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Article

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Fiscal reaction under endogenous structural changes in Brazil

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Abstract

Regarding the importance of fiscal policy in smoothing the impact of shocks such as the international financial and economic crises, the paper analyzes the sustainability of the Brazilian fiscal policy by taking into consideration the possibility of multiple endogenous structural breaks on the coefficients of government reaction function. From monthly data in the period 1991–2008, tests on the reliable estimates dictate the occurrence of structural change in May 1994, and another in February 2003. There has been a situation of fiscal solvency in Brazil, but only from May 1994 the hitherto innocuous actions of government to formulate policies on public debt turn out to be significant, as it rose twofold after February 2003. This reinforces the existence of a more flexible alternative to implement strategic policy in Brazil, if an eventual alternative for increasing public spending is a way of hindering the effects of international financial crises without compromising the fiscal targets.

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Resumo

Considerando a importância da política fiscal na suavização dos impactos de choques como as crises financeiras e econômicas internacionais, o artigo analisa a sustentabilidade da política fiscal brasileira a partir da estimação de uma função de reação que permite múltiplas quebras estruturais endógenas em seus coeficientes. Os resultados evidenciam uma mudança estrutural na política fiscal brasileira a partir de maio de 1994 e outra em fevereiro de 2003. Constatou-se uma situação de solvência fiscal no Brasil, mas apenas a partir de maio de 1994 a até então inócua capacidade de resposta do setor público aos aumentos da dívida pública passa a ser significativa e mais que duplica após fevereiro de 2003. Este fato reforça a existência de uma margem de manobra mais confortável aos formuladores de política no Brasil, se uma eventual opção pelo aumento do gasto público for uma alternativa obstruir os efeitos da crise financeira internacional, sem comprometer as metas fiscais.

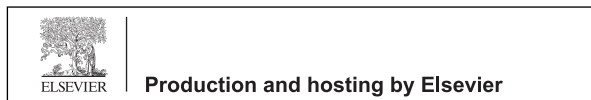
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Palavras-chave: Função de Reação Fiscal; Quebras Estruturais Endógenas; Solvência Fiscal

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1. Introduction

The fiscal surpluses observed in most industrialized countries in the early 90s, and the subsequent occurrence of economic recession with strong impacts on public budgets, brought up back the debate about the sustainability of fiscal policy. Particularly in Brazil in the early 2000s, where the so-called stabilization real plan was already consolidated, the focus of policymakers was driven to control the internal public debt, since the credibility of the national economy would viable the reduction of external debt.

As a result of the financial and economic shocks occurred worldwide at the end of past decade, austerity in the fiscal policy became a necessary condition to maintain the economic growth in many countries, as well as the maintenance of the Maastricht Treaty and continuity of the Euro Zone. Indeed, the international financial crisis of 2008 transferred to the public sector the burden to respond the scarcity of resources arising from the retreat of investors from the financial sector.

Since the expectation of fiscal deterioration by the investors is a decisive factor for economic crises, given that they anticipate the results of long-term economic measures implemented in the current period, insolvency comes to mean economic vulnerability. When the fiscal imbalance occurs and the market expectation follows an unsustainable trajectory for public debt in the medium and long term, funding government through the issuance of bonds becomes unviable, and monetary expansion and/or taxing shall be the means for settling its debts (Sargent and Wallace, 1981). So, it is also to be assessed in this paper the long-term implications of fiscal policies in a scenario of possible structural changes in the economy and fiscal austerity measures to combat the uncontrolled growth of public debt.

From this perspective, and taken into account a methodology based on the Government's response to the accumulation of debt, we sought to extend the studies of Luporini (2000, 2002, 2012), Issler and Lima (2000), Lima and Simonassi (2005), by evaluating the Brazil's fiscal performance from two test criteria: (a) debt sustainability of the public sector; (b) existence of policies that strive for fiscal austerity in periods of growing debt.

The contribution in relation to previous studies stands on two pillars: (i) the assessments that the traditional unit root tests often neglect the remedial measures adopted by several governments; (ii) the misconception eventually incurred by researchers who test sustainability of public debt via cointegration analysis between expenditures and revenues. Regarding the first aspect, it is worth mentioning the fact that when these tests are performed to control for structural breaks, the results of non-stationary change considerably, as pointed out by Uctum et al. (2006). Therefore, the analysis of public debt sustainability through fiscal response function of the government expanded to allow multiple structural breaks in their coefficients is supposed to be a more robust and valid technique to obtain the results for addressing economic policies. This occurs both by providing evidence of active policies of fiscal austerity and providing greater predictive power in the changes and evolution of fiscal policy.

In order to accomplish the proposed analysis, monthly data span the period 1991 (before the 1994 stabilization plan) to 2008 (before the political change of Government in 2010). This period choice is appropriate since it covers domestic and external shocks (notably international currency exchange and financial crises with domestic reflex), which are favorable scenarios to test the vulnerability of public accounts.

It should be noted that although there is availability of data for the past three years, the uncertainties of concrete policy actions during the current government would make their use inappropriate in the analysis compared to the time series chosen. These uncertainties arise from inconsistent planned measures in the current Government by ruling, for instance, the implementation of a fiscal adjustment without investment cut. Paradoxically, as evidenced by Giambiagi (2011) with data from the National Treasury Office (STN), the investment outlay increased 5% (in real terms relative to GDP) in the first half of 2011. Thus, we believe that the choice to limit the analysis to 2008, where two governments with the same ideology prevail in continuity provide more solid results, thus avoiding impurities of rhetorical policies for planning public accounts.

The core results corroborate those of some recent studies, as Luporini (2012), and signal for a "shield" of the Brazilian economy in relation to the possible effects of an eventual increase in public spending to stimulate economic growth and/or to minimize the effects of the international financial crisis to explain an increasing capacity to generate primary surplus by the government. Besides, it is found evidence of two structural changes along the period: one in mid-1994 and the second in early 2003, with a duplicate of the initially innocuous fiscal response by the government to the increasing public debt.

Following this introduction, it is stated in section 2 the concepts involved in determining the fiscal results of the public sector in Brazil and the evolution of net debt and the primary surplus as a proportion of GDP along the period of analysis. Section 3 provides a review of the literature related with this issue in order to support the advantages of the methodology detailed in Section 4. The empirical exercise and the relevant results are treated in Section 5, followed by the final remarks.

2. The timely trend of public debt in Brazil

There is consensus in the public finance literature that the consolidation of the Real Plan and the subsequent reduction of the Brazilian external debt redirected the concerns of policy makers to control the domestic debt of the public sector. However, since this reduction consisted basically of replacing bonds with the external sector by domestic borrowing, the analysis of each item separately does not reflect the actual fiscal situation of the Brazilian public sector. Consequently, it can be inferred that there is a strong tendency for an explosive path of the domestic but a declining trajectory of the external debt. So, to measure the solvency of the government the focus of the analysis should aim the public sector total debt.

For the measurement of fiscal results, the concept of public sector here used includes the Central Bank of Brazil (BCB) and the so called non-financial public sector, which in turn comprises the direct and indirect administration of the Federal Government, the state governments, the state enterprises and the National Social Security Institute (INSS).¹

The balance of the consolidated public sector comprises the results of the General Government and, residually, the business activities. The Gross General Government Debt (GGGD) covers the total debt in the three spheres of government² to the private sector, public financial sector, BCB and the rest of the world. The Net Debt is the balance between the total credits and debts of the Government in its three levels, which include assets with different degrees of liquidity. Among the assets with higher degrees of liquidity are the bank deposits of Social Security, the tax collected and not transferred and other deposits in the National Treasury and the BCB, while those of lower liquidity include the credits from the state enterprises, the resources of the Workers Support Fund (FAT) and equity of constitutional funds. This is the concept of Public Sector Net Debt (DLSP) to be considered in this study.

Considering the importance of economic growth for the sustainability of the Government's fiscal policy, Fig. 1 depicts the path of the net debt/GDP and the primary surplus/GDP ratios in Brazil, from BCB monthly data (December 1991–December 2008).

In order to improve the transparency of informations in its data bank, the BCB started to disclose in 1996 the recognition of contingent liabilities³ in the fiscal statistics. This attitude, connected with the substitution of internal debt for external debt, implied a significant increase in both the indicator illustrated in Fig. 1 for the DLSP and specially the amount of net domestic public debt (DILSP) as a proportion of national GDP.⁴

It is also worth mentioning the effect of some political devices implemented by the Brazilian government to restrain an eventual acceleration of the public debt. First, the Law No. 8727/93 succeeded only up until February 1994, when the debt/GDP ratio remained stable at around 32%,⁵ while the Law No. 9496/97 generated stability for only two months after its implementation. The Law of Fiscal Responsibility (LRF) created in 2000 to discipline public expenditures obtained the best performance among other devices, either in real terms or in relation to GDP. Due to the rigidity nature offered by this device kept the net debt of the public sector stable at 50% of GDP over the year of its implementation, although in May 2001 this indicator turn to a new upward trend.

2.1. Public debt and crises

Several papers have focused on the effects of crises/exchange devaluations occurred in 1998/99 and 2002 on the dynamics of the Brazilian public debt. Mendonça et al. (2008) for instance, use data for the period post-Real Plan

¹ See Bulletin of BCB (2005). Data of primary surplus here used are from the BCB for the consolidated public sector.

² Each one includes direct and indirect administrations, and the INSS.

³ They are commonly referred as "skeleton" of the public debt.

⁴ See Fig. 2 for the consolidated net internal debt in monthly data.

⁵ In the period June 1993–December 1993, the internal debt/GDP ratio kept stable below 18%.

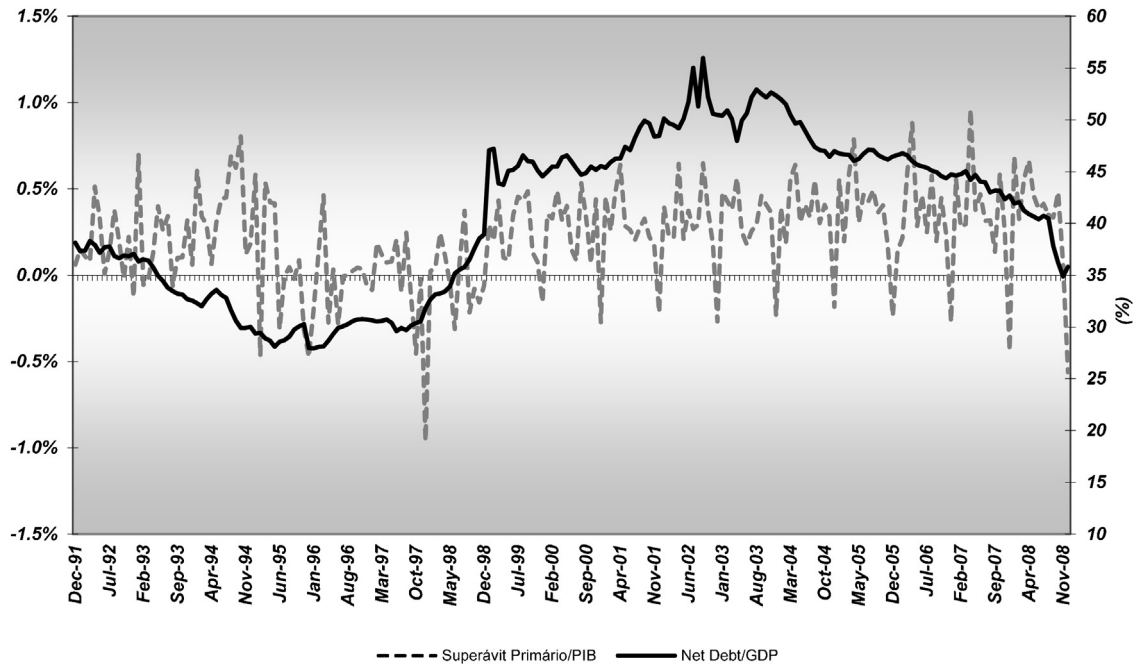


Fig. 1. Monthly trend of primary surplus/GDP and net debt/GDP, December 1991–December 2008.

Source: Central Bank of Brazil (BCB).

(1994) and test two possible regimes for the parameters of the estimated reaction function. They found a structural change in the year 2000.

Fig. 2 is drawn based on annually data from the BCB, which also generated Fig. 1, calculated through a moving average. It shows that from 1998 to 1999 DLSP/GDP rises from 35.4% to 45.5%, while the primary surplus to GDP ratio, which was near nil in 1998, rises to approximately 2.9% in 1999. Thus, there has occurred an increase in the DLSP associated with a greater response from the Government in terms of generating a primary surplus. These results are less conservative than those found by Giambiagi (2004) uses values from December 1998 and 1999 and finds an increase from 41.7% to 48.7% in the NPSD/GDP ratio.⁶

For the analysis to be here developed from the methodology proposed in Section 4, the scarcity of data from primary surplus of the consolidated public sector imposes to us the option for a monthly rate as a mean of obtaining consistent estimates in the proposed modeling. As seen in Fig. 1, an immediate consequence of this option is a smoothing effect of currency devaluations cited in Giambiagi (2004).

It is observed rising trajectories for both ratios, DLSP/GDP and primary superavit/GDP, in the period 1999–2003, while the latter kept on growing until 2005, when then stabilizes at around 4.0%. On the other hand, the DLSP, although shows a systematic declining path from 2003, presents high monthly volatility in the period, which is associated with an upward trend of the internal debt⁷.

2.2. Theoretical framework: dynamic budget constraint

The usual theoretical framework for approaching sustainability of fiscal policy is the government budget constraint. This restriction implies an equilibrium condition, such that government expenditures on goods and services and interest payments are financed either through tax revenues or issuance of public debt bonds.

$$B_t = (1 + r_t)B_{t-1} + (G_t - R_t) \quad (1)$$

⁶ Taking December as reference, data of 2008 from BCB reveal an increase from 38.9% to 44.5% in the DLSP/GDP ratio for the same period. These are the data here applied.

⁷ See Fig. 3 in Section 5.

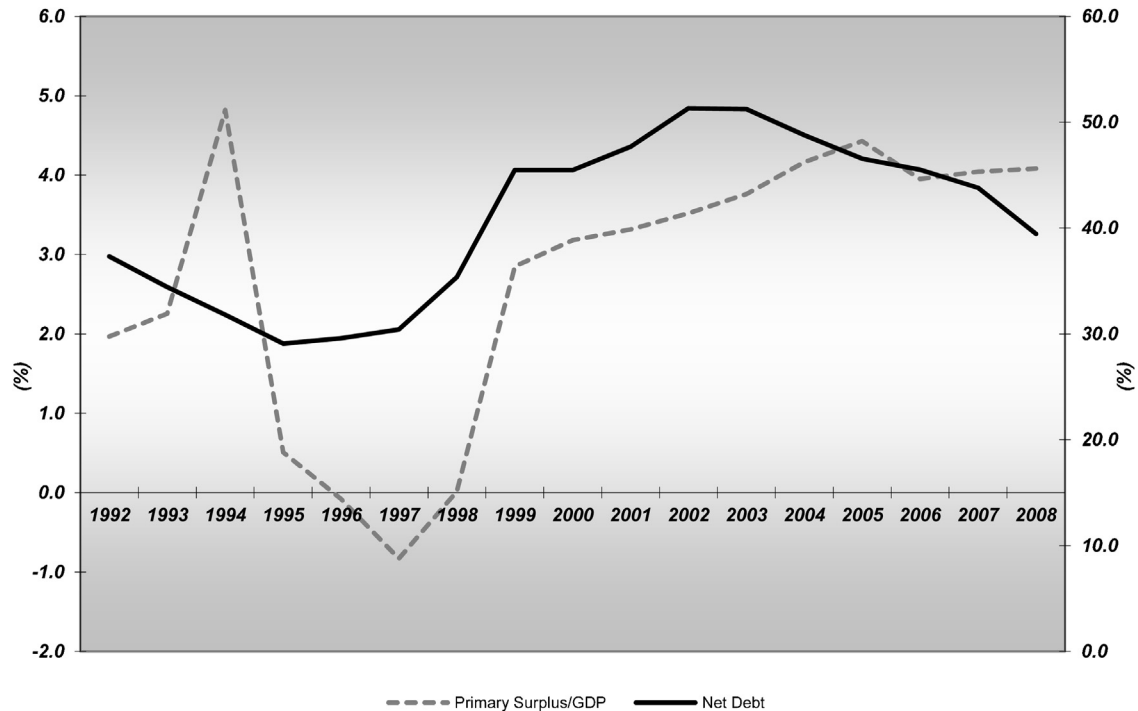


Fig. 2. Annually trend of primary surplus/GDP and net debt/GDP, 1992–2008.

Source: Central Bank of Brazil (BCB).

Solving Eq. (1) forward and assuming a perfect forecast, it comes:

$$B_0 = \lim_{n \rightarrow \infty} \prod_{s=1}^n \left(\frac{1}{1 + r_s} \right) B_r + \sum_{t=1}^{\infty} (G_t - R_t) \quad (2)$$

If $\lim_{n \rightarrow \infty} \prod_{s=1}^n (1/(1 + r_s)) B_r$, then, the Government does not makes use of “Ponzi game” to finance itself, therefore, achieving the government temporal budget constraint (ROI) means the sustainability of the country’s fiscal policy.

Testing the null hypothesis of unit root in the statistical process that describes the appropriate series of debt or deficit, as well as the existence of cointegration between expenditure and revenue, is the methodology to be adopted. But there are evidences that the accuracy of these tests is very low if the country has experienced a change or break in the fiscal administration over the sampled period of analysis, as proposed by [Uctum et al. \(2006\)](#).

Aiming at eliminating difficulties involving unit root tests, nonlinear models have been implemented to investigate how the government reacts to the increase in public debt. Then, a sufficient condition for government solvency is to test whether there is systematic reduction of deficits or surpluses increasing whenever the public debt rises. This approach is the core of the updated literature.

3. Approaches in the literature

The literature on sustainability of fiscal policy that applies the temporal government budget constraint started with the seminal article by [Hamilton and Flavin \(1986\)](#) who test whether the budget deficit path follows a stationary stochastic process. The rejection of the null hypothesis of a unit root on that series would imply that the deficit would be consistent with the government budget constraint.

Following Hamilton and Flavin, other authors apply the cointegration analysis to data of expenditure and revenue as the methodology to test the consistency of the temporal government budget constraint. [Hakkio and Rush \(1991\)](#) make assumptions about the stochastic process described by the revenue and expense variables and propose an alternative

model for the testable implications. Similarly, [Bohn \(1991\)](#) estimated Eq. (3) below to test whether the debt sustainability is related to the existence of cointegration among the variables expenditures, revenue and debt.

$$B_t = G_t - T_t + (1 + r_t)B_{t-1} + \varepsilon_t \quad (3)$$

where B_t is the public debt, G_t is expenditures on goods and services, T_t is tax revenue and r_t is the interest rate. The error term ε_t is supposed to be a white noise. If B_t is not stationary with $I(1)$, then ΔB_t is stationary, which is derived by subtracting B_{t-1} from both sides of Eq. (3):

$$\Delta B_t = G_t - T_t + rB_{t-1} + \varepsilon_t \quad (4)$$

Therefore, the stationarity of ΔB_t implies a cointegration restriction on the following vector: $\vec{X}_t = \{T_t, G_t, B_t\}$. By Eq. (4), the cointegration vector would be $(1, -1, r)$.

In passing it is worth mentioning the possibility of launching specific hypothesis on the trajectory of interest rates for testing sustainability, although it makes the tests more restrictive, consequently, less reliable.

[Rocha \(1997\)](#) applied this model to Brazilian data in the period 1980–1993 and concluded that revenues and expenditure cointegrate, so that the budget deficit is stationary. However, the sustainability of public debt occurs only when the revenue is adjusted by the inflation tax, that is, tax revenue and the monetary expansion contribute essentially to the government budget balance. Despite this application, the literature in Brazil is even enhanced due to the paper of [Issler and Lima \(2000\)](#), who built a similar analysis of [Hamilton and Flavin \(1986\)](#) using data in the period 1947–1992. They conclude that the sustainability of the Brazilian debt is not rejected as seigniorage is included in the government revenue. This conclusion reveals clearly the way fiscal funding is managed in an economy with high inflation.

Contrary to any prior hypothesis on the interest rate distribution, [Bohn \(1998\)](#) proposes a new test of sustainability. In order for the temporal government budget constraint to be satisfied, he argues that it is sufficient that the primary surplus increases when the debt/GDP ratio rises, which implies that the temporal government budget constraint is achieved and then the debt is sustainable.

The budget constraint at the beginning of the period is defined as follows:

$$B_t = (B_{t-1} - S_t) + (1 + R_t)B_t \quad (5)$$

where S_t is the primary surplus, $(1 + R_t)$ is a factor of interest rate and B_t is the public debt. If an economy grows continuously over time, deflating the variables by the GDP (Y_t) would provide the following restriction:

$$b_t = (b_{t-1} - s_t)x_t \quad (6)$$

where $b_t = B_t/Y_t$; $s_t = S_t/Y_t$; $x_t = (1 + R_t)(Y_{t-1}/Y_t) \approx 1 + r_t - y_t$, and. The variable r_t is the real interest rate and y_t the real growth rate of the economy.

By incorporating the tax smoothing model of [Barro \(1979\)](#) to this approach, the relationship between primary surplus and the debt/GDP ratio can be expressed by the equation:

$$S_t = \rho b_{t-1} + \alpha Z_t + \varepsilon_t = \rho b_{t-1} + \mu_t \quad (7)$$

where the error term $\mu_t = \alpha Z_t + \varepsilon_t$ and Z_t is a vector composed of variables that explain the primary surplus and the debt, such as government expenditures and the output deviation relative to its potential level. The empirical exercise carried out by Barro through U.S. data demonstrated that the Dickey-Fuller and Phillips-Perron unit root tests do not reject the unit root hypothesis.

The analysis conducted in this study meets further support on [Goldfajn's \(2004\)](#) work, which establishes that the main problem related to finance imbalance in Brazil is not the debt/GDP ratio itself, but its latest evolution. The government response to this is then the premise to generate primary surplus to stabilize the debt/GDP ratio.

An example of application related to the present study would be through the computation of the current debt/benchmark, where benchmark could be defined as the present value of future primary surplus calculated under conservative assumptions.

[Garcia and Rigobon \(2004\)](#) investigate the future dynamics of the Brazilian debt from a perspective of risk management. According to [Goldfajn's \(2004\)](#) arguments, risk management stems from the fact that the equation of debt accumulation, by any country encompasses variables that are stochastically related to one another. The formal procedure is then to specify a vector autoregressive (VAR) to estimate the pattern of correlations among macroeconomic variables and take the correlation matrix to conduct Monte-Carlo simulations. Thus, it is possible to calculate the probability

that the simulation of the debt/GDP ratio exceeds a certain value, for instance 75%, and subsequently compare it with the perception of risk in the market, in which is provided by the index of the emerging countries bonds (EMBI).⁸ In spite of the debt tending to be sustainable within a riskless economic environment, there are several paths scenarios in which fiscal policy would not be sustainable.

By contrasting the issues in this literature with the ones of structural breaks, [Luporini \(1999\)](#) contributes to the debate by investigating the performance of the Brazilian fiscal policy by dividing the original sample into sub-periods, according to the occurrence of changes in the debt/GDP ratio. In so doing, the sample she uses is divided into two sub-periods due to the impact of the oil shock of 1979 on the Brazilian public accounts. Although the results of the tests indicate the sustainability of debt in the period 1966–1996, it is found that from 1981 on this debt would follow an unsustainable trajectory.

Imposing ex-ante the structural breaks in a time series, as done by [Luporini \(1999\)](#), constitutes a shortcoming in this procedure for lacking acceptable economic arguments. Indeed, by taking a glance at [Fig. 1](#) in section, it is impossible to identify an exact number of these breaking changes. So, instead of being a deterministic event, it seems more theoretically plausible to accept the breaking dates as a stochastic variable.

It is also worth pointing out another potential shortcoming that might be implicit in the modeling of the papers cited previously for using Brazilian historical series of public finances. This may occur because the longer are the series on these data, the more inaccurate are the informations on them, due to the lack of incorporating the so-called skeletons and/or investments of state-owned enterprises under the heading of public expenditure. [Goldfajn \(2002\)](#) corroborates this argument by performing simulations with different long-term economic scenarios for the Brazilian economy. He infers about the sustainability of the debt/GDP over the next decade, and concludes that even for conservative scenarios on the GDP growth rate and the fiscal surplus, the results point to debt sustainability.

By the same token, [Mendonça et al. \(2008\)](#) estimate a fiscal reaction function via Markov-Switching model for Brazil in the post-Real Plan (1994) period. They find a regime change after 2005 and a loss of response by the Brazilian government for generating primary surplus after that year. Another study of [Mendonça et al. \(2008\)](#) applies the same estimation technique that allows regime change and takes into account the importance of equity adjustments in the bulk of the public debt. They confirm the sustainability of the public debt in the medium term.

This article will rely upon a recent proposal of [Bohn \(2006\)](#), which presents a critique on the traditional techniques of stationarity and cointegration tests, besides stating that the government solvency is achieved if the debt is stationary from any finite number of differentiations. In other words, the ROI remains satisfied if revenues and expenditures⁹ are stationary in differences for any arbitrary order without any cointegration prerequisite. Thus, there is a broad class of stochastic processes that violate the conditions of stationarity and traditional cointegrations for testing the sustainability of the fiscal, although the ROI remains satisfied. A testable implication of this argument is that the common practice of judging whether a government is solvent or not from the unit root and cointegration tests fails.

Besides, [Bohn \(2006\)](#) suggests that the procedures for testing sustainability through the estimation of the government reaction function provide solid results for understanding deficit trajectories. Thus, the methodology proposed in the following section adds the possibility of structural breaks in the parameters of the government reaction function. Contrary to the arguments of [Mendonça et al. \(2008\)](#), the methodology scheme to be employed will allow multiple regimes in accordance with a finite number of possible structural breaks according to the coefficients of the estimated function.

4. Methodology

4.1. The model

Following [Bohn's \(2006\)](#) proposal, let the identity of government budget at any time t :

$$B_t = G_t^0 - T_t + (1 + r_t)B_{t-1} \quad (8)$$

⁸ In this case, it is applied the Emerging Markets Bonds Index spread of the JP Morgan bank.

⁹ It includes expenditures with interest.

B_t is public debt, G_t^0 is primary expenditure, T_t and r_t are revenue and interest rate, respectively. By applying the first difference in (8), $\Delta B_t = B_t - B_{t-1} = G_t^0 - T_t + r_t B_{t-1}$, which defines the government debt as interest rate is included, and the term $(G_t^0 - T_t)$ represents the primary deficits. These variables may be defined in nominal or real terms, as well as a proportion of GDP or per capita, as long as it satisfies the accumulation factor r_t . Let the following hypotheses:

$$\begin{aligned} H_1: r_t = r > 0 \text{ and } \rho = [1/(1+r)] < 1; \\ H_2: E_t(r_{t+1}) = r > 0 \text{ and } \rho = E_t[1/(1+r_{t+1})] < 1 \end{aligned}$$

Then, the identity (8) becomes:

$$B_t = \rho E_t[T_{t+1} - G_{t+1}^0 + B_{t+1}] \quad (9)$$

There is also the possibility of a third hypothesis (H_3), if r_t is any stationary stochastic process with mean $r > 0$, such that $G_t = G_t^0 + (r_t - r)B_t$. Therefore, keeping similar properties with the primary expenditures, it is then defined $G_t = G_t^0$ considering the hypotheses H_1 and H_2 . After substitution, Eq. (9) is rewritten by simply substituting G_{t+1} for G_{t+1}^0 , and $\rho < 1$ is kept in both cases. Defining $S_{t+1} = T_{t+1} - G_{t+1}$ and solving forward, it comes:

$$B_t = \lim_{n \rightarrow \infty} \rho^n E_t[B_{t+n}] + \sum_{i=0}^{\infty} \rho^i E_t[S_{t+1+i}] \quad (10)$$

$\lim_{n \rightarrow \infty} \rho^n E_t[B_{t+n}] = 0$ is a sufficient condition for debt sustainability, and the summation term in (10) is the ROI of the government, if the transversality condition above mentioned is valid.

4.2. Alternative methodology

Initially, [Bohn \(2006\)](#) argues that in order to the transversality condition be satisfied it suffices that the debt series be integrated by any finite order. The reasoning for this is that the discount factor ρ^n dominates $E_t[B_{t+n}]$ asymptotically, therefore, the hypothesis that $\rho < 1$ is robust, regardless the interest rate level.

Bohn launches further formal critiques to the sustainability analyses that rely upon cointegration techniques, that is: $G_t^0 \sim I(m)$ and $T_t \sim I(n)$, with the possibility of $m \neq n$ and both variables not cointegrated, then both the transversality condition and the government ROI remain valid as long as $B_t \sim I(k)$, where $k \leq \max[m, n] + 1$.

In the case of cointegration between primary deficit and debt, the core of investigation is whether or not $(G_t - T_t) + \alpha B_{t-1} = \varepsilon_t \sim I(0)$.

$\alpha \neq 0$ denotes a stationary linear combination of those variables. Adding this to the budget identity¹⁰ (Eq. (8)), it can be rewritten as: $B_t = (1 + r_t - \alpha)B_{t-1} + \varepsilon_t$.

According to [Trehan and Walsh \(1988\)](#), the main point under investigation is whether $(G_t - T_t) = -\alpha B_{t-1} + \varepsilon_t$, that is, whether the error correction mechanism can be interpreted as the government reaction function.

4.2.1. The government reaction function

The methodology to test the sustainability of the government's fiscal policy will be based on the estimation of the its reaction function, as described in [Barro \(1979\)](#) and [Bohn \(1998\)](#), whose technique is to estimate the following equation:

$$S_t = \mu_t + \alpha_t b_{t-1} \beta \tilde{g}_t + \gamma \tilde{y}_t + v_t \quad (11)$$

All variables are ratios of GDP, but \tilde{g}_t \tilde{y}_t are defined as deviations from the expenditure and the final values are obtained through application of Hodrick–Prescott filter. The coefficients expected signs are $\beta < 0$ and $\gamma < 0$, and the sustainability condition is that $\alpha > 0$, which indicates a positive response from the government for generating a primary surplus to the accumulation of public debt.

¹⁰ $G_t = G_t^0$.

Additionally, Eq. (11) can eventually be estimated for smaller samples (shorter periods of time) in accordance with the verification of structural breaks in the μ and α parameters, following the proposal of Bai (1997a,b) and Bai and Perron (1998). The tests for structural breaks will allow concluding about the occurrence of adjustments in the government's fiscal policy from the relationship between debt and primary balance. Given $m = 0, 1, 2, 3, \dots$ possible structural breaks, Eq. (11) can then be rewritten as:

$$S_t = \sum_{i=1}^{m+1} (\mu_i + a_i b_{t-1} I_{t \in I_i}) + \beta \tilde{g}_t + \gamma \tilde{y}_t + v_t \quad (12)$$

As $m = 0$, Eq. (12) turns back to Eq. (11). I_i is the sub-sample of a shorter period of time dictated by the structural breaks t_{i-1} and t_i , and $I_{t \in I_i}$ is a função that takes value "1" if $t_{i-1} \leq t \leq t_i$, and value "0" otherwise. It is worth emphasizing that for each sub-period "i" there is a correspondent intercept μ_i and a sustainability condition $\alpha_i > 0$, while the parameters β and γ are defined for the full sample.

Two procedures due to Andrews (1993) and Bai and Perron (1998) in the estimation process for detecting endogenous structural breaks call for further comments. First, the technique is applied to nonlinear models and only one break is selected. Nonetheless, it is implicit the restriction that the asymptotic distributions used for the F -type tests are built for covariates without any trend, which is fallacious for the deterministic trends in the parameters of Eq. (11). Second, the technique, which is adopted in this paper, is more robust in the choice of breakpoints process because it is not required that the regressors are trendless, as it occurs in the series of public debt/GDP and primary surplus/GDP. This technique also allows that the multiple breaks can be estimated jointly through the algorithm described in Bai and Perron (1998), besides requiring less computational effort. The adoption of the latter technique has been further corroborated by preliminary estimates obtained via Chow tests for Eq. (11), which have showed instability in the coefficients.

Bai and Perron (1998) establish hypotheses of regularity for ensuring that each regime has a sufficient number of observations similar to the methodologies of threshold autoregressive models, as well as a broad general condition for the residuals of the estimated regression. Thus, the breaking dates in the time series are estimated consistently.¹¹ According to Uctum et al. (2006) there are several other methods to test the instability of the parameters of the reaction function equation (12). Albeit they may generate estimates of the break point, they are not appropriate to estimate structural changes for the debt-surplus.

If the number of structural breaks is known, the correct method consists in estimating the first breaking point (\hat{t}_1), such that, $\hat{t}_1 = \underset{t_1}{\operatorname{argmin}} S_T(t_1)$ where $S_T(t_1)$ defines the sum of squared residuals from the estimation of Eq. (12) in the full period (Bai and Perron, 1998). Afterwards, the sample is divided into two sub-samples, and then a model of one break is estimated on each of them, from which arise two new breaking points. The second breaking point, \hat{t}_2 , corresponds to the one that generates greater reduction in the sum of squares of the residuals (SSR) of the full sample. This process is repeated until all breaks are found. On the other hand, if the number of breaks is unknown, the continuity of the process consists in keeping on testing the null hypothesis of "m" structural breaks against the alternative $m + 1$ ($m = 0, 1, 2, \dots$) up to the null hypothesis is rejected, that is, m will be the number of breaking points for which this hypothesis was not rejected. The table of critical values for such sequential tests [$F_T(m + 1)/m$] is found in Bai and Perron (1998, p. 61).

As illustrated in Fig. 1, the time series of the Public Sector Net Debt (DLSP) shows no evidence for an exact number of structural breaks, which justifies the adoption of the latter procedure. The estimation technique is labeled as sequential method of least squares, whose procedures meet the following steps: Eq. (11) is estimated with $m = 1$ for the full period and $\hat{t}_1 = \underset{t_1}{\operatorname{argmin}} S_T(t_1)$ is identified, where $S_T(t_1)$ defines the sum of the squares of residuals of the model with one break. The sample is then divided into two others and for each subsample $[1, t_1]$ and $[t_1, T]$ is estimated a model with one break, providing two potential breaks at \hat{t}_1 and \hat{t}_2 , respectively. If $S_T(\hat{t}_1, \hat{t}_1) < S_T(\hat{t}_1, \hat{t}_2)$, then $\hat{t}_2 = \hat{t}_1$ otherwise $\hat{t}_2 = \hat{t}_2$. Note that $S_T(\hat{t}_1, \hat{t}_1)$ represents the SQR for Eq. (11) with $= 2(\hat{t}_1, \hat{t}_1)$. Bai and Perron (1998) showed that if t_1^* and t_2^* are the true breaking points, then (\hat{t}_1, \hat{t}_2) are consistent for (t_1^*, t_2^*) . The full sample is then divided into three sub-samples: $[1, \hat{t}_1]$, $[\hat{t}_1, \hat{t}_2]$, $[\hat{t}_2, T]$, and so on.

An alternative way to test this procedure is to combine the sequential method above discussed with the Bayesian Information Criterion- $BIC(m)$ (Yao, 1988) and the $LWZ(m)$ (Liu et al., 1997 in Bai and Perron, 1998). The optimal

¹¹ See hypotheses A1–A5 in Bai and Perron (1998) p. 50–51.

Table 1
Estimates of the structural breaking dates.

	Breaks	
	\hat{t}_1	\hat{t}_2
Date	05/1994	02/2003
95% C.I.	[11/1993; 07/1994]	[03/2001; 06/2004]
$N=205$		

Source: Own calculations.

Table 2
Estimates of the reaction function with two structural breaks.

$$S_t = \sum_{i=1}^{m+1} (\mu_i + a_i b_{t-1} I_{t \in I_i}) + \beta \tilde{g}_t + \gamma \tilde{y}_t + v_t$$

Parameters	μ_1	μ_2	μ_3	α_1	α_2	α_3	β	γ
Estimates	0.002 (0.000)	-0.007 (0.001)	-0.015 (0.006)	-0.001 (0.02)*	0.018 (0.003)	0.041 (0.013)	-0.027 (0.074)*	1.672 (0.764)
N	R^2		BIC			LWZ		
205	0.30		-11.87			-11.69		

Notes: Standard errors in parenthesis.
(*) represents non-significance at 5%.

number of breaks is found when the minimum value of these information criteria is achieved. These criteria¹² are appropriate for models with multiple breaks, since they introduce a factor penalty for adding additional breaks, which would necessarily decrease the value of SQR.¹³ The results are shown in Tables 1 and 2 and discussed in the following sections.

5. Empirical application

The limitations of traditional unit root tests and cointegration techniques in the analysis of public debt sustainability, especially in the presence of structural breaks in the time series, this article relies on a combination of tax smoothing model of Barro (1979) with a procedure that allows multiple endogenous structural breaks in the coefficients of the government reaction function.

Based upon the proposals of Bai (1997a,b) and Bai and Perron (1998), it is aim to investigate whether the accumulation of public debt implies more restrictive policies by the Brazilian government. In the Barro’s (1979) model, also applied by Rocha (1997) and Luporini (2000), the sustainability condition is supported by the positive response of the primary superavit to the debt, while Bai’s (1997a,b) technique enables the estimation of a fiscal response function with multiple structural breaks in the estimated parameters for the intercept and the response of the primary surplus to the debt. Similarly, we estimate a reaction function for Brazil by considering the structural breaking points as random variables. In so doing, the political response of the Government to the accumulation of debt is supposed to be analyzed properly, even in periods of structural changes in fiscal policy or in subsamples defined endogenously by the criteria described above.

¹² For m structural breaks, these criteria are defined as:
 $BIC(m) = \log S_t(\hat{t}_1 \dots \hat{t}_m) - \log T + (p^*/T) \log T$
 $LWZ(m) = \log S_t(\hat{t}_1 \dots \hat{t}_m) - \log(T - p^*) = c_0(p^*/T)(\log T)^{c_1}$
 where $c_0 = 0.299$; $c_1 = 2.1$; $p^* = (m + 1)q + m + p$. The latter term represents a penalty factor that offset the reduction in SQR for each additional break between the regimes (Perron, 1989).

¹³ According to Bai (1997a,b), if regressors with trends are considered, then a 95% confidence interval for the estimated breaking point can be computed by, $[\hat{t}_i - (c/\hat{L}_i) - 1; \hat{t}_i - (c/\hat{L}_i) + 1]$, where $\hat{L}_1 = [(\hat{\alpha}_{i-1} - \hat{\alpha}_i)^2 B_{\hat{t}_i-1}^2 / \sigma_v^2]$; (c/\hat{L}_i) represents the closest integer to the 97.5% quintile; $\hat{\alpha}_{i-1}$, $\hat{\alpha}_i$ and σ_v^2 are, respectively, the estimates from the government responses before and after the break \hat{t}_1 and the estimated variance of v_t in Eq. (11).

5.1. Data base

Monthly data in the period December 1991–December 2008 disclosed by the Central Bank of Brazil (BCB)¹⁴ for the stock of net debt of the public sector (DLSP) and primary surplus are to be used in the empirical exercise. These data refer to the consolidated public sector, whereas data of revenues and expenditures account for the federal government only, in accordance with the methodology of calculation “above the line”¹⁵ implemented by the National Treasury Secretariat (STN).

The revenue and expenditure variables are in deviations form, which can mitigate¹⁶ problems of magnitude when using only the federal government as a proxy for the consolidated public sector. The deviations of the expenditure and revenue variables compared to their original magnitudes, in accordance with equation (11), were obtained from the differences between these sets relative to the respective series extracted via the Hodrick–Prescott filter, as performed in Barro (2003). It is also worth noting that the latter two variables of the expression (11) are of less importance in our study, since the condition of sustainability is solely linked to the estimated coefficient of the lagged debt/GDP ratio. The estimation program to obtain the estimates was written in GAUSS 8.0, following the methodology of Bai (1997a,b) and Bai and Perron (1998).

5.2. Results

The estimates of the structural breaking dates and the estimates of Eq. (12) in each regime with the conditions for sustainability via the coefficient sign of the debt first lag are displayed in Tables 1 and 2, respectively. Initially it is analyzed the possibility of occurring structural changes in government fiscal policy, and if the periods in which such changes take place can be related to the fiscal adjustment measures implemented in the 90s or to the devaluations observed in the end of this decade and the early 2000s. The estimates point to the impact and/or effectiveness of these devices through the response of the primary surplus to an increase in the public sector debt.

The results in Table 1 indicate the occurrence of two structural breaks; the first one in mid-1994, which took place in the period between the two laws of debt renegotiation mentioned in section 1, and the second one in early 2003, after the exchange rate depreciation in 2002. Yet, the latter break occurred during a period of high uncertainty about the economic policy to be implemented in Brazil as a result of a political ideology change in transition from a liberal to a non-liberal Government.

Giambiagi (2004) argues that there are two inflection points in the Brazil’s fiscal policy path in the period. The first in 1999 when was performed a primary fiscal adjustment, although the dimension of equity adjustments made at that time would have prevented the path change of the debt/GDP ratio, which kept on rising in the next years. The second in 2004 when it was supposed and expected since 1994 that the cycle of ten years of increasing public debt/GDP ratio had been terminated.

Although the option for monthly frequency data may have smoothed the possible change in 1999, as argued before, the findings are consistent with both Giambiagi’s (2004) arguments and reports published by the National Treasury and the Central Bank.

Moreover, since the variable of interest is the total debt of the public sector, the impact of the disciplinary provisions of public expenditures is just partially compromised, so that the credibility seems to be the dominant factor of the structural change in 1994. Yet, it is noteworthy that the Mexican moratorium occurred in 1995, which resulted in a reduction of the national GDP, and an ascending growth of domestic debt, so that the DLSP/GDP indicator reverses the downward trend in 1994. This fact is depicted in Fig. 3.

The results in Table 2 testify the poor and innocuous Government response to the accumulation of public debt up until 05/1994, since the coefficient of α_1 is not statistically significant.¹⁷ Although the fiscal situation has been worse off from that date on (reduction of $\hat{\mu}_i$ from $\hat{\mu}_1$ to $\hat{\mu}_2$), the net debt of the public sector remained sustainable. It is

¹⁴ See www.bcb.gov.br/seriestemporais.

¹⁵ The BCB methodology is based upon the financing sources, which is named “beneath the line”, whereas the STN methodology relies upon the headings revenue and expenditures only, that is, “above the line”.

¹⁶ It is worth informing that the revenues of federal government are greater than the sum of the total revenue of all states and municipalities together.

¹⁷ These results are ratified even if seigniorage is considered as a form of financing. Such extensions have been omitted due to the current irrelevance of this funding mechanism.

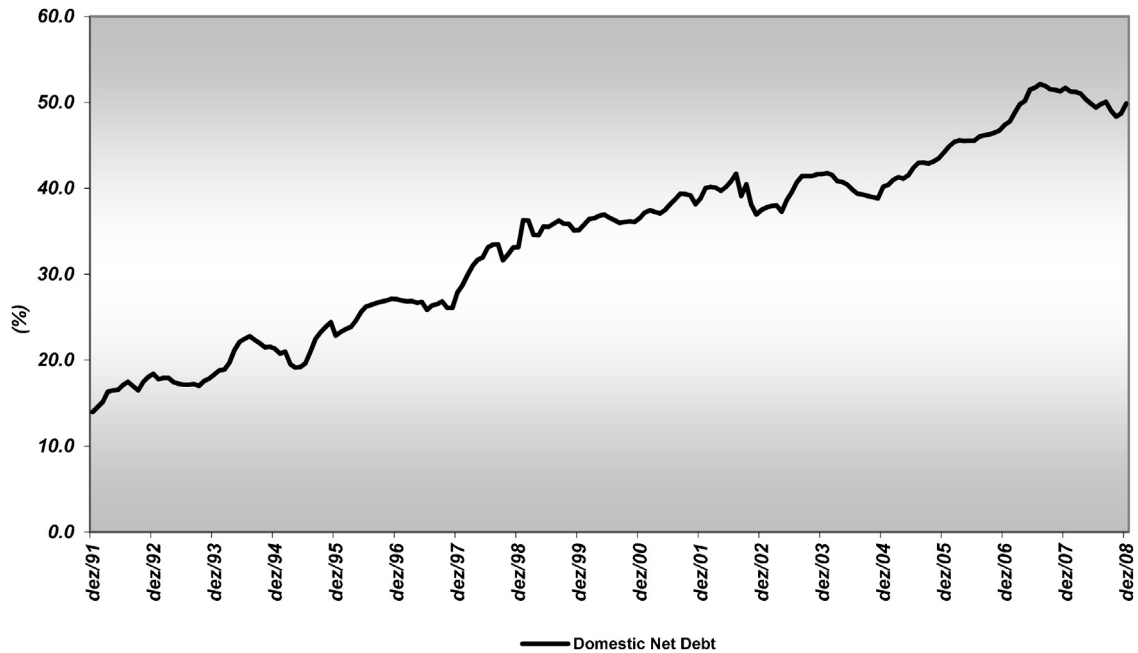


Fig. 3. Domestic net debt/GDP, December 1991–December 2008.

Source: Central Bank of Brazil (BCB).

worthwhile noting the considerable rise in the magnitudes of the estimated coefficients $\hat{\alpha}_i$ ($i = 1, 2, 3$), besides the progression of their statistical significance. The estimates of $\hat{\alpha}_1 = 0.018$ and $\hat{\alpha}_2 = 0.041$ indicate that the economic policy implemented in the country more than double the capacity to generate primary surplus from a period of two ideologically distinguished governments.¹⁸

In sum, the results support the effectiveness of fiscal adjustment undertaken by the public sector from the second half of the 90s, besides corroborating the Goldfajn's (2002) arguments, who states that, even in the most unfavorable scenarios for the interest rate, the fiscal policy in Brazil would be sustainable in the period 1998–2002. Based upon this reasoning, the country seems to be economically shielded from eventual international crises.

6. Concluding remarks

The paper sheds light in the latest debates about the sustainability of fiscal policy in Brazil, which is taken as a measure of strength of the Brazilian economy to financial and economic shocks. It can also be attained through multiple endogenous structural breaks in the coefficients of a fiscal response function of the Government.

The methodological approach follows Bohn (2006), who deals with the strategy of investigating the response from the Government for generating primary surplus facing the public debt accumulation. This methodological choice provides more robustness to analyze the sustainability of the fiscal policy of a country.

Monthly data of the stock of public net debt and flows of revenues and expenditures were fit in a reaction function for Brazil in the period December 1991/December 2008. Tests for the occurrence of endogenous structural breaks are based upon Bai and Perron (1998).

The advantage of this approach over earlier proposals, such as Luporini (1999, 2000, 2012) who also shows that the Brazilian public debt is sustainable, is not to impose a priori the date at which the structural change occurs. Structural breaks must be treated as random variables. The results here found go beyond those of Lima and Simonassi (2005), who also confirm the sustainability of public debt in Brazil in the period 1947–1999, since we allow the possibility for

¹⁸ The downward trend in the debt/GDP ratio in early 2003, together with the stability of the primary surplus of around 4% of GDP, as shown in Fig. 2, justify the estimated results.

more than one structural break in the estimated parameters. Moreover, an additional advantage of this methodology is to identify whether a fiscal austerity policy is active in periods that the public debt eventually grows.

The empirical results turned out two structural changes in the Brazilian fiscal policy, one in May-1994 and another in February-2003. These findings are consistent with Giambiagi (2004) who argues that it was expected the ten-year cycle of increases in public debt/GDP to terminate in 2004. Nevertheless, the first break occurs during a period marked by two laws of debt renegotiation and several restrictions on indebtedness imposed to state and municipal governments, and the second break occurs in a scenario of exchange devaluation crises of severe uncertainty about the future of the Brazilian economy, in spite of its increasing economic growth rate.

Although the Brazilian fiscal policy had shown to be sustainable over the sampled time series, only from May 1994, to hitherto innocuous responsiveness of the public sector to increases in public debt, it becomes effective. This improvement in the fiscal balance of the government is linked to the relative irrelevance of the use of seigniorage as a source of finance funding. These results support the arguments of Goldfajn (2002) who predicted that the sustainability of the Brazilian public debt started in 1998, in spite of the adverse scenarios of economic growth and interest rate. The solidness of the Brazilian economy to potential impacts of the financial international crises is also testified in the results.

After the second structural break (February-2003) it is observed that the public sector net debt remains not only sustainable but also has increased the public policy makers' efforts to generate primary surplus to offset eventual rising in the public debt. As a matter of fact, the debt/GDP ratio presented a declining trend and the primary surplus/GDP ratio remained steady at 4%.

Despite the application of a distinguished methodology that treats structural changes endogenously, the general meaning of the estimates here obtained resemble those of other authors such as Luporini (2011, 2012). It could also be established from the estimate magnitudes that the government response to hinder the progress of the Brazilian public more than doubled, as indeed occurs in the last eight years of the sampled time series. This fact reinforces the idea that there is a confidence margin available to policymakers in Brazil, from which they can eventually take the option for increasing public expenditures as an economic strategy for smoothing the effects of the international financial crises without compromising the fiscal targets.

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