Estimating Private Investment Functions for Brazilian Coke Production, Oil Refining, Nuclear Fuel Preparation and Alcohol Production

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Abstract

This article examines the determinants of Brazilian private investment for sector 23 (coke production, oil refining, nuclear fuel preparation and alcohol production) from 1996 to 2010. All the signs of the analyzed variables are consistent with theory, with the exception of real interest rates, where the coefficient is positive and insignificant in the estimated equation. It shows that, within the time span it was analyzed, the reduction in credit volume and the existence of political and economic instabilities have been harmful to private investment. By using the industry's sectorial data, it is possible to avoid smoothing in this aggregate series and it may help to understand aggregate investment dynamics. Sector 23 invested relatively more than other sectors in the Brazilian economy. Results reveal the importance of the available volume of funds for investment, with complementarity between public and private investment.

Keywords: *Cross-section; Private investment; Fixed effects; Oil refining*

1. Introduction

The coke production, oil refining, nuclear fuel preparation, and alcohol production sector accounts for the existence of a complex domestic energy grid that is directly related to economic growth while also playing an important role in disseminating new technologies. Various industrial segments make up this sector, within which important domestic and international companies operate.

It is the most important segment in the energy-producing sector, as according to EPE (2012), it represents 60% of the domestic energy capacity and as such, it is of great significance to Brazil. According to Tadeu (2010), it is clearly necessary to increase investment in Brazilian energy generation and diversification as well as to deal with the high costs involved in the transportation infrastructure that supports the sector. Besides these factors, it is suggested that increased credit through private operations could drive production in a segment whose resources are limited due to its operational risks.

Thus, this paper aims to follow CNAE 1.0 nomenclature and assess the determinants of private investment in Sector 23 (coke production, oil refining, nuclear fuel preparation, and alcohol production) by means of an econometric simulation model using fixed-effect, cross-section data for the 1996 to 2010 timeframe.

2. Theory Review

The study of investment behavior, specifically in the private sector, stems from the fact that this is a typically endogenous variable and from the consideration that adopting market oriented economic reforms will lead to the increased relative importance of private investments in aggregate capital formation. Two of the particularly relevant dimensions of the problem are measuring the effect of macro economic instability on the level of private sector investment and determining the kind of relationship that exists between public and private investment (complementarity or substitutability).

The econometric results obtained in other studies on the theme of investment and their determinants in Brazil and in other countries were the foundation to determine the variables used to prepare the econometric model proposed by this paper (Studart,1992; Rocha & Teixeira, 1996; Melo & Rodrigues Júnior, 1998; Serven, 1998; Pereira, 1999; Lenderman, Menéndez, Perry & Stiglitz, 2000; Ribeiro & Teixeira, 2001; Serven, 2002; Rossiter, 2002; Aysan, Pang & Varoudakis, 2004; Ferreira, 2005; Santos & Pires, 2007; Luporini & Alves, 2010). The following macro economic variables were used to explain private investment: GDP, the use of industrial capacity, public investment in infrastructure, public investment in other areas not related to infrastructure, actual interest rates, the relative price of capital goods, inflation, a proxy for credit availability, tax load, external effects (external restrictions and the exchange rate).

3. Methods

The current paper assessed the behavior of macro economic variables in the Brazilian economy and the impacts they had over Brazilian private investment between 1996 and 2010. More specifically, it was the coke production, oil refining, nuclear fuel preparation, and alcohol production sector that was assessed to allow us to understand private investment behavior in this sector. Thus, the method adopted for the econometric assessment was the panel data model using fixed-effect, cross-section application.

This method was chosen due to the better inference of the parameters that were studied, as they allow greater degrees of freedom and greater variability in the sample when compared to cross-section data or temporal series data, which leads to greater refinement as regards the efficiency of econometric estimates. Hsiao (2006) expounds on the advantages allowed by Panel Data analysis. On the other hand, in the case of the fixed-effect model it is the best option to model panel data when intercept α_i is correlated to the explanatory variables at any period. Furthermore, as the model's intercept is treated as a fixed parameter, it is also desirable to use fixed effects when observations are obtained from the whole population and when one wishes to make inferences for the individuals whose data are available.

The econometric model that was adopted aims to test the hypothesis that the series of private sector investments, the gross amount of sectorial industrial production, the gross formation of fixed capital, the interest rate, among other factors, are co-integrated and will thus allow us to model the long-term behavior of private investments.

The following general econometric model was estimated for the 1996 – 2010 timeframe, with the variables expressed in natural logarithms (except for the actual interest rate), to allows us to obtain the elasticity of the variables directly: $LnInvest\_priv_t = \beta_0 + \beta_1 LnVBPI_{it-1} + \beta_2 LnUCAP_{it} + \beta_3 R_{it} + \beta_4 LnCred_{it-1} + \beta_5 LnFBKF_{it-1} + \beta_6 LogE_{it-1} + \beta_7 LogEE_{it-1} + \beta_8 D1 + \varepsilon_t$.

Where:

Invest_priv = a proxy for sectoral investment spending; data refer to Fixed Assets Acquisitions (machinery and equipment) by industrial segments (the transformation Industry), in thousands of Reals, at 1995 prices;

VBPI = a proxy for the economic activity level; data refer to the Gross Industrial Production Value per industrial segment, in thousands of Reals, at 1995 prices;

UCAP = Capacity Utilization rate (%) – time series data for installed capacity utilization by industrial segment are available at Fundação Getúlio Vargas (FGV) and were made compatible for the CNAE according to information provided by the IBGE Census Bureau;

R = Actual Interest Rate (%), representing the nominal interest rate on Bank Certificates of Deposit (BCD) as deflated by the General Price Index (IGP-DI) and annualized, provided by the Brazilian Central Bank (BCB).

Cred = Credit Indicator – represented by Credit disbursements made by the National Bank for Social and Economic Development (BNDES), available for each segment of the transformation industry, in millions of Reals, at 1995 prices;

FBKF = Government Investment – represented by the Fixed Capital – Gross Formation – Public Administration series, in millions of 1995 Reals, applying the GDP deflator as computed by the data available from the IBGE Census Bureau/ National Accounts System;

E = Actual Foreign Exchange Rate;

EE = External Restriction – the proxy used is the annual Debt Service/GDP (%) series provided by DEPEC-BCB, Central Bank of Brazil (BCB);

D1 = Dummy control variable for international crises periods;

The data used was supplied by the Brazilian Institute of Geography and Statistics (IBGE, 2012) and IPEA (2012) and were available in the Annual Industrial Survey. They are discriminated by sector according to the domestic classification for economic activities (CNAE) for the 1996 - 2010 timeframe. The timeframe chosen is related to the availability of data from the Annual Industrial Survey, as from 1996 onwards it was changed in terms of the classification of the division of activities and the methodology used for the sample. Nevertheless, among the 20 sectors in the transformation industry, this paper will focus on Sector 23 (coke production, oil refining, nuclear fuel preparation, and alcohol production).

4. Results

As it occurs in the study of time series, the existence of a unitary root in panel data can lead to spurious estimated econometric relationships. To avoid this problem, the variables were submitted to unitary root tests (Levin, Lin and Chu (LLC), Im, Pesaran and Smith, (IPS), Fisher ADF and Fisher PP).

An analysis of the findings shows that most of the series are stationary, that is, they do not have a unitary root. However, for some variables such as the exchange rate and industrial production, tests confirm the absence of a common unitary root but do not eliminate the possibility of the existence of an individual unitary root. As regards macroeconomic variables (R, FBKF, E, EE), the findings show that they are stationary and that they have neither a unitary nor an individual root. The only exception is related to the exchange rate (E) series, which must be differentiated to become stationary.

At first, to identify the feasibility of using the panel data methodology, the models are estimated through Ordinary Minimum Squares (OMS) and all units are grouped (pool cross-section or pooling), that is, possible specific sectorial effects are not taken into account. Test F (Ho: fixed effects = 0) results suggests that the use of panel data methodology supplies relevant information gains, and in this case an OMS (pooling) estimate can lead to biased results. As the panel data methodology is the most appropriate one, the issue then becomes the choice of an estimate method, either by fixed effects (EF) or by random effects (EA). In such cases when the data used have not been randomly extracted from a larger sample, the fixed effects model is the most appropriate estimate method. Furthermore, the estimator in the fixed-effect model is robust to the omission of relevant explanatory variables that will not vary through time, and even when the random effect approach is valid, the fixed effect estimator is consistent, even though it will be less efficient. Therefore, a fixed-effect estimate seemed to be the most appropriate one for these sectorial investment models.

The results presented on Table 1 show that the quantitative variables Industrial Production and Gross Amount (LogVBPI) and industrial capacity use (LogUCAP) were relevant as regards explaining private investment. The signs that were found for the estimated coefficients were positive ones. The actual interest rate (R) was found to have a positive and significant coefficient, which goes against that which investment theory expects. However, the magnitude of these coefficients is close to zero, which shows that between 1996 and 2010 fluctuations in actual interest rate levels did not effectively influence private sector investment.

Table 1: Sectorial Investment Equations

Fixed Effect Estimate – Dependent Variable: Private Investment 1996-2009							
Explanatory Variables[(1)]	EQ1	EQ2	EQ3	EQ4	EQ5	EQ6	EQ7
C	-12.5731	-14.4577	-15.9587	-12.6178	-12.2551	-19.071	-17.757
	[-0.3120]	[-0.2579]	[-0.1788]	[-0.4179]	[-0.8675]	[-09718]	[-1.172]
	(0.7570)	(0.7981)	(0.8592)	(0.6788)	(0.3921)	(0.3392)	(0.2509)
LnVBPI(-1)	1.0619	1.1104	1.0608	1.6108	1.0622	1.1262	0.8993
	[3.0732]	[3.5707]	[3.0361]	[3.0476]	[3.4756]	[3.8041]	[3.6193]
	(0.0042)	(0.0011)	0.0047	0.0046	(0.0015)	(0.0007)	(0.0012)
LnUCAP	1.8673	2.1943	1.8866	1.8665	1.8769	2.2629	2.2345
	[0.6921]	[0.1461]	[0.6581]	[0.7677]	[1.0372]	[0.5824]	[0.7956]
	(0.4937)	(0.8847)	(0.5152)	(0.4482)	(0.3074)	(0.5647)	(0.4329)
R	0.0232	0.0215	0.0258	0.0229	0.0204	0.0256	0.0322
	[1.5618]	[1.7484]	[1.4729]	[1.6920]	[1.7061]	[1.9003]	[2.0886]
	(0.1279)	(0.090)	(0.020)	(0.1004)	(0.0977)	(0.0674)	(0.0460)
LnCred(-1)		0.4900				0.2393	0.2763
		[1.7212]				[1.3930]	[1.5217]
		0.0949				(0.1742)	(0.1393)
LnFBKF (-1)			0.3376			0.4529	0.6076
			[0.2179]			0.9280	[1.1694]
			(0.8289)			0.3610	(0.2521)
LnE(-1)				-0.0238		-0.8437	-0.3793
				[-0.8581]		[-0.289]	[-0.733]
				(0.3972)		(0.7744)	0.4693
LnEE(-1)					-0.3542	-0.4698	-0.5134
					[-1.7488]	[-1.833]	[-2.026]
					0.0899	(0.0770)	(0.0523)
Dummy							-0.2978
							[-0.891]
							(0.3803)
R-squared	0.9204	0.9272	0.9206	0.9222	0,9274	0.9370	0.9387
Adjusted R-squared	0.9084	0.9135	0.9057	0.9077	0.9138	0.9174	0.9168
S.E. of Regression	0.3382	0.3286	0.3432	0.3396	0.3281	0.3211	0.3222
Log Likelihood	-9.8066	-8.0800	-9.7776	-9.3629	-8.0265	-5.2633	-4.7175
DW stat	1.2576	1.4946	1.2753	1.2955	1.2964	1.6326	1.5897
Prob (F-statiscs)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Source: Research results

(1) Statistic-t in brackets, followed by p-values in parentheses.

Despite the theoretical importance of the investment's cost of opportunity, the difficulty in finding negative and significant coefficients for this variable is quite well reported in literature, including international literature (Chirinko, 1993). In Brazil, the results found for the effect of the interest rate on private investment can be explained by the common practice among Brazilian companies of using their own resources to finance investment. Another possible explanation for the results found for the interest rate may be related to the low availability of resources.

The importance of credit availability on private investment is confirmed as estimated by Equation 2 (EQ2). Results show that increasing credit offer through greater credit opportunities made available by the BNDES system to industrial sectors will increase investment in periods that follow, which shows the relevance of the existence of long-term financing streams, at a stable amount, aimed at financing the private sector's investment projects. Equation 3 (EQ3) tests the impact of public investment on private sector investment. The public investment variable's coefficient (FBKF) was significant and positive, which shows that public investment tends to complement private investment. The estimated coefficients for the exchange rate was negative (see EQ4 on Table 1), which suggests that a more devalued exchange rate discourages the importation of capital goods, at least in the short term, and increases the financial commitments of companies that carry foreign debts. As regards foreign indebtedness, Equation 5 (EQ5) points to the existence of a negative relationship between investment and foreign debt servicing, that is, the existence of external restrictions may have limited private sector investment in recent times. This result can be explained by the increase in foreign indebtedness on the part of the private sector in the 1990s and the decreased participation of the public sector in the funding and financing of investment in times of foreign crises in recent years (1996 - 2010). Equation 6 (EQ6) tests all the variables together, but without the dummy control variable. The signs are coherent with the theory and were the same when compared to the equations tested separately with each variable.

Lastly, a control variable was inserted into the estimated equation for periods of political instability, which is represented by dummy (D1) that bears a unitary value for 1997 (Asian Crisis), 1998 (Russian Crisis), 1999 (Argentinean Crisis and Brazilian Exchange Rate Devaluation) and 2008 (Worldwide Crisis) and a nil value for times when there were no crises. The results show the relevance of determining investment, and the negative coefficient found shows that private investment is lower in times of international economic crises.

4.1 Fixed Effect Coefficients

To assess the specificities of the sector, the magnitude of sectorial *fixed effect* coefficients was estimated. Each sectorial coefficient estimated corresponds to the *pure effect* of each sector, that is, it is the difference of a specific sector's average investment compared to the yearly average by sector, which is not due to variations in the dependent variable (Greene, 1999). Thus, the coefficient represents the investment made that is related to the specific factors of each industrial sector, independently of the variables inserted into the model.

Table 2 shows the sectorial coefficient found for the Coke Production, Oil Refining, Nuclear Fuel Preparation and Alcohol Production Sector and referred to the seven equations that were tested. It was necessary to take into account calculations for all the other sectors to make the cross-section model feasible.

Table2: Fixed Effect Coefficients

Sectors	EQ1	EQ2	EQ3	EQ4	EQ5	EQ6	EQ7
23	1.602298	1.638560	1.575055	1.567027	1.619550	1.489545	1.475811
$\mathbf{R^2}$	0.915651	0.916269	0.916617	0.917477	0.915574	0.918429	0.919195

Source: Research results

The results presented on Table 2 point to positive coefficients for Sector 23, which means to say that the investment it has carried out within this timeframe have been relatively superior to those carried out by other sectors, independently of changes in the explanatory variables considered in the model.

It can be observed that the intensity varies according to the inclusion of the variables in the econometric equations that were tested. This sector shows a coefficient that amounts to 1.602298 for the first equation. Such a result may be pointing out that the specificities of the oil industry are determined at the moment investments are made, and factors that are specific to this sector and that also determine investment decisions, contributed to make the investment made during the timeframe studied higher than the average for other sectors.

One of the possible specificities inherent to Sector 23 is the magnitude of the oil industry, which demands very large investments that are relatively higher than what is demanded for the transformation industry as a whole. Furthermore, efforts made at self-sufficiency in the oil market by state-owned Petrobras may also have contributed towards the relatively higher investments made in this sector. For example, such characteristics are ignored when aggregate investment models are estimated, but taken into account in panel estimate.

5. Conclusion

The current article carried out a preliminary analysis of the main determinants of private investment for some sectors in the transformation industry in Brazil, based on a panel analysis of the 1996 to 2010 timeframe. The investment models estimated confirmed the relevance of quantitative variables, the gross amount of industrial production and the use of capacity when explaining private investment. The relationship found between interest rates and private investment was positive and significant in sectorial models, but the coefficient found was close to zero, which suggests that a rising actual interest rate between 1996 and 2010 did not bear a negative impact on private investment. Such empiric evidence, which apparently goes against economic theory, may be related to the financing conditions of private investment in the country as it limits company investment to the use of accumulated profits and bank credit due to the low volume of the resources available. Results also showed that greater credit offer through the BNDES system's making more credit available increased private investment in the periods that follow, which confirms the hypothesis that Brazilian companies depend on long-term financial resources made available by official development agencies.

The existence of instability may also be a factor that hurts investment financing, as it causes uncertainty and hurts long-term resource sources. The negative relationship between a differentiated exchange rate and investment also reflects entrepreneurs' aversion to uncertainty and instability, as results suggest that times when the exchange rate is highly volatile exert negative impact on private investment. When the

exchange rate is more devalued, it also discourages the importation of capital goods and raises the financial commitments of companies that carry foreign debt, which decreases investment in the economy.

A suggestion for future studies is that scenario simulation models should be used to seek to analyze the behavior of the Brazilian economy when compared to Sector 23 in a quest to find suggestions for private investment. Lastly, it will also be satisfactory to carry out analyses related to the quality of energy resources, in a quest to help the policies that guide the use of machines, equipment and costs in Sector 23.

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