector, and the identification of the type of relationship that exists between public investment and private investment.

Table 1. Comparison of the macro-economic variables used in Brazil and abroad

Methods and Variables	Luporini and Alves (2010)	Santos and Pires (2007)	Pereira (2005)	Serven (2003)	Schmukler and Serven (2002)	Melo and Rodrigues Júnior (1998)	Rocha and Teixeira (1996)
Sampled country	Brazil	Brazil	Brazil	61 Countries	USA	Brazil	Brazil
OLS	X	-	X	-	-	X	X
Private investment	X	X	X	X	X	X	X
Productivity and Technology Investments	-	-	-	-	X	-	-
Tributes	-	X	X	-	-	-	-
Util. of Ind. Cap.	X	-	X	-	X	-	-
Credit	X	-	X	X	X	-	-
Public Investment	X	X	X	X	X	X	X
I_pb/Y (--)	-	-	-	X	-	-	-
Relative Prices of Capital Goods	-	X	X	-	-	X	X
Inflation (Uncertainty)	X	-	X	X	-	X	-
GDP	X	X	X	-	X	X	X
Cost of Capital (r)	X	-	X	X	-	X	-
Dummies	X	-	-	-	-	-	-
External Debt	X	-	-	-	-	-	-
R^2	0.92092	-	0.9521	N/D	N/D	0.89	0.85
Log Variables	Yes (Except r)	Yes	Yes (Except r)	Yes (Except r)	Yes	Yes (Except r)	Yes

Source: Authors.

2 Methodology

We tried to not only explain the theoretical model underlying the regression analysis, but also to test the existence of stationary and the co-integration between the temporary series we used.

The proposed econometric model combines the use of a series of data related to economic performance - observing organization's behaviors, productive aspects and growth.

In this model we will present data related to the 1996-2016 period, as this timeframe is relevant for the determination of sector analysis in Brazil, and also to indicate in future studies, the insertion of financial products for organizations.

Section “revising the literature” shows the importance of economic assessment. Thus, the present section tries to conduct a bibliographical survey, with the objective of extracting the relevant data to execute the econometric study. The goal of the econometric model in question is to test the hypothesis that the series of private investments, governmental investments, the GDP, interest rates, inflation, among other factors, are correlated, which enables the modeling of long term behavior of productivity and the technology impact. Using

empirical studies, we will try to identify if there is an inhibiting factor for private investments derived from the macro-economic instability and from governmental investments, over the course of the timeframe.

The vital role of capital formation in sustainable economic growth is widely recognized. However, in Brazil and in many other developing countries the investment rates were reduced until the mid 1990's, a fact which was a result mainly of the external debt crises and of lack of inflationary control. The gross formation of fixed capital in relation to the Brazilian GDP, measured at constant prices, had an average decrease of 23% in the 1970's, of 18.5% in the 1980's and of 15.2% in the 1990-1995 period, according [4].

The study of investment behavior, specifically in the private sector, results from the fact that this is a typically endogenous variable and from the observation that the adoption of specific economic actions in the market will increase the relative importance of private investments in the creation of aggregated capital. Particularly important dimensions of this problem are related to measuring the effects of macro-economic instability on the levels of investments in the private sector, and the identification of the type of relationship that exists between public investment and private investment.

3 Econometric Model

To explain the issue of private investments we chose the following data as part of the functional form: GDP, utilization of industrial capacity, public investments, productivity and technology impact, real interest rates, relative prices of capital goods, inflation, a credit availability proxy, tax burden, external restrictions and exchange rates.

The GDP and the utilization of industrial capacity are commonly used factors when specifying equations for level investments, as they reflect the conditions of the demands of the economy and are used to measure the accelerating effect of investment and possible economic cycles. Typically pro-cyclic economies, such as the ones in developing countries, tend to show a strong correlation between private investments and the variables related to demand.

To measure the impact of public investments on private investments we used public investments in a disaggregated form, separating public investments in infrastructure from the investments in electric energy, telecommunications and transportation. All other public investments are considered as non-infrastructural. It is crucial to verify if there is empirical evidence of the crowding-in theoretical effect of public investments in infrastructure over Brazil's private investments, and if not, does the expected crowding-out effect occur.

The possible crowding-in effect of public over private investments in infrastructure is theoretically explained by the fact that such investments increase the productivity of capital for future investments, and save private investors from additional investments they would otherwise have to make in these areas. As for the crowding-out effects of non-infrastructural public investments, these can be theoretically explained by the competition between them for scarce resources available for investments.

A frequently used variable to explain private investments is the real interest rate, the first theoretic proxy of the cost of capital opportunity. This justifies the choice of this variable as a pre-candidate to compose the final functional form.

The relative price of capital goods is also a key-variable in investment decisions, because it directly affects the cost of capital opportunity. It can assess the effects of low competition in the industry of capital goods that result in increasing the prices of these goods above the prices practiced in the rest of the economy, which would negatively impact investments.

Inflation is a commonly used variable as a proxy for uncertainties in the economies of developing countries. This variable was included in the study conducted by Rodrigues Júnior (1998) at Table 1 to assess the impact of Brazil's macro-economic stability over investments.

A proxy variable for the availability of credit in the economy is also commonly used in investment studies, especially in developing countries, in which credit access is very limited. Obtaining credit or not is, in many projects, a key-element for the impact of credit itself. Thus, the availability of credit should also be taken into account as a pre-candidate variable. In this article we considered the volume of annual disbursements of the BNDES as a proxy for credit availability in Brazil.

The total tax burden (as a percentage of the GDP) should be used as a possible explanatory variable for private investments. Very few empirical articles use this variable, but in the Brazilian case it may be quite relevant, especially with the significant increase of taxes over the last few years. The motivation for using this variable is due to the fact that economic agents of the public and private sectors have been complaining about the excessiveness of Brazilian taxes as being one of the major obstacles for private investments.

As for external influences, several indicators were used on the empirical work, such as deviation

of products from their long-term trends, the volatility of the stock exchange, the variability of inflation rates and/or of the exchange rates in relation to the debt/GDP, with negative results for private investments, [18]

And finally, [13] uses the relationship between external debt and exports to investigate the effects of external conditions on private investments in Brazil, and in other Latin American countries, confirming the negative results already uncovered in other studies. More recently, [5] investigated the relationship between exchange rates and private investments. The results indicate that the exchange rates affected negatively and significantly private investments over the analyzed timeframe, which was from 1956 to 1996.

Taking Table [1] into consideration, we propose the following generic theoretical model:

Priv_Investments = f(Y, UCAP, Pub_Infra_Invest, Non_Pub_Infra_Invest, Productivity and Technology Investments, r, P_rel_bens_k, IGP-DI, Emprest_BNDES, t, EE, E)

In which:

Priv_Investments = *strictu sensu* gross investment of the private sector (excludes state organizations);

Y = Real Gross Domestic Product;

UCAP = average utilization of the industrial capacity;

Pub_Infra_Invest = public investments in infrastructure;

Non_Pub_Infra_Invest = non-infrastructural public investments;

Productivity and Technology Investments= productivity, as a function of technology investments;

r = real interest rate;

Rel_Prices_K = relative prices of capital goods;

IGP-DI = Inflation

BNDES_Dis = Real disembursement of the BNDES;

T = Tax burden as a percentage of the GDP;

EE = External restriction, using as a proxy the series Debt Service/GDP (%);

E = Real exchange rate;

Dummy = control variable for times of international crises

Based on this expression, we estimate the following econometric equation for the 1996-2016 timeframe, with expresses variables in natural logarithms (except for the real interest rates variable), in order to directly obtain the elasticity of the variables:

$$LInvest\_priv_t = \beta_0 + \beta_1 LY_t + \beta_2 LUCAP + \beta_3 LPub\_Infra\_Invest + \beta_4 LNon\_Pub\_Infra\_Invest + \beta_5 LProductivityTech + \beta_6 Lr + \beta_8 LReal\_Prices\_K + \beta_9 LIGP\text{-}DI + \beta_{10} LBNDES\_Dis + \beta_{11} LT + \beta_{12} LEE + \beta_{13} LE + \varepsilon_t$$

In which ε_t is a random disturbance.

In conformity with the model of the investment accelerator, we expect that the increased GDP will generate an increase in productivity and technology investments, because increased production requires more investments and innovation. The effect of the interest rate is negative and reflects the adverse impact of the cost of capital utilization over investment decisions. Used as a proxy for uncertainty and instability, we expect that the elevation in the inflation rates will decrease investments in the private sector; here the implicit hypothesis is that instability increases the *waiting price* for new information and increases business risks. The relationship between the Private Investment and Public Investment variables is ambiguous, because both crowding-in and crowding-out can predominate between the two types of investment.

Table [2] presents a summary of the pre-candidate variables used to explain annual series since 1996 and what are the theoretic expected signals.

Table 2 - Pre-candidate variables

Pre-candidate variable	Expected signal
Real GDP	Positive
Average utilization of industrial capacity	Positive
Public investments in infrastructure	Positive
Non-infrastructural public investments	Negative
Productivity and technology investments	Positive
Real interest rates	Negative
Relative prices of capital goods	Negative
Inflation	Negative
Real disbursements of the BNDES	Positive
Tax burden as a percentage of the GDP	Negative
External restrictions	Negative
Real exchange rates	Negative

Source: authors.

4 Results

For the econometric analysis all variables, with the exception of the real interest rates variable, were log-linearized using the natural logarithm, and the remaining series were calculated using the fixed prices of 1995. Because the series used in the

estimations of the investment equations are temporal series, we presume that these series are random variables ordered over time. The usual methods of estimation and inference presume that these variables are stationary. The non-stationarity of a stochastic process is due to the existence of a unit root or a stochastic trend in the auto-regressive process (AR), which generates the presence (or absence) of stationarity in the variables used in the estimations.

4.1 Stationarity tests

Initially the series were subjected to augmented Dickey and Fuller (ADF) unit root tests [2], in level and in first difference. The ADF test is well known and will be described in this section, [3]. It should be remembered that the test statistic is similar to the t-student test.

The aim of the tests is to show statistical evidence of the integration order of the variables and are, in fact, pre-tests for co-integration, since theoretically only variables with the same integration order can co-integrate.

According to [8], the null hypothesis is that $\alpha=0$, in which α is the coefficient associated to the first lag range of the series, which enters as a regressor AR(p) for the first difference of the hypothesis. The criterion of rejection indicates rejecting H_0 if $|ADF|>VC$, in which VC is the critical value of the distribution. As in the case of the existence of a unit root, the asymptotic distribution of t is not the same if the series is stationary (in this case the i of student). Thus, we used critical values tabulated by [9]. The correct choice of lags is important, as they can influence the performance of the tests. What we did was choose a number which was sufficient to eliminate any possible serial correlation of residues. The choice was made by minimizing information criteria.

The Table [3] bellow summarizes the results of the stationarity tests. For the timeframe being analyzed the results of the tests favor the hypothesis of a unit root and also indicate that the series contains a stochastic trend.

The unit root tests for the selected on level variables do not reject the possibility of the existence of a unit root in all cases at a 1% level, the only rejection occurred in the LnIGP-DI variable. In other words, there are no statistical evidences that the variables are I(0). The analyses of the results indicates that the series for private investments (Ln Priv_Investments), GDP (LnY), utilization of industrial capacity (LnUCAP), public investments (LnPub_Infra_Invest and Ln Non_Pub_Infra_Invest), Productivity and Technology Impact (Ln_Productivity_Tech), real interest rates (r), relative prices of capital goods (Rel_Prices_K), loans from the BNDES (LnBNDES_Dis) and taxation (LnT), may all be considered stationary.

Based on this, one can say that there is statistical evidence that the variables in question can be treated as I(1), and that regressions without their levels (log on level, in the case of the specification used here) are possible and will not present dubious results, as long as the conditions of co-integration are verified. The theory suggests the possibility of a trend, besides the constant, for the formulations of the unit root tests for the GDP and investments, and that was properly considered.

Considering the other in level significances, we observed that there were rejections for the variables: LY for 5% and 10%, LnUCAP for 10%, LnBNDES_Dis for 5 and 10%, and LnIGP-DI for 1%, 5% and 10%. A possible explanation for this fact is that the stationarity tests are susceptible to the specification and the measure unit of the variables, which creates difficulties for the analysis of results. Furthermore, the unreliability of the tests makes it difficult to discriminate stochastic series with high dependencies. The real exchange rate (LnE) can be considered stationary with the ADF of -2.6534 with the rejection of the null hypothesis at a 10% level of significance. For the EE variable we have an ADF, in level, of -2.2719 with an integration order I(1).

Given these characteristics, the investment equations were estimated by means of the Ordinary Least Squares methodology. Some of the studies of investment determinants presented in literature use the co-integration technique by means of a system of auto-regressive vectors (VAR). The estimator of Ordinary Least Squares is one of the few estimators whose properties are solidly established in specialized literature.

Table 3. Results of the stationarity tests for the pre-candidate variables on the productivity model using annual data from 1996-2011

Variables	t-ADF	Critical value test 1% significance	Critical value test 5% significance	Critical value test 10% significance	p-value
On level variables					
LnPriv_Invet	- 1,874	- 4,0579	- 3,1199	- 2,7011	0,332
LnY	- 3,433	- 3,9591	- 3,0810	- 2,6813	0,026
LnUCAP	- 2,342	- 3,9591	- 3,0810	- 2,6813	0,172
Ln_Pub_Infra_Inves	- 1,169	- 3,9591	- 3,0810	- 2,6813	0,658
Ln_Non_Pub_Inv_I	- 0,771	- 3,9591	- 3,0810	- 2,6813	0,797
Ln_Productivity_Tech	- 0,980	- 3,1974	- 3,0081	- 2,6801	0,252
R	- 1,842	- 3,9591	- 3,0810	- 2,6813	0,347
Ln_Real_Prices_K	- 1,206	- 3,9591	- 3,0810	- 2,6813	0,642
LnIGP-DI	- 5,265	- 4,2000	- 3,1753	- 2,7289	0,002
Ln_BNDES_Dis	- 3,982	- 4,0044	- 3,0988	- 2,6904	0,010
LnT	- 2,062	- 4,0579	- 3,1199	- 2,7011	0,260
First difference variables					
DLnInv_Priv	- 1,874	- 4,0579	- 3,1199	- 2,7011	0,087
DLY	- 3,433	- 3,9591	- 3,0810	- 2,6813	0,004
DLnUCAP	- 2,342	- 3,9591	- 3,0810	- 2,6813	0,035
Ln_Pub_Infra_Inves	- 1,169	- 3,9591	- 3,0810	- 2,6813	0,263
Ln_Non_Pub_Inv_I	- 0,771	- 3,9591	- 3,0810	- 2,6813	0,454
Ln_Productivity_Tech	- 1,101	- 3,0004	- 3,0780	- 2,6544	0,039
Dr	- 1,842	- 3,9591	- 3,0810	- 2,6813	0,088
DP_Real_Prices_K	- 1,206	- 3,9591	- 3,0810	- 2,6813	0,249
DLnIGP-DI	- 5,265	- 4,2000	- 3,1753	- 2,7289	0,000
DLnBNDES_Dis	- 3,982	- 4,0044	- 3,0988	- 2,6904	0,001
DLnT	- 2,062	- 4,0579	- 3,1199	- 2,7011	0,069

Source: authors.

For the unit root tests of the selected variables in first difference we observed that the results repeat themselves, as they do not reject the possibility of the existence of a unit root in all of the cases at a level of 1%, the only rejection occurred in the DLnIGP-DI variable. In other words, there are no statistical evidences that the variables are I(0).

The main objective of the estimations presented on Table [3] is to test the hypothesis of the crowding-in effect of public investments on infrastructure over private investments.

4.2 Final functional form for annual data related to 1996-2016

The Table [4] bellow shows a summary of the pre-candidate variables used to explain productivity and technology impact in Brazil, in annual series from 1996 onwards, and the expected signals for the relationship between each one of them and private investments.

Contrary to the study performed by [1], this analysis opted for including the variables that presented low significance in the final model. The model presented low significance for the variable that assesses uncertainties (LnIGP-DI), which was also confirmed by the stationarity tests, and also for the total tax burden variable (LnT).

Furthermore, our analysis specified a dynamic model, including the lag in the private investment variable (DLnInv_Priv(-1)), because by using contemporaneous variables the model would present problems with the auto-correlation of residues. The first lag of the private investment variable is commonly used in several studies, due to the fact that some investments cannot be completed in only one year, which explains the use of this variable to assess the inertia effect on investments.

In the first equation estimated we inserted a control variable for times of political instability, represented by a dummy (D1), which assumes unitary values for the years of 1997 (Asian Crises), 1998 (Russian Crises), 1999 (Argentinean Crises and the Brazilian Currency Devaluation) and 2008 (World Financial Crises).

Overall the model presented a satisfactory explanatory rate (R^2 = 0.95), which is a result

coherent with the majority of the studies shown in Table [1]. One can also observe the importance of the irreversibility of the investment, reflected in the coefficient of the first lag of private investment, which was positive and significant, indicating that current investments depend on their past values.

This evidence indicates the existence of lags in the decision making process and in the implementation of private investments, and suggests that current investments not only reflect partial adjustments of current capital to desired levels, but also tend to happen in an accumulated manner or clustered in time (lumpiness).

The signs found for the estimated coefficients were positive, statistically significant and are in accordance with the economic theory, which indicates income increase (LnY) and increase in economic activity (LnUCAP), encouraging and increasing productivity in the country. In the case of the utilization of industrial capacity (LnUCAP) we observed the extremely pro-cyclic characteristic of the Brazilian economy, with a high and positive coefficient (2.86).

This result is compatible with the majority of the existing empirical studies concerning the determinants of investments in Brazil and in other developing countries, where the variables used to assess the conditions of demand were also significant and relevant in the estimated models.

The results show empirical evidence of the crowding-in effect on public investments in infrastructure (Ln_Pub_Infra_Invest) over private investments, a positive sign. This means that a stimulus of 1% in public investments for infrastructure will result in a 0.113% increase in private investments.

As for non-infrastructural public investments (Ln_Non_Pub_Infra_Invest) the sign obtained is also correct (negative), which suggests that the impact of the crowding-out effect dislocates private investments. This means that a stimulus of 1% in non-infrastructural public investments will result in a 0.0741% decrease in private investments.

Table 4. Productivity and technology investments determinants

Ordinary Least Squares - Dependent Variables: Private Investment (1996-2011)

Explanatory Variables	Coefficients	Expected signal	Obtained signal
Constant	- 9,3598 (-6,0383) [0,0000]	Negative	Negative
DLnProv_Inv(-1)	0,4876 (3.76613) [0,0009]	Positive	Positive
LY	0,510 (1,8263) [0,0697]	Positive	Positive
LnUCAP	2.866 (9,7258) [0,0000]	Positive	Positive
Ln_Pub_Infra_Inves	0,113 (7,3445) [0,0000]	Positive	Positive
Ln_Non_Pub_Inv_I	-0,0741 (-8,0360) [0,0000]	Negative	Negative
Productivity and technology	0,0881 (6,0091) [0,00000]	Positive	Positive
R	(7,3445) [0,0000] [0,0527]	Positive/ Negative	Positive
Ln_Real_Prices_K	-1,3593 (-9,8211) 0,0000	Negative	Negative

Explanatory Variables	Coefficients	Expected signal	Obtained signal
LnIGP-DI	-0,0474 (0,0522) [0,0000]	Negative	Negative
Ln_BNDES_Dis	0,1705 (9,791057) [0,0000]	Positive	Positive
LnT	- 1.1800 (0,008) [0,0000]	Negative	Negative
LnE	-0.09251 (-2.19204) [0.03720]	Negative	Negative
Dummy 1	-6,45 (-3,0061) [0,9951]	Negative	Negative
R^2	0.956458		
Adjusted R^2	0,953631		
DW	2.59		
Log Likelihood	338.5426		
Statistic F	338.2824		
Prob(F)	0,0000		

Source: Elaborated by the authors

Note: t statistics are between parentheses and p-values are between brackets.

However, the theory suggests that after the initial perverse effect of the competition for resources between private and non-infrastructural public investments, it is reasonable to suppose that these investments can also contribute (even if just a little, when compared to the infrastructural investments) to increase the productivity of private capital to be invested in the future (public investments in new technologies, R&D among others).

In the case of the real interest rates variable (r) we observed that the coefficient is positive and non-significant in the estimated equation. Although the estimated coefficient signal goes against what was theoretically expected, the coefficient is numerically very close to zero (and non-significant), which indicates that this proxy for capital use costs did not contribute to the productivity. This evidence was also found by [7] who also estimated equations using macro-economic data for the 1972-1996 and 1970-2005 timeframes, respectively.

Although capital cost is theoretically important for the determination of the productivity, the difficulty to obtain significant coefficients with negative signs for this variable is widely spread in specialized literature. In the Brazilian case, especially, cost capital coefficients so close to zero can be explained, on one hand, by the organizational tradition of not seeking external financing for the company, and on the other hand, by the volatility of the interest rates during periods with high inflation, which made interest rates a negligible reference for calculating the opportunity costs of investments.

Literature also indicates that if interest rates rise and if competition for limited resources increases this will result in the dominance of the crowding-out effect over the crowding-in effect. This can be partially explained by the progressive deterioration of the Brazilian's government capacity to invest in infrastructure, because it is the type of public spending that presents the most evident complementarities with private inversions.

Results indicate that an increase in the offer of credit (Ln_BNDES_Dis), by means of elevating credit operations aimed at the private sector, will increase private investment in the subsequent years, which confirms the hypothesis that Brazilian organizations face credit restrictions. The results obtained are consistent with the studies performed by [12] and [18], which include financial variables in their empirical studies and indicate that credit availability is one of the relevant variables for private investments in developing countries.

The uncertainties caused by international crisis (assessed by the Dummy 1 "International Crisis" variable) were also relevant in the determination of investments in Brazil, and the negative coefficient obtained indicates that in times of international economic crisis private investments decrease. Thus, the implementation of responsible and consistent policies over the course of time is crucial to

minimize economic uncertainties and to encourage private investments in the country.

We tried to investigate the impact of external conditions on private investments in Brazil, using the External restriction variable (EE), having as a proxy the series Debts of Service/GDP (%). As for external conditions, we suggest that external debts of service did not affect private investments in a significant way during the analyzed timeframe. In fact, the effect of this variable was insignificant in the model and thus, was not included in the final model. One possible explanation for this result is the participation of the public sector in obtaining resources during periods of external crisis, acting as a guarantor for loans contracted by the private sector, and financing investments during periods of external restrictions, and even encouraging the improvement of conditions for external financing.

Finally, the estimated coefficient for exchange rates (LnE) was significant and presented a negative sign, indicating that increased (or devalued) exchange rates do not encourage imports of capital goods, and consequently reduces economic investments. This result is confirmed by [12], who obtained results indicating that the first difference of exchange rates has a significant and negative effect over private investments in Brazil.

5 Conclusion

This article analyzed the productivity in Brazil for the period of 1996 to 2016, using data obtained from the Novo Sistema de Contas Nacionais do IBGE (New System of National Accounts of the IBGE), which were recently published by the IPEA. We proposed the elaboration of a model of econometric simulation, focused on productivity connected to the real possibilities of economic growth for the coming years and the technology impact.

The empirical evidence obtained in the models tested confirm the predominance of quantitative variables, such as product and capacity of use, which indicates that increases in income and in economic activity encouraged productivity in Brazil over the course of the studied period. The accelerating effect observed is complemented by the existance of lags in the decision making processes and in the implementation of private investments, which suggests the hypothesis of irreversibility of invetsment.

The estimation shows evidence that if interest rates are increased and/or if the competion for real limited resources increases, this will cause the dominance of the crowding-out effect over the crowding-in effect.

The cost of capital utilization, measured by the real interest rates, was not significant, which indicates that the real interest rates do not contribute to reduce productivity, which is a result consistent with the elevated volume of auto-financing by Brazilian organizations. On the other hand, in a wider perspective, the volume of credit for the private sector demonstrated its importance by positively affecting private investment. In this aspect, expanding long term financing lines, adequate for the creation of fixed capital by the organizations, would be extremely important to increase the rate of economic investments.

Besides credit, external factors and exchange devaluations caused, in general, adverse effects on the gross formation of fixed capital in the private sector and on the Brazilian economy during the timeframe analyzed. These reults indicate the existence of credit restrictions for Brazilian organizations and also indicate the importance of macro-economic stability and the execution of public policies as an encouraging factor for productivity.

The analysis conducted identified very few articles conducive to econometric studies analyzing sector performance, especially on the productivity and the technology impact. As a result of these analysis, it is essential that data surveys be conducted to simulate the impacts of macro-economic variables on the productivity, by regions and by sectors in Brazil, adopting the Monte Carlo simulation models, in an attempt to obtain long term estimates. And finally, we hope that this article encourages new studies, with strategic biases and long term vision of innovation, in order to propose innovation strategies.

References:

[1] Corrado, C., Mattey, J. (1997). “Capacity Utilization”, *Journal of Economic Perspectives*, Winter.

[2] Dickey, D. A., Fuller, W.A. (1981). “Distribution of the Estimators for Autoregressive Time Series with a Unit Root”, *Econometrica*, Vol.49, pp.1057-1072.

[3] Hayashi, F. (2000). “Econometrics”, *Princeton University Press New Jersey*.

[4] Instituto de Pesquisas Econômicas Aplicadas (IPEA). (2012). “Ipeadata”, Source: <www.ipea.gov.br>

[5] Johansen, S., Juscelius, L. (1998). “Maximum Likehood Estimation and Inference an Cointegration – with Applications to the Demand for Money”, *Oxford Bulletin of Economics and Statistics*, Vol.52, pp.162-211.

[6] Lederman, D. (2010). "International Trade and Inclusive Growth: a Primer for Busy Policy Analysts", *Working Paper Series 5886*, The World Bank.

[7] Luporini, V., Joana, A. (2010). "Investimento Privado: Uma Análise Empírica para o Brasil", *Economia e Sociedade*, Vol.10 No.3, pp.449-475.

[8] Maddala, G., Kim, I. (1998). "Unit Roots, Cointegration and Structural Change", *Cambridge University.*

[9] Melo, G. M., Rodrigues Jr, W. (1998). "Determinantes do Investimento Privado no Brasil: 1970-1995", *Instituto de Pesquisas Econômicas Aplicadas – Texto para Discussão 605*, pp. 35-42.

[10] Pereira, A.M. (1999). "Export Growth and Domestic Performance", *Review of International Economics*, Vol. 8 No. 1, pp.60-73.

[11] Pereira, R.M. (2005). "Investment and Uncertainty in a Quadratic Adjustment Cost Model: Evidence from Brazil". *Revista de Economia Política*. Vol.55, pp.283-311.

[12] Ribeiro, M. B., Teixeira, J. R. (2001). "An Econometric Analyses of Private-Sector Investment in Brazil", *Cepal Review*, No.74, pp.153-166.

[13] Rocha, C., Teixeira, J. (1996). "Complementariedade versus Substituição entre Investimento Público e Privado na Economia Brasileira: 1965-1990". *Revista de Economia*, Vol. 50, pp. 378-383.

[14] Santos, C. H., Pires, M. C. C. (2007). "Qual a Sensibilidade dos Investimentos Privados a Aumentos na Carga Tributária Brasileira? Uma Investigação Econométrica", *Coordenação de Finanças Públicas (DIRUR/IPEA),* Vol.1 No 2, pp-75-78.

[15] Serven, L. N. (2003). "Real_Exchange-Rate Uncertainty and Private Investment in LDCS", *The Review of Economics and Statistics*", Vol. 85, pp 212-218.

[16] Serven, L. N. (2010). "Global Imbalances Before and After the Global Crisis", *Policy Research Working Paper Series 5354*, The World Bank.

[17] Schmulker, S. L., Serven, L. (2002). "Pricing Currency Risk Under Currency Boards". *Journal of Development Economics*", Vol. 69, pp 367-391.

[18] Studart, G. G. (1992). "Investimento Público e Formação de Capital do Setor Privado no Brasil: Análise Empírica dos Efeitos de Curto e Longo Prazos Durante o Período 1972-1989", *XXII Encontro Nacional de Economia,* Campos do Jordão, Anais.

[19] Terra, C. M. (2003). "Credit Constrains in Brazil Firms: Evidences from Painel Data", *Revista Brasileira de Economia*, Vol. 7 No 2, pp.443-464.