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CONTENTS

ABSTRACT

This paper provides new evidence for the empirical literature that investigates the presence of political cycles in fiscal policy and, more precisely, public investments in Brazil. The approach differs from most of the studies for applying the state-space modeling. The greatest benefit is to estimate the cyclical component endogenously and with greater precision. Another difference is that it considers the presence of cycles in central, state and local investments and central government capital transfers. This allows a wider picture of the general government and intergovernmental relationships. The main contributions come from the identification of qualitative differences among the political cycles of each government level – pointing to a smaller degree of direct influence of local elections as it goes from local to state and central levels – and a close relation between cycles of central government transfers and cycles of state and local governments.

Keywords: political cycles; public investment; space state models.

SINOPSE

Este trabalho provê novas evidências para a literatura empírica que explora a presença de ciclos políticos eleitorais nos investimentos públicos no Brasil. A abordagem se diferencia da maior parte dos trabalhos da área por aplicar a modelagem de espaço de estados. Sua maior vantagem é estimar o componente cíclico com maior precisão e de maneira endógena. Outra distinção é considerar a presença de ciclos nos três entes federados, além das transferências do governo federal, permitindo-se uma visão mais abrangente da administração pública e das inter-relações federativas. As contribuições mais relevantes foram: *i*) a identificação de diferenças qualitativas nos ciclos eleitorais de cada ente federado, constatando-se menor grau de influência direta das eleições municipais conforme se caminha da esfera local para as esferas estadual e federal; e *ii*) a observação de estreita relação entre os ciclos bienais das transferências do governo federal e dos investimentos dos demais entes federados.

Palavras-chave: ciclos políticos; investimento público; modelo de espaço de estados.

1 INTRODUCTION

The political business cycle literature constitutes one of the most exciting research agenda in economics nowadays. It has received contributions from authors working with different approaches, from the seminal Kalecki's (1943) heterodox perspective to models of opportunistic cycles and adaptive expectations (Nordhaus, 1975), as well as its rational expectations formulation (Rogoff; Sibert, 1988; Rogoff, 1990). The unifying feature of these different approaches is the aim of understanding the connections between economics and politics and, therefore, taking into consideration political factors as an additional explanation to economic fluctuation. Following Frey and Benz (2002), it is possible to group this literature into two main building blocks: ideological and political cycle models.

In this paper we contribute to the latter block, which is focused in studying the presence of political cycles in economic policy variables and its impacts on macroeconomic aggregates. Previous studies are usually focused on investigating the presence of cyclical components in public expenditure data. The general idea consists in discussing whether or not public expenditures accelerate before election and slow down afterwards, showing, therefore, temporal trajectories that coincide with electoral periods. But there are also studies that rely on other variables of fiscal, monetary and foreign exchange policy. Among fiscal policy variables, public investment is one of the most important when analyzing the political cycles given that this type of expenditure is generally more visible to voters and has larger multiplier effects on aggregate demand and employment. Furthermore, public investments have an intrinsically discretionary nature which makes them more sensitive to politicians' decision. Once identified the presence of political electoral cycles, a second direction of research focuses on studying its impacts on macroeconomic variables in terms of fiscal and monetary instabilities (public debt, inflation etc.) as well as in the behavior and fluctuation of other variables (unemployment, product growth, income distribution etc.).

The contribution of this paper consists in investigating the presence of political electoral cycles in gross fixed capital formation of Brazilian general government using time series econometric methods in a state-space framework. In state-space models it is possible to decompose time series in several structural components, including the cyclical one, which captures regular movements whose frequency can be endogenously

estimated. The inclusion of cyclical components in state-space models is common in the business cycle literature, but, as shown by Orair and Silva (2012), it can be easily adapted to electoral cycles. These authors use the state-space framework to analyze series of monthly investments by Brazilian state and local governments over 2002-2010 and find evidence of political electoral cycles.

This paper, meanwhile being an extension of Orair and Silva (2012) as it updates their analysis to 2011, presents innovative contributions by investigating the presence of political cycles in the series of monthly investments by the central government and its capital transfers that finance investments by local and state governments. This is an important extension as it provides a wider picture of the Brazilian general government and its relationships between government levels, which is characterized by high decentralization of investments and a complex intergovernmental transfer system. To give an idea of the numbers involved, Brazilian general government investments in 2010 reached R$ 104.9 billion (approximately US$ 59.1 billion), being R$ 30.7 billion from the central government, R$ 40.1 billion (US$ 17.5 billion) from state government and R$ 34.1 (US$ 22.9 billion) from local government. In the same year, central government transfers for investments were of R$ 15.4 billion (US$ 8.8 billion) that are almost fully given to local and state governments and finance about 20% of their investments (19% and 21% in state and local levels, respectively).[1]

Therefore, the aim of this paper is to test the hypothesis of political electoral cycles in aggregate time series data of the Brazilian general government investments – central, state and local governments – and central government capital transfers. The methodology employed is quite simple: it consists in adjusting univariate structural time series model for each series and then evaluating if the estimates of frequency and temporal trajectory of cyclical components are compatible with the political electoral cycles hypothesis.

The main contributions to the existing literature are worth of mention. First, concerning the empirical strategy, our approach lies in the use of state-space framework which allows to decompose time series into their structural components and, thus, isolate the cyclical component from the influence of the other components (trend, seasonality, irregular etc.). In fact, estimating the cycles in this way – which has not

1. State and local governments account for 96% of the total amount of capital transfers (R$ 7,5 billion and R$ 7,3 billion, respectively).

been fully explored so far in the literature – permits a better identification of the cycles turning points and, at the same time, it allows an analysis of the qualitative differences between government levels.[2] This is a considerable improvement in relation to the dominant approach of testing the presence of cycles by estimating time series regressions with electoral dummies. Second, by extending the analysis of public investments to all government levels and central transfers, we are able to obtain a wider picture of the general government. Therefore, while previous studies in Brazil usually are restricted to specific government levels, we explicitly incorporate the commonly neglected relations between central government and subnational governments. Being based on aggregate time series, however, makes it impossible to analyze individual effects in each government unity, this consists of the paper´s greater weakness.

Given our purpose, the next section briefly summarizes the theoretical literature on political business cycles and reviews empirical papers about the Brazilian case. Section 3 describes the empirical strategy while the results of its application to the series of public investments and central government transfers are discussed in section 4. Finally, the fifth section contains some concluding remarks.

2 LITERATURE REVIEW

Since Kalecki (1943), in *Political aspects of full employment*, the relation between economic and political cycles has been studied by economists. According to Kalecki (1943), even though at that time there was a consensus that the government could lead the economy to a full employment position, its maintenance would face the opposition of capitalists, although periods of higher output and employment benefit not only workers, but also capitalists as their profits raise. The reason for this opposition is deemed to be politically motivated and related to three factors: *i)* aversion to government control on subjects concerning employment; *ii)* aversion to the direction of government's spending; *iii)* aversion to possible social and political changes due to the maintenance of full employment. Adopting a heterodox view of the economy, Kalecki (1943) assumes that there is no tendency in capitalist economies to employ all the productive factors available and, therefore, economies normally operate below full employment. In depressions,

2. As far as we know, Orair and Silva (2012) is the only paper that uses the state-space framework to analyze the existence of political electoral cycles, meanwhile Bond, Fleisher and Wood (2003) use it to discuss cycles in ideological models.

however, when unemployment rates are high, political pressure against anti-cyclical policies based in rising public investments is mitigated as far as the government faces more pressure of the working class and, while the policy is viewed as temporary, a lesser capitalist opposition. As the employment rate gets higher in the next boom, political opposition to public expending will rise, pressuring the government to return to an orthodox policy of fiscal adjustment by decreasing budget deficits and public investments.

Meanwhile scrutinizing Kalecki's analysis of the political business cycles is not an issue here, it is worth to retain that his greatest contribution is to introduce the idea that economic outputs and, in particular, economic cycles might be influenced by political factors. This consists of an innovation to the literature which only stated the relevance of the opposite direction of causality: political events and elections being exogenously determined by the economy's performance (Olters, 2004).

Indeed, the emergence of models based on the Phillips curve has boosted the studies on political business cycles, giving raise to a field conventionally known as "the new political macroeconomics" (Snowdon; Vane, 1999). The central idea of this framework is that cycles are originated in the fact that policymakers undertake self-interested decisions. This means that policymakers are not focused in achieving optimal social results, but use economic policies with the opportunistic intention of reelection or pursuing government ideology. As shown by Snowdon and Vane (1999) and Frey and Benz (2002), these political cycles models can be classified into four groups, which differ in two main theoretical considerations. The first refers to the previously described assumptions about politicians' motivation: self-interest or government ideology. Each one of these can also be divided into other two groups according to what are assumed about agents behavior toward governments actions: agents expectations are rational or adaptive. As we have no intention to discuss the whole theoretical literature about political business cycles, only the seminal contributions of these four groups are briefly discussed thereafter.[3]

Nordhau´s (1975) seminal contribution set up the group of opportunistic political cycles with adaptive expectations. His model is based in the assumption of self-interested policymakers whose goal is to obtain the largest support at elections. For that, they

3. Detailed reviews can be found in Persson and Tabellini (1999), Fialho (1999), Frey and Benz(2002) and Olters (2004).

exploit the short-term trade-off between unemployment and inflation as predicted by the extended Phillips curve. Expansionary measures to increase economic growth and reduce unemployment should be adopted before elections, therefore, aiming to gain popularity and raise the probability of reelection. Consequently, contractionary policies would be applied after election to reduce inflation rate caused by the previous expansion. Therefore, the idea that politicians can systematically fool voters is decisive to the existence of cycles in this type of model.

As a consequence of the debate rational *versus* adaptive expectations, political cycles models were extended to incorporate the hypothesis that voters cannot be systematically fooled by politicians. As shown by Rogoff and Sibert (1988) and Rogoff (1990), even without the possibility to explore the Phillips curve due to agents forward-looking behavior, political business cycles might emerge because of the asymmetric information between voters and government. The most important hypothesis of these models is that the electorate is not capable to determine the administrative competence of incumbents. Therefore, incumbents currently in office have the opportunity to signal their ability to voters by putting in practice policies to stimulate the economy, actions that unqualified politicians would be unable to do. However, as pointed out by Olters (2004), it is controversial that precisely the efficient politicians undertake suboptimal policies, while the inefficient ones pursue optimal outcomes.

Hibbs (1977), using the same modeling strategy as Nordhaus (1975), introduced the idea that politicians' leading motivation can be ideological. Different ideologies adopted by parties might result in distinct choices between inflation and unemployment. Leftwing parties, which electoral basis mainly consisted of workers, will probably be more concerned about unemployment than inflation, the opposite being true for rightwing parties. Therefore, different preferences of supporters influence parties decisions about what kind of policies to pursue. Cycles are, then, generated by the alternation in office of parties with distinct political ideologies.

Alesina (1987) extended the partisan approach to incorporate rational expectations. Cycles originate from the fact that contracts are adjusted in discrete time intervals and nominal wages are set prior to elections following agents inflation expectation. The election results are unknown *ex ante*, so it is the macroeconomic policy to be pursued. This creates the potential for a post-election inflationary surprise as demand policy

management will be influenced by parties ideological considerations. Therefore, output and inflation will deviate of their natural levels.

It should be noted from the discussion above that different approaches were used to model the existence of political business cycles. On the empirical front, there have been several tests of the political business cycle hypothesis for a variety of countries, individually or in group. To highlight this paper´s contributions to the Brazilian case, we review the empirical literature on political electoral cycles in fiscal variables. Following the international literature, Brazilian literature has been dominated by the strategy of testing the significance of electoral dummies in regression models. This approach was largely used in macroeconomic and microeconomic studies analyzing aggregate time series and state and local government panel data, respectively.

Preussler and Portugal (2003) tested the political opportunistic hypothesis between 1980 and 2000 in Brazilian macroeconomic variables and also in the instruments of fiscal policy and interest rates.[4] The authors estimated autoregressive integrated moving average (ARIMA) models for each macroeconomic series, including dummy variables that assume value 1 in the six or eight months before elections and zero otherwise. The results suggested that unemployment growth rates and output are not affected by election, while inflation rate is negatively affected in the first six months preceding elections. To investigate the existence of cycles in instruments of fiscal policy, ARIMA models with dummies were estimated for the series of central government total expenditures and primary deficits. In these cases, however, Preussler and Portugal (2003) used, besides the dummies previously mentioned, dummies that assume value 1 in the first six or eight months after elections. The reasoning for that according to the authors is the fact that the data used in the estimations are measured by cash-basis accounting and policymakers have incentives to authorize the acquisition of goods and services before elections, postponing the payment to the next mandate, imposing a lag between the expenditure generation fact and its effective payment. Indeed, these estimation results suggest that it is important to take this fact into consideration for the total expenditure series as the pre-election dummies are not significant, but the post-election ones are. For the fiscal deficit series, all dummies turned out to be irrelevant.

4. Preussler and Portugal (2003) can be understood as an extension of Fialho (1997). The latter, however, did not tested the existence of cycles in series of fiscal instruments and the results are compromised by the fact that their sample (1953-1995) covers several years of dictatorial regime (1964-1988).

Following Preussler and Portugal (2003), Salvato *et al.* (2007) found evidences of pre-electoral manipulation in output and unemployment growth rates over the period 1985-2006 and in the case of inflation rate only after the Real Plan, an inflation stabilization plan adopted in 1995. The authors also did not reject the opportunistic hypothesis for public spending and government deficits. Besides the univariate ARIMA approach, Salvato *et al.* (2007) employed a multivariate strategy based on the estimation of an autoregressive vector (VAR) for the macroeconomic variables, finding results in accordance with those previously described.

The most recent empirical literature on political cycles and instruments of fiscal policy in the Brazilian economy has been dominated by the use of panel data techniques applied to state and local governments datasets. Using two simple indexes of fiscal impulse based on states primary surplus as a share of their Gross Domestic Product (GDP), Cossio (2002) showed that fiscal expansions between 1985 and 1997 were more likely to occur in election years and that the source of these expansions were primary expenditures and not tax reduction. The author, then, estimated a model to explain changes in states primary expenditures with categorical variables to test for the presence of opportunistic and partisan cycles. Therefore, besides controlling for a series of variables, the estimated models include a dummy variable that assumes value 1 in election years for governor and zero otherwise and other dummies indicating if governors parties are left, right or center wing and whether or not they offer political support to the president of the Republic. The results suggest that: *i)* expenditures are influenced by electoral cycles; *ii)* left wing parties have shown a more expansionist attitude than center ones; and *iii)* there is no evidence of significant differences in fiscal stance between center and right wing parties.

Evidences for states were also presented by Botelho (2002) and Nakaguma and Bender (2010). The first paper showed that states budget deficit increased in electoral years over the 1986-2000 period. Besides that, the results did not support the partisan cycles hypothesis, but indicated the existence of fiscal moderation in pre-election years as a measure of saving resources to expend them closer to the polls. The second paper tested the existence of electoral cycles in the states budget execution during the 1986-2004 period. The results support the existence of well-defined cycles on revenue and expenditure variables, which increased strongly in election years and fell sharply after them. Models estimated by Nakaguma and Bender (2010) showed also the existence of cycles in the current, tax and capital revenues and current transfers as well as in the

current and capital expenditures and intermediate consumption. Given our objectives, it is worth to highlight the results for capital revenue and expenditure, which, despite not increasing significantly in electoral years, fall in average 60% and 28%, respectively, in post-election years, "showing the occurrence of cyclical adjustments in these periods" (Nakaguma; Bender, 2010, p. 8). Finally, it is worth to point out that the authors found evidence of reduction in the amplitude of electoral cycles in the long term, which they attribute to a process of learning of voters due to the consolidation of democracy in Brazil.

Concerning Brazilian municipalities, the most important contributions are from Sakurai (2005; 2009), Sakurai and Greamud (2007), and Sakurai and Menezes-Filho (2008; 2011). The first two papers test the political cycle hypothesis for the municipalities of Sao Paulo over the period of 1989-2001. Sakurai (2005), using the procedure proposed by Petterson-Lidbom (2001), found evidences that rulers who succeed in being reelected spend more in average in electoral years than in others. Moreover, federal and state transfers received by municipalities impact their budget execution. Sakurai and Greamud (2007), in turn, evaluate the existence of impulses in different items of municipal expenditures and whether or not they vary significantly among political parties. The results showed significant impulses in pre-election years in some categories of expenditures. Strong effects of elections were found for current and budget expenditures, meanwhile they did not exist or were contradictory for current transfers, investments and expenditures with public employees.

Similar results were obtained by Sakurai and Menezes-Filho (2008) using a sample of Brazilian municipalities over the 1988-2003 period. Evidences of electoral cycles were found for the aggregated public expenditures, and mainly for current expenditures. They were weak, however, for some specific types of expenditures like compensation of public employees, transfers and investments, which did not seem to be affected in all elections. Investments, for example, did not appear to be influenced by the electoral calendar over the most part of the sample, the 2000 election being the only exception. As Nakaguma and Bender (2010), the authors found evidences of a reduction in the cycles at the end of the period, which they presume being due to the institutional changes introduced along the years, mainly the adoption of the possibility of reelection and the implementation of the Law of Fiscal Responsibility (LFR). Sakurai (2009) investigated the existence of cycles in the budget functions of Brazilian municipalities in the 1989-2005 period, finding evidences of expressive cycles in health and sanitation, habitation and urbanism,

assistance and social security and transports functions. Sakurai and Menezes-Filho (2011) tested the hypothesis of opportunistic and partisan cycles for Brazilian municipalities over the 1989-2005 period, finding evidences that the municipal budget deficits increase in electoral years, to the extent that total and current expenses increase and local taxes decrease. Besides that, evidences pointed out that different party ideologies do affect budget administration.

At the best of our knowledge, Ferreira and Bugarin (2007) is the only paper to explore intergovernmental relations – taking into consideration the existence of distinct levels of government and transfers – in the Brazilian literature. The authors explored the effect of voluntary transfers from the central government and states on the fiscal policy and electoral behavior of 2,090 municipalities over the 1999-2004 period. However, their main objective was not to test the political or partisan cycles hypothesis, but to evaluate how transfers affect mayors' political parties positioning and alignment. The authors found positive correlation between received voluntary transfers and mayors' political alignment with coalitions that elected the governors and the president. Then, they concluded that the existence of interpolated elections can motivate governors and president elected to use voluntary transfers to support allied mayors.

As shown in this literature review, there is no paper about the Brazilian economy that evaluates the existence of cycles in all three levels of government. Therefore, given the objective presented in the introduction, this will consist of one of the innovative contributions of this paper.

3 STRUCTURAL TIME SERIES MODELS

The state-space framework is very general considering that any linear time series model can be formulated in a state-space representation.[5] One of the distinctive characteristics of this approach is the assumption that observed time series, represented by the vector y_t for $t = 1, \ldots, n$, consist of unobserved structural components, α_t, that can represent trend, seasonal, cycle, irregular or other regression components. The relation between

5. This section focus the gaussian linear models even though the recent improvements of SSMs are mainly related to non-linear and non-gaussian models. Further discussions can be found in Harvey (1989) and Durbin and Koopman (2001).

the observed series and the unobserved components is specified in the state-space model (SSM) as:

$$y_t = Z_t'\alpha_t + \varepsilon_t, \quad \varepsilon_t \sim NID(0, H_t) \tag{1}$$

$$\alpha_t = T_t\alpha_{t-1} + R_t\eta_t, \quad \eta_t \sim NID(0, Q_t) \tag{2}$$

Equation (1) is named *observation equation* and equation (2) is the *state equation* (or transition equation). The basic idea of the model is very simple: the development of the time series is determined by the m x 1 state vector α_t that can vary over time, accordingly to its first order autoregressive structure defined in equation (2). But, as previously stated, this vector is not observed and, then, the analysis relies upon the p observed time series in vector y_t, as established in the observation equation (1). Therefore, the purpose of the SSM is to estimate the development of the state of the series over time given the observed values. Z_t and T_t are the observation and transition matrices, with dimensions p x m and m x m, respectively. The error terms ε_t and η_t are assumed to be serially independent and independent of each other at all time points, with H_t and Q_t variance matrices.

In this paper we use the basic structural model, which plays an outstanding role in Harvey's (1989) approach, plus a cycle component. In this specification the observed series is modeled by additive components of trend (μ_t), seasonality (γ_t), cycle (ψ_t) and irregular (ε_t). The observation equation for this specification can be described as:

$$y_t = \mu_t + \gamma_t + \psi_t + \varepsilon_t, \quad \varepsilon_t \sim NID(0, \sigma_\varepsilon^2) \tag{3}$$

and the structural components (elements of the state vector α_t) as:

$$\mu_t = \mu_{t-1} + v_{t-1} + \xi_t, \quad \xi_t \sim NID(0, \sigma_\xi^2)$$

$$v_t = v_{t-1} + \zeta_t, \quad \zeta_t \sim NID(0, \sigma_\zeta^2)$$

$$\gamma_t = -\gamma_{t-1} - \gamma_{t-2} + \omega_t, \quad \omega_t \sim NID(0, \sigma_\omega^2) \tag{4}$$

$$\psi_t = \rho\cos\lambda\psi_{t-1} + \rho\sin\lambda\psi_{t-1}^* + k_t, \quad k_t \sim NID(0, \sigma_k^2)$$

$$\psi_t^* = -\rho\sin\lambda\psi_{t-1} + \rho\cos\lambda\psi_{t-1}^* + k_t^*$$

using simplified formulations. The trend component is modeled by a level element (μ_t) and its slope (v_t). The seasonal component is represented by $s-1$ elements, being s the frequency of the time series, which in this example is $s = 3$ (four-month period), and a disturbance term to allow the seasonal pattern to change over time. The cyclical component (ψ_t), in its turn, is modeled as a wave generated from trigonometric functions, where λ is the frequency of the cycle measured in radians corresponding to the period of $2\pi/\lambda$ $(0 \leq \lambda \leq \pi)$ and ρ is the damping factor. It should be noticed that the seasonal component is given by the frequency of the time series (monthly, quarterly etc.), which is known, and the cycle normally has a greater period defined by its unknown frequency, which is a parameter to be estimated.[6]

The model described in equations (3) and (4) is just a particular case of the general specification of SSM in (1) and (2), as follows from the definitions below:

$$y_t = y_t,\ \alpha_t = \begin{pmatrix} \mu_t \\ v_t \\ \gamma_t \\ \gamma_{t-1} \\ \psi_t \\ \psi_t^* \end{pmatrix},\ Z_t = \begin{pmatrix} 1 \\ 0 \\ 1 \\ 0 \\ 1 \\ 0 \end{pmatrix},\ \varepsilon_t = \varepsilon_t,\ H_t = \sigma_\varepsilon^2,$$

$$Q_t = \begin{pmatrix} \sigma_\xi^2 & 0 & 0 & 0 & 0 \\ 0 & \sigma_\zeta^2 & 0 & 0 & 0 \\ 0 & 0 & \sigma_\omega^2 & 0 & 0 \\ 0 & 0 & 0 & \sigma_k^2 & 0 \\ 0 & 0 & 0 & 0 & \sigma_{k^*}^2 \end{pmatrix},\ T_t = \begin{pmatrix} 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \rho\cos\lambda & \rho\sin\lambda \\ 0 & 0 & 0 & 0 & -\rho\sin\lambda & \rho\cos\lambda \end{pmatrix},$$

$$R_t = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix},\ \eta_t = \begin{pmatrix} \xi_t \\ \zeta_t \\ \omega_t \\ k_t \\ k_t^* \end{pmatrix}$$

6. More details and alternative formulations of the components in the basic structural model can be found in Durbin e Koopman (2001).

The SSM also allows the inclusion of other regression components, for example explanatory and intervention variables. To give an example, the univariate model defined below:

$$y_t = y_t,\ \alpha_t = \begin{pmatrix} \mu_t \\ \beta_t \\ \delta \end{pmatrix},\ Z_t = \begin{pmatrix} 1 \\ x_t \\ w_t \end{pmatrix},\ \varepsilon_t = \varepsilon_t,\ H_t = \sigma_\varepsilon^2,\ T_t = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix},$$

$$R_t = \begin{pmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \end{pmatrix},\ \eta_t = \begin{pmatrix} \xi_t \\ \zeta_t \end{pmatrix} \text{ and } Q_t = \begin{pmatrix} \sigma_\xi^2 & 0 \\ 0 & \sigma_\zeta^2 \end{pmatrix}$$

considers a trend component (μ_t), modeled by a level element, a regression component related to the inclusion of an explanatory variable and its associated parameter ($\beta_t x_t$) and an intervention effect modeled as a categorical variable (w_t) that assumes values 1 from the period τ onwards and zero otherwise and represents a change (δ) at the level of the observation equation. It is important to notice that this SSM can be generalized, for example, to include other observed series (multivariate models), autoregressive components, independent variables or the combination of other structural components represented in the basic structural model.

As regards the definition of which elements of the state vector should be modeled as stochastic or deterministic processes, it depends on the evaluation of the estimated disturbance variances of each component: values close to zero indicate a deterministic modeling strategy (fixed over time) and a stochastic one otherwise (variable over time). The non-null lines of the m x r selection matrix R_t (with $r \leq m$ columns of an identity matrix of order m), indicate the r state components modeled as stochastic, which disturbances are represented in the vector η_t. The parameters in equations (1) and (2) are estimated making use of the Kalman Filter and the Maximum Likelihood estimator.[7]

As we try to show in this brief presentation, the state-space is a very general formulation that allows to decompose time series into several structural components explicitly modeled, that have a direct interpretation (trend, seasonal, cycles etc.) and

7. For a detailed exposition about the Kalman filter and the estimation of the parameters, see Harvey (1989) and Durbin and Koopman (2001).

make possible the identification of stylized facts. The approach constitutes, therefore, a useful analytical tool for describing the development of time series that contain very singular components, as the cyclical ones in Brazilian public investments that will be shown in next section.

4 STRUCTURAL COMPONENTS OF THE BRAZILIAN PUBLIC INVESTMENTS SERIES

This section presents the results obtained by applying the basic structural model, plus cyclical and intervention components, to the series of public investments in Brazil by government levels – central, state and local – and capital transfers from the central government to state and local governments. The monthly series of investments for the three government subsections during the 2002-2011 period are from Santos *et al.* (2011) and Orair and Silva (2012). The capital transfers were obtained directly from the central government information system (Sistema Integrado de Administração Financeira do Governo Federal – SIAFI). All series were converted into Real values (december 2011 constant R$) by the consumer price index (Índice Nacional de Preços ao Consumidor Amplo – IPCA).

The models were adjusted in logarithms and the specifications allowed the presence of one or two cyclical components. The main purpose of the analysis is to evaluate if the endogenous estimates of frequency and cyclical trajectory are compatible with the hypothesis of political electoral cycles; in other words, if the cyclical components reach their peaks in the pre-electoral periods and have biannual or quadrennial frequency that coincides with the electoral calendar in Brazil. The estimation strategy is fairly simple: each model is initially estimated without intervention variables. If necessary, interventions for outliers and structural breaks are included. As we will see in the next subsections, these irregularities are very common in Brazilian government statistics.

4.1 State government investments

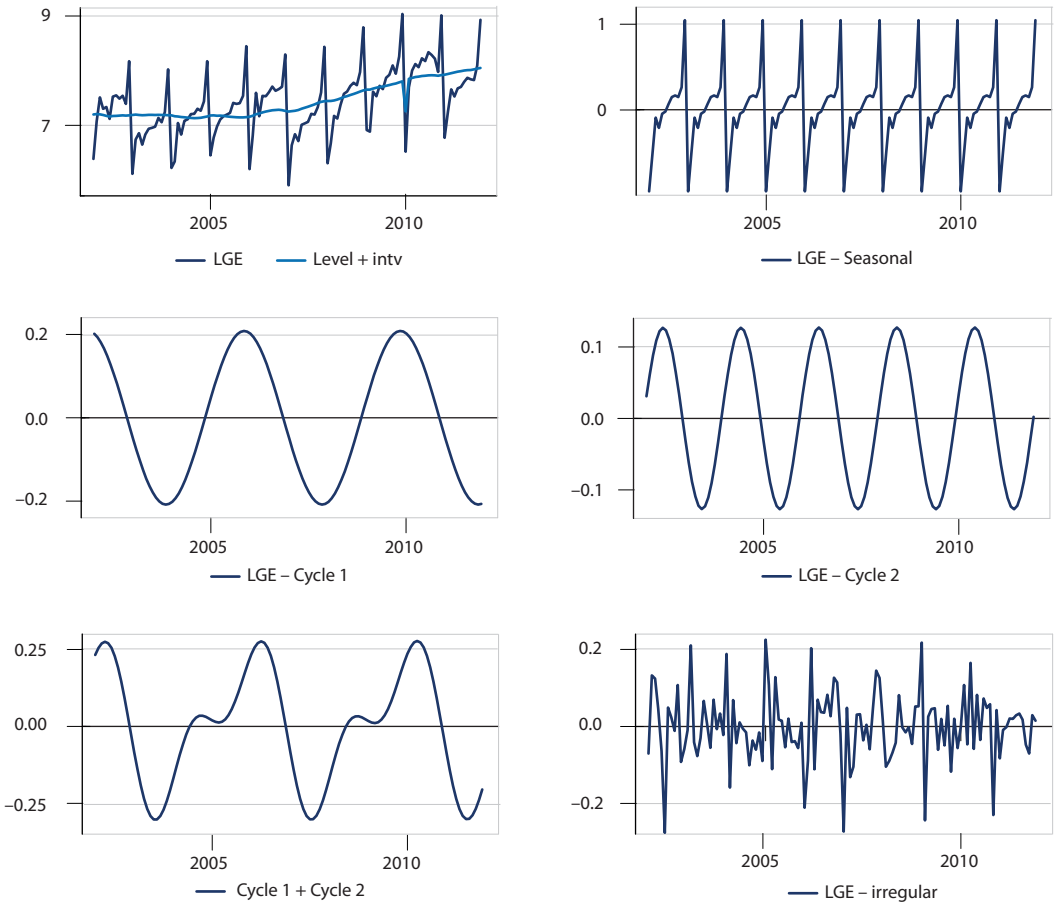
The results for the state government, including estimated parameters and test statistics, are presented in table A.1 (appendix). The initial models adjusted include one or two cyclical components and are indicated at GE1 and GE3. Diagnostic tests for both models showed evidences of non-normality of residuals and an outlier in January 2010. The

models were re-estimated with intervention variables and are indicated at GE2 and GE4. These new models had similar parameters results and more suitable diagnostics, despite the evidences of non-normality in residuals. The estimated parameters for seasonality are deterministic and the other parameters are stochastic with variance estimates close to zero. Hence the estimation resulted in very regular cyclical and seasonal components and a smooth trend component for the evolution of state government investments.

The trend component in figure 1 suggests a stagnation of state government investments in the beginning of the series and inflection for a growing trend after 2005. On the other hand, the seasonal component shows a regular pattern in the budget execution of investments that accelerates throughout the year. The most outstanding results are related to the cyclical components. Models GE2 and GE4 with the best diagnostics estimated a nearly biennial cycle (1.97 and 2.0 years respectively). Model GE4 also found evidence of a nearly quadrennial cycle with larger amplitude (4.0 years).

Considering the joint effect of both cycles it can be seen in the lower part of figure 1 that cyclical growth of state government investments begins around the middle of the first year after the elections for governors (2003, 2007 and 2011). This trajectory is temporarily interrupted due to the slowdown in the post-electoral period of local governments (2004 and 2006). On the other hand, the cyclical peak of investments occurs exactly in the pre-electoral periods for governors (2002, 2006 and 2010) when the ascending phases of both cycles combine. The coincidence between downwards phases of both cycles makes the post-electoral slowdown even deeper. Avoiding details for now, it might be said that the estimated cyclical components fit the hypothesis of electoral cycles. This aspect will be further discussed, after analyzing the presence of cycles in other public investment series.

FIGURE 1
State government investments: Logarithms of observed series (*LGE*) and structural components of trend, seasonality, cycles and irregular (2002-2011)



Note: Elaborated with the results of GE4 model from table A.1 (appendix).

4.2 Local government investments

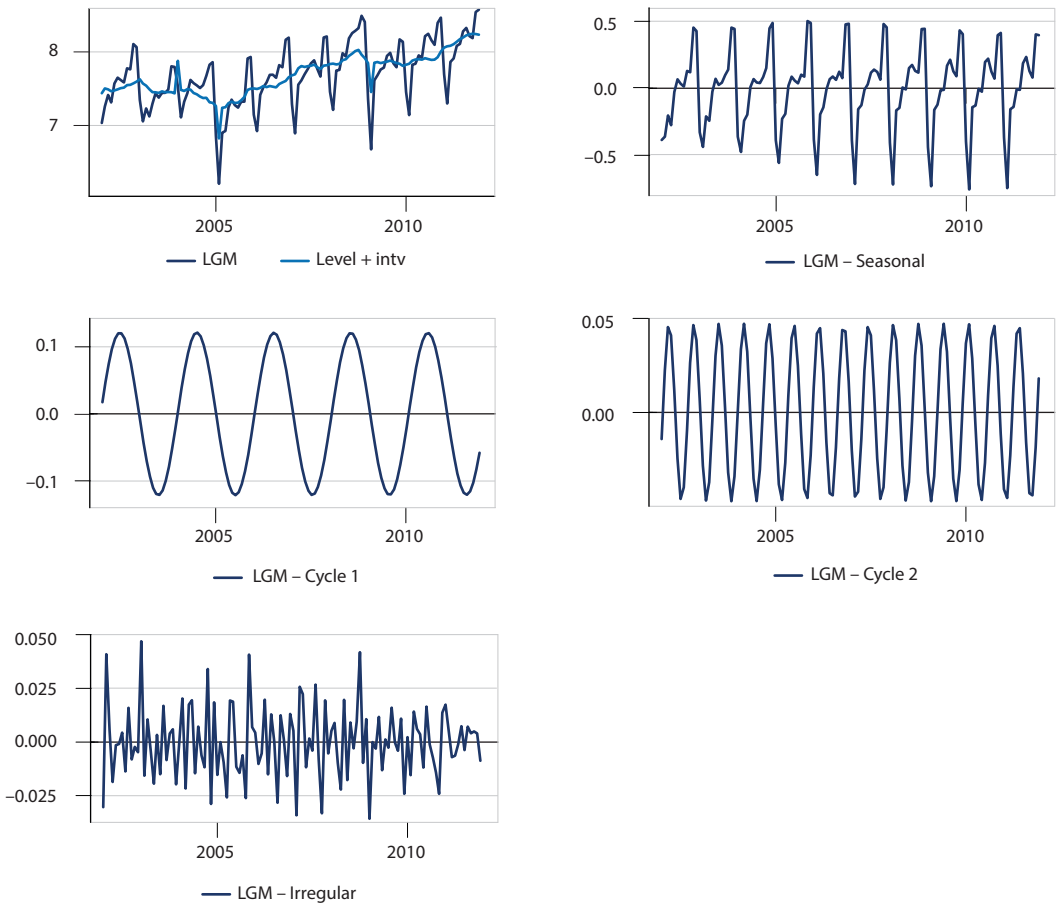
The results of models for local government investments are at table A.2 (appendix). The GM1 and GM3 models were estimated with one and two cyclical components, respectively, and present strong evidences of non-normal residuals. This is due to several potential outliers and structural breaks and might be related to the lower quality of the local government investments series.[8] To obtain better specification, the GM2 model with a cyclical component and the GM4 model with two cycles were estimated including intervention variables. These models showed more appropriate diagnostics, but still have evidences of non-normality of residuals and heteroscedasticity.

8. See Orair *et al.* (2011) to a discussion about the problems found in the primary data sources of municipal public finances in Brazil.

The estimated parameters for trend level of these models are stochastic, while the parameters of trend slope and the seasonality component are deterministic. The estimated components showed results that are quite similar to those obtained at the state government investments, as it can be seen in figure 2. The trend for local government investments also pointed to an inflexion after 2005, when it passed from a period of decline to a growing period, although it exhibits many irregularities. The seasonality presented the same regular pattern of acceleration in budget execution along the year, but with an increasing amplitude over time and smaller than the state government seasonality.

FIGURE 2

Local government investments: Logarithms of observed series (LGM) and structural components of trend, seasonality, cycles and irregular (2002-2011)



Note: Elaborated with the results of GM2 model from table A.2 (appendix).

Finally, the models estimated a biennial cycle (2.03 in both GM2 and GM4 models) with trajectories and amplitude that are quite similar to those obtained at the state government. The main distinction in the results is the lack of evidences for a quadrennial cyclical component at local level. The GM4, which is the model with two cyclical components that best fitted, estimated a cycle with frequency of 0.6 years and reduced amplitude that seems to be capturing a seasonal effect and not a cyclical one.

4.3 Central government investments

Tables A.3 and A.4 (appendix) show the results of the models for central government investments. Initial specifications are indicated at GF1 and GF4 that include one and two cyclical components, respectively. Both models found evidence of quadrennial cycles (3.99 and 3.98 years, respectively). The diagnostics did not indicate strong serial autocorrelation in the residuals but detected structural break on trend level in 2003 and potential outliers at the beginning of the sample and thus evidences of non-normality in residuals and heteroscedasticity.

Models GF2 and GF5 were estimated with intervention variables for the structural break in 2003 and also detected nearly quadrennial cycles (4.04 and 4.30 years, respectively). Although they presented poor residual diagnostics and evidences of many outliers and structural breaks through the period of 2002-2004. It is worth pointing out that this period that concentrates the irregularities matches the transition to the Lula government and the tight fiscal policy of the beginning of this government.

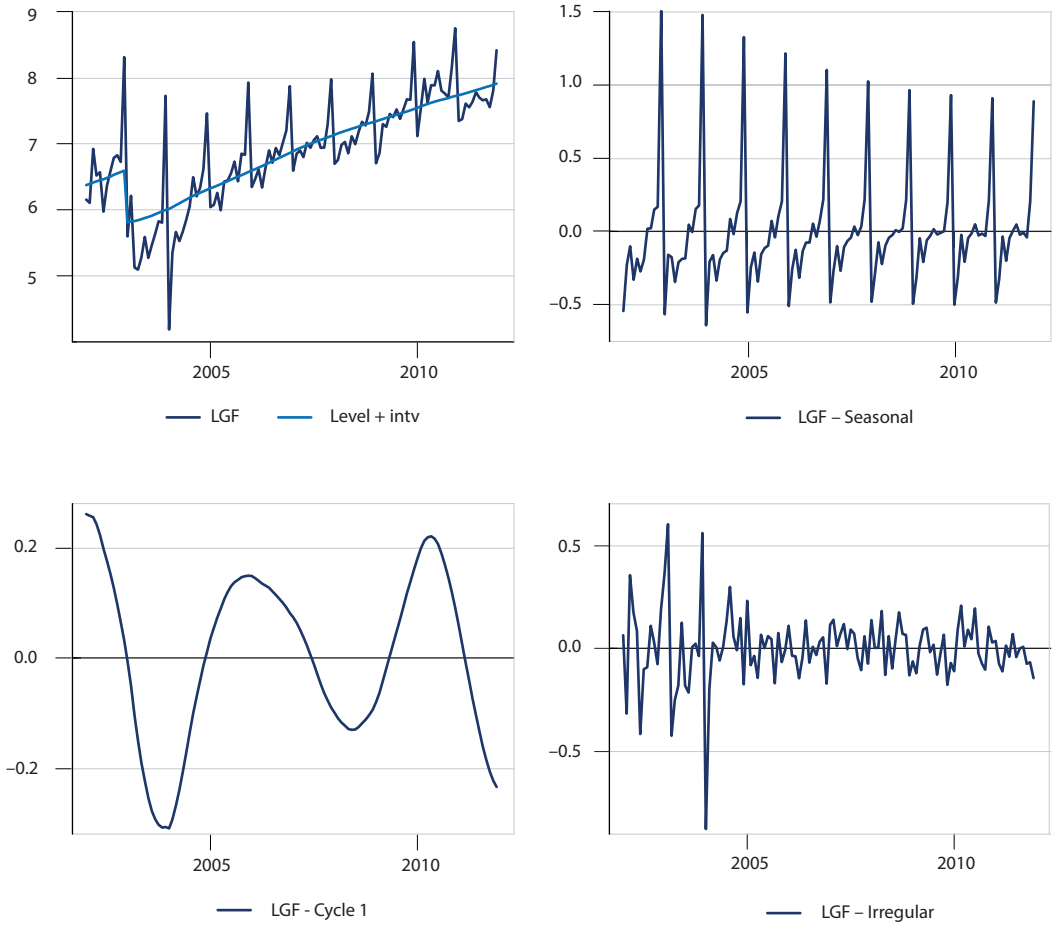
To deal with these problems the time-sample was restricted to the years 2005 to 2011 and models GF3 and GF6 were fitted in. These new models presented better diagnostics despite the little evidence of serial correlation. The cyclical frequency estimated in GF3 model was of 3.7 years and the peaks occurred in the third quarter of 2006 and second quarter of 2010. Model GF6 estimated a cyclical component of 3.4 years with peaks in the third quarter of 2006 and first quarter of 2010. The second cyclical component estimate is about one year long and apparently captures a seasonal effect and not a cyclical one. It must be highlighted that all of the models show cyclical components that reach peaks right before presidential elections (2002, 2006 and 2010) and a slowdown afterwards. The cyclical reversion occurs in the second year of the elected government. Some of these cyclical components might be seen in figures 3 and 4, as well as the other structural components.

The results for the central government also indicates a smooth trend and a regular seasonal pattern that follows from deterministic or stochastic parameters with almost zero variance. The trend component showed a progressive expansion of investments after the structural break in 2003. Seasonality holds a pattern similar to those of the state and local governments, which concentrates budget execution in the last months of the year, but with decreasing amplitude over time.

Concerning the cyclical components, two aspects may be underlined that distinguish the results of central government. First, the structural component related to the electoral cycle showed a wider irregularity in its amplitude – alternating a higher fluctuation in the first cycle with peak in 2002, smaller in 2006 and intermediate in 2010 – compared to the regular pattern that prevails among the other government levels. The second aspect is the lack of evidence of biennial cycles at central government level. Results point only to a quadrennial component.

FIGURE 3

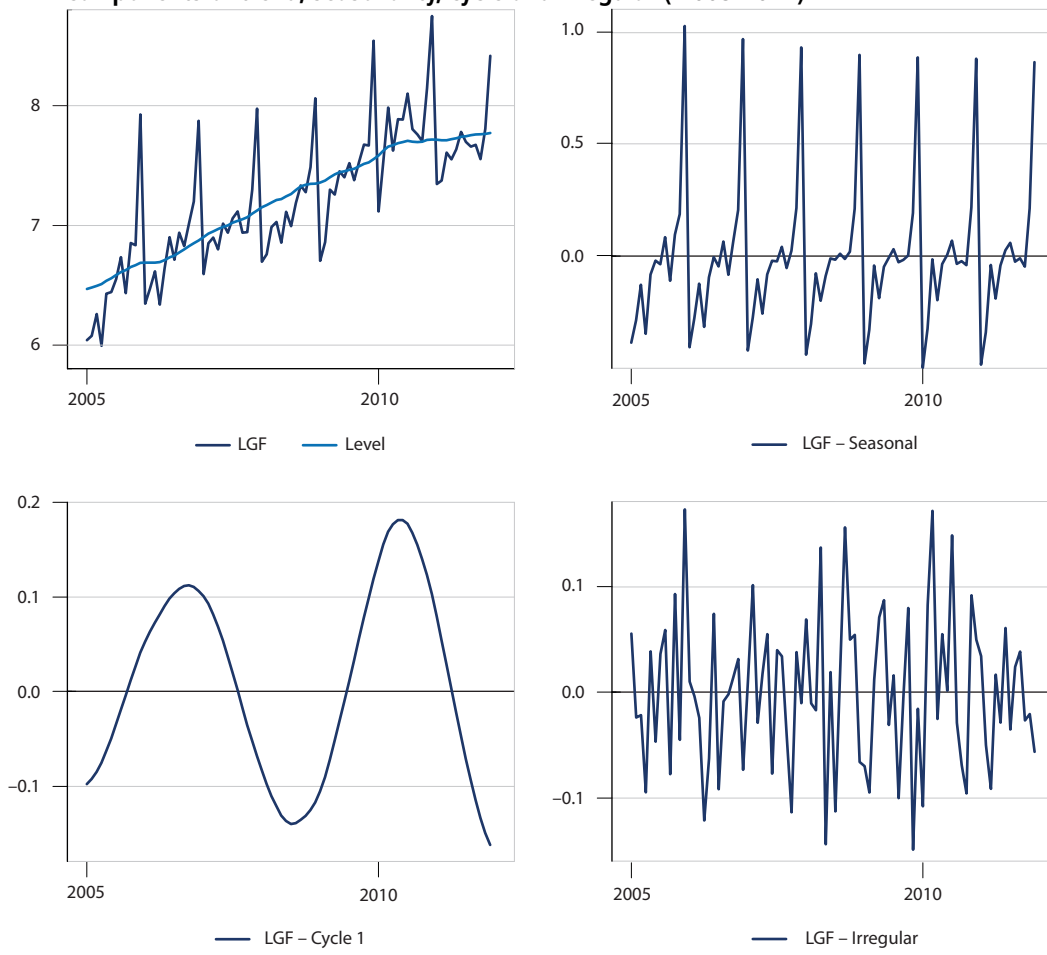
Central government investments: Logarithms of the observed series (*LGF*) and structural components of trend, seasonality, cycle and irregular (2002-2011)



Note: Elaborated with the results of GF2 model from table A.3 (appendix).

FIGURE 4

Central government investments: Logarithms of the observed series (*LGF*) and structural components of trend, seasonality, cycle and irregular (2005-2011)



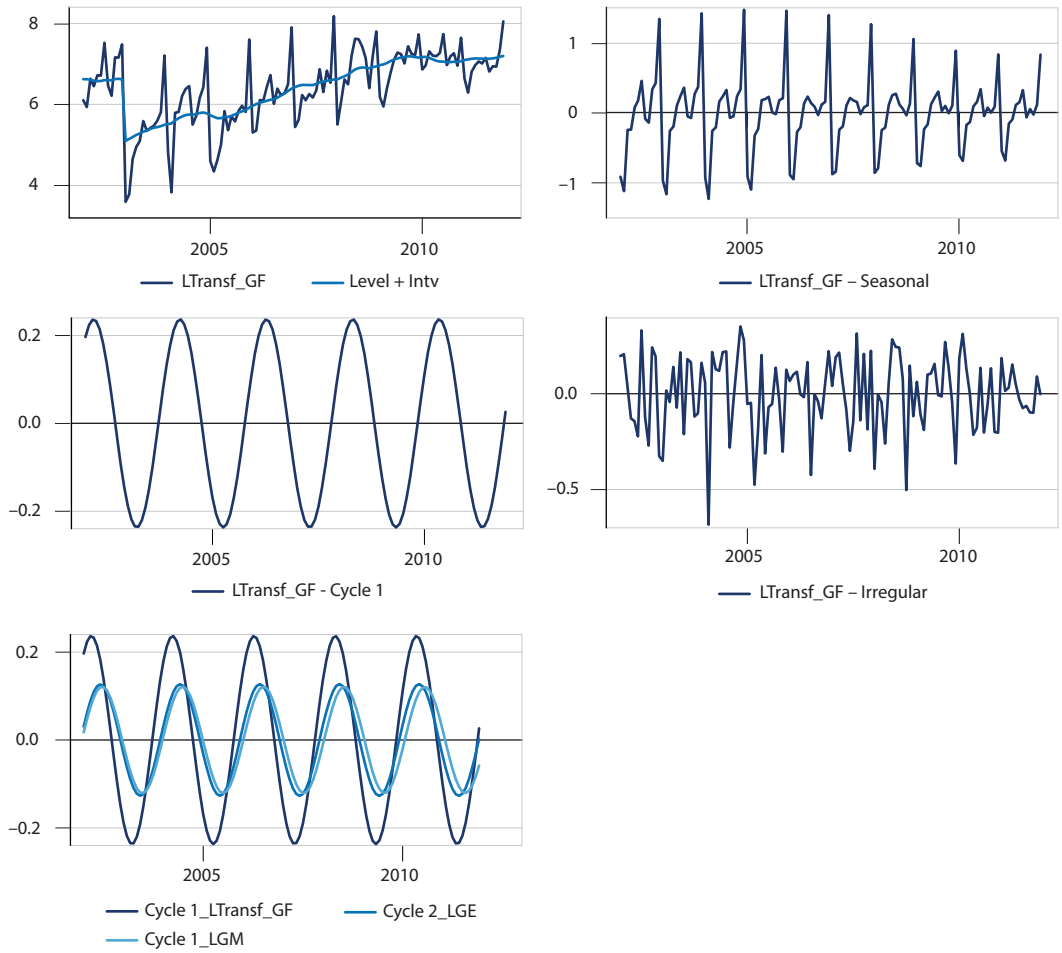
Note: Elaborated with the results of GF3 model from table A.3 (appendix).

4.4 Central government capital transfers

Table A.5 (appendix) shows the results of the models for central government capital transfers that finances investments by local and state governments. Initial specifications are indicated as Transf1 and Transf3 and had evidences of a structural break in the trend level at the beginning of 2003. Models Transf2 and Transf4 were then estimated with an intervention variable and presented better residuals diagnostics.

Results did not show evidences of a second cycle and all models estimated a biennial component with trajectory similar to those found in state and municipal governments. As, for example, the component of 2.04 years of model Transf2 presented on figure 5. In the lower part of the figure it is possible to observe that the biennial cycle of transfers has larger amplitude and slight temporal precedence compared to the biennial cycle of investments by state and local governments – that reach their peaks in the second quarter of electoral years while the peak of transfers occurs in the first quarter.

FIGURE 5
Central government's transfers for investments: Logarithms of the observed series (Transf_GF) and structural components of trend, seasonality, cycle and irregular (2002-2011)



Note: Elaborated with the results of Transf2 model from table A.5 (appendix).

The seasonal component is stochastic and has the same pattern as the other series concentrating the budget execution of investments in the last months of the year. Its amplitude is decreasing over time similarly to the investment series of central government. Finally, the trend component presented growth in most of the period after the pronounced structural break in 2003, during the beginning of Lula's government. Even though there are signs of stabilization in the most recent period.

5 SUMMARY OF MAIN RESULTS AND CONCLUDING REMARKS

This paper uses the state-space model (SSM) framework to analyze structural components of monthly series investments by each Brazilian government sub-sectors. The models presented some common results. First of all, they indicated an expansion trend of public investments in most of the period. This expansion began in 2003 for the central government series, right after the structural break with a pronounced fall in public investments during the period of 2002-2003 marked by the transition to Lula´s government and a tight fiscal adjustment. In state and local government levels the inflexion occurred only from 2005 and after an initial period of stability or even retraction of investments. Seasonal components hold a common pattern in all series characterized by an acceleration on budget execution of investments over the year and its concentration in the last months. This seasonal pattern reflects mainly the way that the budget execution has been operating under the fiscal regime in Brazil that targets primary deficits. This regime imposes limits for discretionary spending like most of public investments that usually become more flexible at the end of the year as the fiscal authorities make sure that the targets will be accomplished.

The most interesting results are related to the biennial and quadrennial cyclical components with temporal trajectories that match electoral calendars. They were found at the series of investments in every government levels and capital transfers by central government. Such cyclical components were estimated endogenously by various econometric specifications and are very robust. The biennial components indicate a cyclical acceleration that reaches its peak in even years – that corresponds to pre-electoral periods of mayoral elections (2004 and 2008) and governors' and presidential elections (2002, 2006 and 2010) – followed by a post-electoral slowdown with cyclical bottom in odd years. On the other hand, quadrennial cyclical components of public investments reach higher levels during governors' and presidential pre-electoral periods (2002, 2006

and 2010) and the decreasing post-electoral phase will be reversed only at the second year of the elected government (2004 and 2008). Our findings provide empirical evidences for the hypothesis of political electoral cycles.

Results also allow us to establish qualitative differences in political electoral cycles between government levels. Local government evidences point to a single and regular biennial cycle that suggests that investments are influenced with similar magnitudes by both cycles of local elections (2004 and 2008) and state and central elections (2002, 2006 and 2010). A biennial cycle like the one in local government was found at state government and also a second quadrennial cycle with larger amplitude. Results outline that state government investments are influenced by the calendar of local elections but its degree of influence is smaller than state elections. The additional quadrennial cycle suggests that state government investments follow closely the calendar of governors and presidential elections. By contrast, evidences in central government are for a single quadrennial cycle directly correlated with the calendar of governors and presidential elections, as it was not possible to capture influences of electoral cycles of municipalities on federal investments.

These differences in the cyclical components of the three government levels seem to point to a smaller degree of direct influence of municipal elections as we move from local to state and federal levels. However, this affirmation is concerned only with the execution of public investments and can not be generalized to capital transfers.

The series of central government capital transfers presented a biennial cycle that indicates simultaneous influences of similar magnitudes from both cycles of mayors elections (2004 and 2008) and governors` and presidential elections (2002, 2006 and 2010). This suggests that the impact of local elections on the central government is more visible through the financing channel – that is, through transfers that finances investments of local and state governments – and not through the execution of investments itself.

It is also important to highlight that the biennial cycles of capital transfers have larger amplitude and temporal precedence compared to the biennial cycles of investments by state and local governments. This result suggests a close relationship among these cycles and an important roll played by fundings from central government (transfers) as a

source of political electoral cycles in the investments by local and state governments.[9] Of course this does not diminish the importance of local factors on such cycles, as federal transfers represent only a supplementary source of financing and the schedule of transfers is also influenced by decisions from local and state governments.[10] Stronger conclusions in this direction need more advanced studies that might be an extension from this paper.

In short, this paper provides empirical evidences for the literature that studies the presence of political electoral cycles. The approach differs from most of the works because it applies state-space modeling for aggregated time-series to investigate the presence of these cycles in fiscal policy. The greatest advantages of this approach are: *i)* it provides a better way of controlling the influence of trend and other structural components; *ii)* it provides an endogenous estimation for the frequency of the cycles; and *iii)* it allows a more precise estimation of the cyclical trajectory. Other distinction of this study is that it considers the presence of cycles in all three government levels and in central government's transfers. This allowed an analysis that explores the relations between different government levels. Without any doubt, the most important contribution to the literature comes from identifying qualitative differences in electoral cycles of investments in each government level – indicating a smaller degree of direct influence of municipal elections as the analysis moves from local to state and central levels – and a close relationship between biennial cycles of central government's transfers and the investments from other government levels.

9. Central government's capital transfers finance about one-fifth of local and state government's investments, oscillating between 20% above the trend in electoral years and 20% below it in non-electoral years. In its turn, biennial cycles of local and state governments oscillate around +10% and -10%.

10. Capital transfers occur mainly through a mechanism that divides investments projects into several steps. It is necessary that states and municipalities execute each step to the resources for the next step became available. State and local governments may influence the schedules of central government transfers as they concentrate projects to electoral years, postponing steps of the projects that already have resources or even accelerating the conclusion of steps that will require resources for the next step in electoral period.

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APPENDIX A

PARAMETERS AND DIAGNOSTIC STATISTICS[1]

TABLE A.1

Models for state government investments (GE) (2002-2011)

	Model	GE1		GE2		GE3		GE4	
Estimated parameters	Level	7.83748 (0.00203225)	[0.00000]	7.81905 (0.00179779)	[0.00000]	7.98782 (0.00184156)	[0.00000]	8.0756 (0.000790383)	[0.00000]
	Slope	–0.00505 (0.0000417115)	[0.80081]	–0.00777 (0.0000522532)	[0.71007]	0.00611	[0.15593]	0.01061 (0.00000145356)	[0.10048]
	Irregular	(0.0127514)		(0.0103369)		(0.0118884)		(0.0112589)	
	Intervention variables – Impulse			–0.55907 2010(1)	[0.00001]			–0.55768 2010(1)	[0.00001]
	Cycle								
	Disturbance variance	4.41E-11		0.573437		0.0019914		4.55E-08	
	Cycle variance	0.00796		0.00841		0.03783		0.02277	
	Period	23.87101		23.64103		45.8675		48.02378	
	Period in years	1.98925		1.97009		3.82229		4.00198	
	Frequency	0.26321		0.26577		0.13699		0.13083	
	Damping factor	1.00000		1.00000		0.97333		1.00000	
	Cycle 2								
	Disturbance variance					3.93E-06		1.45E-07	
	Cycle variance					0.00045		0.00847	
	Period					1852.3015		23.9745	
	Period in years					154.35846		1.99787	
	Frequency					0.00339		0.26208	
	Damping factor					0.99563		0.99999	
Diagnostic tests	Standard Deviation	0.13857		0.12661		0.14126		0.11653	
	Normality test	10.296	[0.00291]	7.9712	[0.00929]	15.741	[0.00019]	9.3008	[0.00478]
	Seasonal effects test	1641.19291	[0.00000]	1807.144	[0.00000]	1578.06501	[0.00000]	1862.33838	[0.00000]
	Homoscedasticity test	1.421	[0.30333]	0.90724	[0.77499]	1.5559	[0.19597]	0.88286	[0.71451]
	Coefficient of determination	0.7077		0.75825		0.69623		0.79523	
	Residual autocorrelation test								
	6 lags	2.705	[0.2586]	2.8657	[0.2386]	3.1184	[0.0774]	2.1566	[0.1420]
	12 lags	11.327	[0.1838]	10.23	[0.2493]	15.942	[0.0257]	16.045	[0.0247]
	24 lags	20.88	[0.4042]	25.092	[0.1979]	21.445	[0.3127]	28.820	[0.0689]
	36 lags	26.993	[0.7181]	30.225	[0.5566]	27.05	[0.6697]	34.985	[0.2844]
	Test for intervention variable – irregular	–4.12549 2010(1)	[0.00003]			–4.08872 2010(1)	[0.00004]		

Authors´elaboration.

Obs.: 1. Values in parantheses are estimates of variance. Significance levels of the tests are in brackets. One asterisk (*) and two asterisks (**) indicate, respectively, a 5% and 1% significant statistic.

2. Reported parameters are state vector at final period.

3. Data were converted to Reais of December 2011 using the Consumer Price Index (IPCA/IBGE). Models were estimated using variables in logarithm form.

1. For further details regarding normality tests (Bowman-Shenton statistics), homoscedasticity, serial correlation (Box-Ljung statistics) and the inclusion of intervention variables, see Durbin and Koopman (2001).

TABLE A.2
Models for local government investments (GM) (2002-2011)

	Model	GM1		GM2		GM3		GM4	
Estimated parameters	Level	8.08427	[0.00000]	8.22396	[0.00000]	8.21389	[0.00000]	8.23763	[0.00000]
		(0.000756155)		(0.00462159)		(0.00254093)		(0.00264214)	
	Slope	0.00582	[0.05548]	0.00666	[0.29118]	0.00671	[0.15931]	0.00681	[0.15555]
	Irregular			(0.00122607)				(0.00132983)	
	Intervention variables – Impulse			0.44077	[0.00000]			0.426	[0.00000]
				2004(1)				2004(1)	
				–0.45335	[0.00000]			–0.43711	[0.00000]
				2005(2)				2005(2)	
				–0.42669	[0.00000]			–0.40346	[0.00000]
				2009(2)				2009(2)	
	Cycle								
	Disturbance variance	0.0127423		4.86243E-11		0.00729564		4.14273E-07	
	Cycle variance	0.03741		0.0074		0.01148		0.00798	
	Period	10000		24.39409		10.74882		24.29915	
	Period in years	833.33333		2.03284		0.89573		2.02493	
	Frequency	0.00063		0.25757		0.58455		0.25858	
	Damping factor	0.812		1.000		0.6039		0.99997	
	Cycle 2								
	Disturbance variance					5.81E-11		2.26E-10	
	Cycle variance					0.00828		0.00122	
	Period					24.42986		7.87495	
	Period in years					2.03582		0.65625	
	Frequency					0.25719		0.79787	
	Damping factor					1.0000		1.0000	
Diagnostic tests	Standard Deviation	0.14005		0.10685		0.13522		0.098206	
	Normality test	15.614	[0.0002]	7.5617	[0.0114]	13.929	[0.00047]	11.956	[0.00127]
	Seasonal effects test	190.11686	[0.00000]	249.51678	[0.00000]	191.62656	[0.00000]	251.09167	[0.00000]
	Homoscedasticity test	0.35075	[0.0026]	0.35691	[0.0035]	0.37703	[0.00493]	0.44508	[0.02076]
	Coefficient of determination	0.28104		0.59322		0.32971		0.65638	
	Residual autocorrelation test								
	6 lags	6.0749	[0.0480]	4.5868	[0.1009]	6.6219	[0.0101]	0.8267	[0.3632]
	12 lags	13.448	[0.0973]	9.4764	[0.3037]	13.841	[0.0541]	4.510	[0.7195]
	24 lags	41.387	[0.0033]	28.795	[0.0919]	34.757	[0.0149]	15.336	[0.7010]
	36 lags	57.212	[0.0040]	40.674	[0.1398]	56.611	[0.0033]	29.374	[0.5497]
	Test for intervention variable – irregular	3.53984	[0.00029]			3.55489	[0.00027]		
		2004(1)				2004(1)			
		–3.37007	[0.00051]			–3.41499	[0.00044]		
		2005(2)				2005(2)			
		–3.55565	[0.00027]			–3.56367	[0.00026]		
		2009(2)				2009(2)			

Authors´elaboration.

Obs.: 1. Values in parantheses are estimates of variance. Significance levels of the tests are in brackets. One asterisk (*) and two asterisks (**) indicate, respectively, a 5% and 1% significant statistic.
2. Reported parameters are state vector at final period.
3. Data were converted to Reais of December 2011 using the Consumer Price Index (IPCA/IBGE). Models were estimated using variables in logarithm form.

TABLE A.3

Models for central government investments (GF) with one cyclical component (2002-2011)

	Model	GF1		GF2		GF3[1]	
Estimated parameters	Level	7.90757	[0.00000]	8.71347	[0.00000]	7.76974	[0.00000]
				(0.000588428)		(0.00102361)	
	Slope	0.01738	[0.00000]	0.01968	[0.00000]	0.01288	[0.03779]
						(9.14069e-007)	
	Irregular	(0.0332135)		(0.0436190)		(0.00940432)	
	Intervention variables – level			–0.80524	[0.00000]		
				2003(1)			
	Cycle						
	Disturbance variance	3.63E-03		6.82E-04		1.21E-04	
	Cycle variance	0.16846		0.03373		0.01441	
	Period	47.91636		48.44668		44.46292	
	Period in years	3.99303		4.03722		3.70524	
	Frequency	0.13113		0.12969		0.14131	
	Damping factor	0.98917		0.98984		0.9958	
Diagnostic tests	Standard Deviation	2.76E-01		2.67E-01		1.41E-01	
	Normality test	45.078	[0.00000]	21.735	[0.00001]	1.0698	[0.29286]
	Seasonal effects test	51.92289	[0.00000]	65.31768	[0.00000]	205.92997	[0.00000]
	Homoscedasticity test	0.14552	[0.00000]	0.1814	[0.00000]	1.3757	[0.45024]
	Coefficient of determination	0.48998		0.52842		0.60798	
	Residual autocorrelation test						
	6 lags	2.8941	[0.2353]	20.583	[0.0000]	9.7226	[0.0077]
	12 lags	9.7157	[0.2856]	21.866	[0.0052]	10.312	[0.2438]
	24 lags	19.54	[0.4870]	35.113	[0.0195]	17.539	[0.6178]
	36 lags	27.32	[0.7026]	44.594	[0.0686]	33.836	[0.3789]
	Test for intervention variable – irregular	–3.48571	[0.00034]	3.68131	[0.00017]		
		2003(3)		2003(2)			
		3.25568	[0.00074]	3.2942	[0.00065]		
		2003(12)		2003(12)			
		–4.55865	[0.00001]	–5.087	[0.00000]		
		2004(1)		2004(1)			
	Test for intervention variable – level	–3.06491	[0.00134]	–4.70621	[0.00000]		
		2003(2)		2003(3)			
		–5.39416	[0.00000]				
		2003(3)					

Authors´elaboration.

Note: [1] Model GF3 was estimated by restricting sample size to 2005-2011.

Obs.: 1. Values in parantheses are estimates of variance. Significance levels of the tests are in brackets. One asterisk (*) and two asterisks (**) indicate, respectively, a 5% and 1% significant statistic.

2. Reported parameters are state vector at final period.

3. Data were converted to Reais of December 2011 using the Consumer Price Index (IPCA/IBGE). Models were estimated using variables in logarithm form.

TABLE A.4

Models for central government investments (GF) with two cyclical components (2002-2011)

	Model	GF4		GF5		GF6[1]	
Estimated parameters	Level	7.83972	[0.00000]	8.60885	[0.00000]	7.94360	[0.00000]
				(0.00210450)		(1.54600e-005)	
	Slope	0.01626	[0.00000]	0.01781	[0.00066]	0.01746	[0.00000]
	Irregular	(0.0336139)		(0.0426348)		(0.0108573)	
	Intervention variables – level			–0.86580	[0.00000]		
				2003(1)			
	Cycle						
	Disturbance variance	2.89E-03		1.98E-07		0.0003107	
	Cycle variance	0.1247		0.02176		0.0197	
	Period	47.71395		51.61283		40.72167	
	Period in years	3.97616		4.30107		3.39347	
	Frequency	0.13168		0.12174		0.1543	
	Damping factor	0.9883		1.0000		0.9921	
	Cycle 2						
	Disturbance variance	8.14E-11		0.000453383		1.04E-05	
	Cycle variance	0.01824		0.0219		0.0066	
	Period	89.30436		287.63276		12.63732	
	Period in years	7.44203		23.9694		1.05311	
	Frequency	0.07036		0.02184		0.49719	
	Damping factor	1.0000		0.9896		0.9992	
Diagnostic tests	Standard Deviation	2.73E-01		2.63E-01		1.26E-01	
	Normality test	44.819	[0.00000]	24.518	[0.00000]	1.5349	[0.23210]
	Seasonal effects test	53.52471	[0.00000]	72.55084	[0.00000]	312.92352	[0.00000]
	Homoscedasticity test	0.1316	[0.00000]	0.15172	[0.00000]	1.3315	[0.49778]
	Coefficient of determination	0.50256		0.54078		0.6843	
	Residual autocorrelation test						
	6 lags	3.114	[0.0776]	18.863	[0.0000]	9.8207	[0.0017]
	12 lags	9.9676	[0.1904]	20.565	[0.0045]	11.601	[0.1145]
	24 lags	19.995	[0.3949]	36.068	[0.0104]	21.085	[0.3321]
	36 lags	27.584	[0.6425]	46.033	[0.0402]	32.833	[0.3772]
	Test for intervention variable – irregular	–3.48057	[0.00035]	3.79689	[0.00012]		
		2003(3)		2003(3)			
		3.16983	[0.00097]	3.48619	[0.00034]		
		2003(12)		2003(12)			
		–4.52449	[0.00001]	–5.11433	[0.00000]		
		2004(1)		2004(1)			
	Test for intervention variable – level	–3.15759	[0.00101]	–4.89820	[0.00000]		
		2003(2)		2003(3)			
		–5.56522	[0.00000]				
		2003(3)					

Authors´elaboration.

Note: [1] Model GF6 was estimated by restricting sample size to 2005-2011.

Obs.: 1. Values in parantheses are estimates of variance. Significance levels of the tests are in brackets. One asterisk (*) and two asterisks (**) indicate, respectively, a 5% and 1% significant statistic.
2. Reported parameters are state vector at final period.
3. Data were converted to Reais of December 2011 using the Consumer Price Index (IPCA/IBGE). Models were estimated using variables in logarithm form.

TABLE A.5

Models for central government capital transfers (Transf) (2002-2011)

	Model	Transf1		Transf2		Transf3		Transf4	
Estimated parameters	Level	7.07314 (0.00188142)	[0.00000]	8.73691 (0.00570462)	[0.00000]	7.06642	[0.00000]	8.73691 (0.0659943)	[0.00000]
	Slope	–0.00077 (0.000106323)	[0.98134]	0.01776	[0.01874]	–0.00293 (9.70160e-005)	[0.92501]	0.01776	[0.01874]
	Irregular	(0.0696067)		(0.0659942)		(0.000840782)		(0.0659943)	
	Intervention variables – Level			–1.53997 2003(1)	[0.00000]			–1.53997 2003(1)	[0.00000]
	Cycle								
	Disturbance variance	5.81E-04		2.16E-10		0.0004008		2.50E-10	
	Cycle variance	0.06		0.03		0.06		0.03	
	Period	24.15		24.48		24.00		24.48	
	Period in years	2.01		2.04		2.00		2.04	
	Frequency	0.26		0.26		0.26		0.26	
	Damping factor	1.00		1.00		1.00		1.00	
	Cycle 2								
	Disturbance variance					7.71E-02		1.93E-08	
	Cycle variance					0.08		0.00	
	Period					10000.00		10000.00	
	Period in years					833.33		833.33	
	Frequency					0.00		0.00	
	Damping factor					0.27		1.00	
Diagnostic tests	Standard Deviation	0.41		0.35		0.41		0.35	
	Normality test	7.99	[0.00919]	5.44	[0.03297]	3.92	[0.07038]	5.44	[0.03297]
	Seasonal effects test	29.31607	[0.00203]	42.76777	[0.00001]	31.13475	[0.00105]	42.76787	[0.00001]
	Homoscedasticity test	0.38696	[0.00616]	0.57764	[0.10960]	0.3847	[0.00586]	0.57764	[0.10960]
	Coefficient of determination	0.32737		0.51211		0.34782		0.51211	
	Residual autocorrelation test								
	6 lags	3.74	[0.1538]	1.78	[0.4102]	0.83	[0.3629]	1.78	[0.1819]
	12 lags	9.07	[0.3368]	2.91	[0.9399]	5.15	[0.6414]	2.91	[0.8932]
	24 lags	17.94	[0.5916]	12.20	[0.9091]	15.57	[0.6858]	12.20	[0.8770]
	36 lags	26.17	[0.7562]	19.86	[0.9536]	24.90	[0.7724]	19.86	[0.9387]
	Test for intervention variable – irregular	–3.52261 2003(1)	[0.00030]	–3.38137 2004(2)	[0.00049]	–3.43488 2003(1)	[0.00041]	–3.38138 2004(2)	[0.00049]
						–3.10763 2004(2)	[0.00118]		
	Test for intervention variable – slope	–4.06836 2002(12)	[0.00004]			–3.85928 2002(12)	[0.00009]		
		–4.26147 2003(1)	[0.00002]			–4.18345 2003(1)	[0.00003]		

Authors´elaboration.

Obs.: 1. Values in parantheses are estimates of variance. Significance levels of the tests are in brackets. One asterisk (*) and two asterisks (**) indicate, respectively, a 5% and 1% significant statistic.

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