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### Article

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# The effects of public debt management on macroeconomic equilibrium: An analysis of the Brazilian economy<sup>☆</sup>

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## Abstract

The aim of this paper is to study the effects of public debt management on yield curve spreads in Brazil, in order to see possible impacts on the country's economic activity. State space models, together with Kalman Filter estimators, are used for the period ranging from June 2002 to February 2012. The results indicate that increases in the issuance of fixed rate linked bonds lead to increases on yield spreads and the longer the maturity, the longer the effect. The opposite occurs when there is an increased issuance of floating rate linked bonds. Therefore, a change in the structure of the Brazilian public debt is not neutral on the yield curve, with possible impacts on the country's macroeconomic balance.

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*JEL classification:* C32; E43; E63

*Keywords:* Public debt management; Fiscal and monetary policies; Kalman Filter

## Resumo

O objetivo deste artigo é analisar os efeitos da administração da dívida pública sobre os spreads dos títulos públicos brasileiro, a fim de pensar em possíveis impactos sobre a atividade econômica. Para isso, utiliza-se a metodologia do Filtro de Kalman para o período compreendido entre junho de 2002 e fevereiro de 2012. Os resultados indicam que aumentos da emissão de títulos prefixados podem elevar o *spread* e que esse efeito é maior nos vencimentos mais longos. Efeito contrário ocorre com o aumento da emissão

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dos títulos indexados. Desta maneira, uma mudança na estrutura de financiamento da dívida pública não é neutra sobre a curva de juros, podendo impactar a condução da política monetária e o equilíbrio macroeconômico.

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*Palavras chave:* Gestão da Dívida Pública; Políticas Fiscal e Monetária; Filtro de Kalman

## 1. Introduction

There is no doubt every country needs funding to foster economic growth and development. However, such funding needs to be sustainable and it has to be closely in line with the government's fiscal and monetary policies. That is why managing public debt is so crucial. According to [Agell and Persson \(1989\)](#) “*public debt management can be defined as the government's (including the central bank) choice regarding the composition of the outstanding stock of all the securities entering the liability side of its balance sheet*”.

In order to use public debt as part of an economic policy strategy, authorities can change a country's debt portfolio and, as consequence, they can alter the demand for financial assets, which are not perfect substitutes. Therefore, an effective public debt management is able to modify interest rate yield spread premiums and opportunity costs in financial decision-making. As a result, investors are provided with better information with which they can plan their investments and create new portfolios that, consequently, may affect economic activity as a whole.

A great amount of economic literature has dealt with the research related to public debt management in a quite controversial way. For instance, the so-called Ricardian Equivalence theory points out that public debt is neutral with respect to consumption and, as result, with respect to macroeconomic dynamics, so long as agents allocate their savings in order to have a permanent income over their entire lifetimes. In other words, a larger public debt leads to more savings in the present period, because individuals expect to pay higher taxes in the future, which results in no effect in economic activity. On the other hand, [Tobin \(1963\)](#) argues that economic activity can be influenced by public debt management, as authorities can “*determine the size and the maturity structure of debt held by the private sector and, given imperfect substitutability of assets along the maturity spectrum, this will normally influence the shape of the yield curve*” ([Filardo et al., 2012](#)).

From an empirical point of view, public debt administration has been used as an economic policy instrument aiming at different ends, such as the conduct of monetary policy, the public deficit financing, or even to provide hedge to those who borrow in foreign currency. The Operation Twist, which began in 1961, is one of the most well-known actions aimed at affecting US economy through public debt management. In that case, the Federal Reserve tried to compensate its higher short-term interest rate by shortening the maturity of the bonds to achieve lower premiums at the long end of the yield curve. At that time, the focus was to avoid a deeper recession, improving the economy and bringing down unemployment rate. The management of public debt has also been used to fight the consequences of the recent global financial crisis. By means of the Quantitative Easing program and the revival of the Operation Twist, the US Fed provided last resort liquidity to the financial system, and also stimulated aggregate demand.

As for the Brazilian case, the country has been through several changes in its debt management since the mid 2000s. Three measures can be highlighted: (i) the reduction of securities linked to the Selic benchmark interest rate and to the exchange rate; (ii) the lengthening of the country's debt maturity; (iii) the issuance of external debt bonds denominated in Reais. The purpose of the Brazilian government is twofold. On the one hand, it is trying to reduce the exposure of its public debt to adverse circumstances coming from either exchange rate devaluations or sudden interest rate hikes. On the other hand, there has been a search for more efficient economic policies, which still suffer with problems from the hyperinflation period of the late 1980s.

This paper analyses the effects of public debt management in Brazil on the country's yield spread premiums. In other words, we examine the responsive behavior of bondholders to changes in the composition of the public debt. It is this paper's assumption that changes in the gap between the yields on short-term and long-term bonds affect individual investment behavior and, as result, affect economic activity. In order to reach this objective, we make use of state space models, together with Kalman Filter estimators, for the period ranging from June 2002 to February 2012. The results indicate that increases in the issuance of fixed rate linked bonds lead to increases on yield spreads and the longer the maturity, the longer the effect. The opposite outcome occurs when there is an increased issuance of floating rate linked

bonds. Therefore, a change in the structure of the Brazilian public debt is not neutral on the yield curve, with possible impacts on the country's macroeconomic balance.

Besides this introduction, this paper is organized as follows. The Section 2 shows the main debates about public debt management in Brazil, whilst the Section 3 describes the behavior of the Brazilian public debt from 1995 on. Section 4 describes the data series, the descriptive statistics and the econometric model. The Section 5 is about the unit root test results and the last two sections report the econometric results and the conclusions of the paper.

## 2. Public debt management in Brazil: a literature review

Garcia and Salomão (2006) emphasize the relationship between a country's national debt and the systemic risk premium required by investors. Due to the quality of the debt, its maturity and duration cannot increase regardless of factors that buyers consider as non-diversifiable risks. In this scenario, attempting to lengthen the average maturity of the outstanding debt would not be enough, as the voluntary demand for securities from the financial sector might not meet government's expectations. The author argues that a successful lengthening of public debt would only be possible if measures were taken to strengthen the domestic financial market. Among the measures, we could list the reduction of foreign currency-denominated debt, fiscal stability to reduce the Debt/GDP ratio, controlled inflation, as a means of helping the central bank lower interest rates, besides helping diminish the importance of floating rate securities in the total debt.

Levy (2006) called the attention to the actions taken by the Brazilian Treasury aiming at improving the country's debt profile. Two main measures were taken: (i) the issuance of exchange rate linked bonds was diminished; (ii) the investor base was diversified and expanded, attracting more domestic and mainly foreign bondholders, contributing to the improvement in systemic risk perception.

In another line of research, Arida et al. (2005), Lara Resende (2006) e Arida (2006), among others, called the attention to the risk of jurisdictional uncertainty in Brazil. Arida et al. (2005), for instance, argue that the inexistence of a local long-term domestic credit market could be seen as a market failure, which required some sort of governmental intervention, such as: restrictions to currency convertibility, artificial lengthening of public debt maturities, compulsory saving funds, and distorting taxation. According to the authors, these interventions worsen the negative impact of jurisdictional uncertainty on the short-term interest rate in Brazil. Therefore, a change in this scenario would open some room for a composition of debt with a better quality. Hence, improving the country's macroeconomic fundamentals would be crucial to lessening risk perception in Brazil.

Accordingly, Lara Resende (2006) explained that forced changes in the government's debt profile, with no alterations in risk perception, would not be beneficial to a proper debt management. This could be so because, in times of financial difficulties, investors interested in fixed rate bonds would require higher yields, as opposed to floating rate bondholders.

Pastore (1996, 2006) highlighted the ineffectiveness of monetary policy when floating rate linked bonds represent a significant share of public debt. The reason for that relates to the absence of the so-called wealth effect. When there are a lot of floating rate linked securities, interest rate variations do not lead to wealth loss and, thus, may not limit demand. According to the author, when investors construct their portfolios with a lot of sovereign debt, and when the government issues a lot of (high) interest-rate linked securities, the wealth effect may be an efficient monetary policy transmission channel. Nevertheless, this is not the case whenever public debt is mostly comprised of floating rate securities (Pastore, 1996, 2006). It is important to stress that, in general, the wealth effect has been losing relevance as a monetary policy channel, as stressed by the empirical evidences found by Ludvigson et al. (2002) and by Pires and Andrade (2009) for the Brazilian case.

Carneiro (2006) argues that floating rate linked bonds are closely related to higher interest rates in Brazil. The reason for that is the opportunity cost that floating rate securities have in relation to either inflation-rate or fixed rate bonds. As floating rate bonds are not influenced by price variations, when interest rates change, monetary policy becomes ineffective. Therefore, modifications in debt composition, resulted from a reduction in the issuance of floating rate securities, would make monetary policy more potent. Certainly, the financial system would become more susceptible to short-run changes in monetary policy, but on the other hand, interest rates would be lower, helping economic growth.

A third field of contribution concerns the construction of an ascending yield curve in the Brazilian financial system, which may provide more efficiency to monetary policy and allow the private sector to fight for a greater portion of the national savings (Kawall et al., 2004). Moraes (2006) points out that due to a period of great instability of the Brazilian economy, long-term asset pricing would still take into account a large variation of inflation, resulting in a

very short-run long side of the yield curve. The author suggests that, as the Selic rate decreases, the Brazilian Treasury ought to issue fixed rate long-term bonds in order to flatten the term-structure of the interest rates.

Franco (2005) also emphasizes the effects of floating rate securities on the development of private long-term debt, and how public debt management could contribute to that. In order to reach this goal, the Brazilian money market would have to go through reforms, paying lower returns to the excess of liquidity and, at the same time, bringing some volatility to the Selic rate. As a result, investors would respond to this increased volatility migrating to medium and long maturity floating rate bonds. Besides, Franco (2005) advises that the Brazilian Central Bank should be able to set its benchmark interest rate for a longer period than one day.

Loyo (2006) suggests that the construction of a yield curve in the Brazilian financial system could become viable if the National Treasury issued long-term floating rate bonds, with higher returns, and in the meantime the Central Bank decreased the Selic rate, bringing more volatility to this rate. This procedure, says Loyo (2006), might help construct a term structure of the interest rate more compatible with those found in countries with well-developed financial systems. In these conditions, how could monetary policy help public debt management in order to create a positive yield curve in Brazil? Loyo (2006) argues that Franco's (2005) assumption, regarding an increase in the volatility of the Brazilian benchmark Selic interest rate, could raise some doubts once the decrease in demand for higher volatility securities might not mean an increase in other financial assets.<sup>1</sup> In this sense, Loyo (2006) says that a successful lengthening of public debt would involve a great deal of uncertainty reduction regarding monetary policy action. Therefore, the Brazilian Central Bank would have to target inflation as well as interest rate stability and, as soon as investors incorporated these variables to their risk assessment, the lengthening of debt maturity would become feasible. Notwithstanding, Loyo (2006) suggests that monetary policy should keep its benchmark interest rate constant around its neutral rate, and maintain small but persistent deviations, rather than large shocks. This would motivate agents to agree to lengthen their investments and improving the debt profile.

Mendonça and Silva (2008) analyze the relationship between monetary policy focused on a disinflationary process and fiscal equilibrium. The authors argue that when interest rates are high and public debt consists mainly of interest rate-linked bonds, the conduct of fiscal policy would be compromised, due to expensive financial costs to the public budget. Therefore, an effective public debt management would be a good strategy to lessen fiscal policy costs and an adequate tool to avoid deterioration in the Debt/GDP ratio.

### 3. Public debt management in Brazil after 1995

Although the econometric analysis, which will be performed in this paper, goes from 2002 to 2012 due to data availability, this descriptive analysis starts in 1995, as an attempt to show a more complete scenario and a more robust foundation to the trajectory of the Brazilian public indebtedness. Moreover, the analysis will focus on the macroeconomic determinants of debt performance in Brazil but also on the actions taken by the government to manage the country's public debt, mainly regarding its composition and maturity.

The period ranging from July/1994 to January/1999 marks a monetary regime based on the exchange rate as an anchor, i.e., a source of nominal rigidity to other prices. At that time, Brazilian economic authorities used to attract foreign capital flows by managing the country's public debt as an instrument for hedging against the exchange rate risk. In addition to that, the Central Bank raised its benchmark Selic rate to attract even more external savings. As a consequence, the share of Selic-indexed securities increased from 20.46% of the public debt, in 1997, to 61.51% in 1999. At the same time, the share of exchange rate linked securities went from 11.64% to 26.06%, as depicted in Fig. 1.

In 1998, the Brazilian government adopted a target for the primary surplus to guide its fiscal policy and, in 1999, an inflation targeting system was implemented in substitution to the exchange rate anchor, restoring macroeconomic stability. According to Pedras (2009), the new fiscal policy orientation, aimed at reducing Debt/GDP ratio in the medium term, made feasible the issuance of inflation-linked securities, in order to meet potential demand from pension funds, and also to allow for the lengthening of the Brazilian public debt. In 2002, however, uncertainties concerning presidential elections made investors become more skeptical about the Brazilian economy, as they believed fiscal dominance would become a problem if the Labor Party won the elections (Favero and Giavazzi, 2005). Nonetheless,

<sup>1</sup> Bartolini and Prati (2003) contributed to this line of research by interviewing open market brokers. For more on the topic, the reader may refer to Bartolini and Prati (2003).

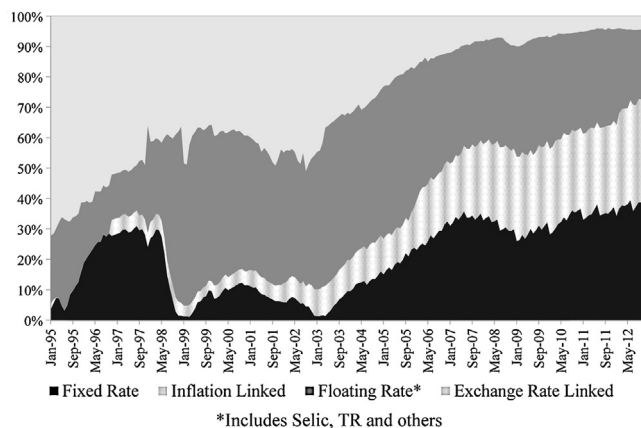


Fig. 1. Federal public debt profile (% of total debt, Jan/1995–Dec/2012).

Source: Brazilian National Treasury.

as the new government sworn in, it pursued credible policies, with more restrictive fiscal and monetary policies. With these actions, the government was able to recover its credibility, reducing sovereign risk and inflation, stabilizing the exchange rate, and controlling public debt dynamics (Bresser-Pereira and Gomes da Silva, 2008).

Since then, the National Treasury has promoted improvements in public debt management, which was something necessary to do, once the share of interest-rate linked bonds reached 60% of total debt in 2002, as shown in Fig. 1. There is no doubt this debt profile caused some problems. Firstly, the benchmark interest rate would partially lose its power as a demand control tool, compromising the conduct of monetary policy, just as mentioned by Pastore (1996, 2006) and Carneiro (2006). Secondly, a high share of interest-rate linked bonds also meant large financial costs, which was a serious problem to the conduct of fiscal policy (Mendonça and Silva, 2008). In line with Levy's (2006) proposal, the government exempted all foreign investors from paying capital-gains taxes on federal bonds, in 2006. This measure paved the way for Brazil to issue its first 10-year fixed rate bond<sup>2</sup> (Pedras, 2009).

From 2008 onwards, the international financial crises forced the government to take a more prudent position regarding the conduct of economic policy. In the beginning of the crisis, the share of fixed rate linked bonds (as a % of total debt) decreased and the share of floating rate bonds increased, as investors demanded more security on their investments. Besides that, the Brazilian government worked to improve its debt profile and, as a result, floating rate linked securities, mainly those linked to the Selic rate and exchange rate, went from nearly 90% of the total debt, in April 2003, to 34.5% in April 2012. In the opposite direction, the sum of fixed rate and inflation-rate linked bonds, which made public debt management and fiscal policy considerably more predictable, totaled 65.5% of public debt. It is also worth mentioning, as depicted in Fig. 1, the reduction of the share of exchange rate linked bonds, after 2002. This happened due to the better outcome of the Brazilian current account, from 2004 on.

Fig. 2 summarizes the Brazilian public debt trajectory from December 1995 until December 2012. As Arida (2006) and Lara Resende (2006) argued, it is clear that between the emergence of the Brazilian external crisis, in 1999, and Lula da Silva's first year in office, there was an increase in investors' systemic risk perceptions. Consequently, the demand for floating rate linked bonds also raised. However, it was only after 2003 that investors decided to hold more fixed rate debt securities. Since 2011, there has been a more prominent replacement of floating rate securities by fixed rate ones.

Two National Monetary Council (CMN) Resolutions are worth mentioning, once their objectives is to align the agents' investment policy to the guidelines established by the National Treasury, of gradually reducing the share of floating rate bonds. The first one is CMN Resolution 3922/2010, which regulates investments of reserves for closed complementary retirement plans. Investments of pension plans for the Federal Government, States, Federal District and Municipalities have to comply with this resolution, investing at least part of their resources in fixed rate securities, instead of Selic Rate linked ones. Secondly, Resolution 4034/2011, which regulates the investment of open plan assets,

<sup>2</sup> They are the National Treasury Notes, F series, 2017.

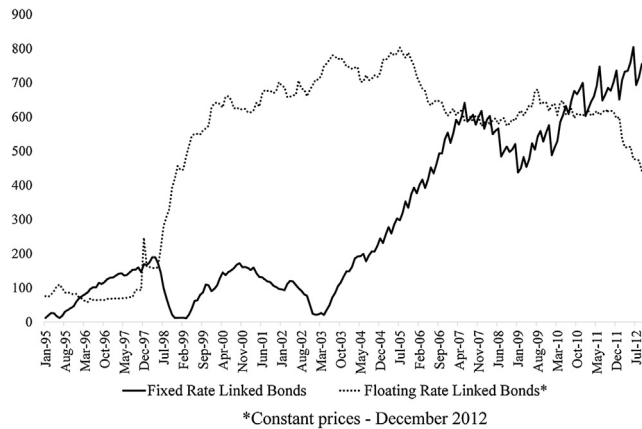


Fig. 2. The Brazilian federal public debt: floating rate and fixed rate bonds (R\$ million, Jan/1995–Dec/2012).

Source: Brazilian National Treasury.

the so-called extra-market funds of state-owned companies, semi-autonomous agencies and government funds. Finally, it is also worth mentioning the issuance of fixed rate securities to the Brazilian Indemnity Severance Fund (FGTS), in exchange of floating rate LFT bonds, the Treasury Financial Bills. This measure amounted to almost R\$ 40 billion (STN, 2012).

Fig. 3 depicts the lengthening of federal public debt average maturity. The first impulse dates back of 1999, the abandonment of the exchange-rate anchor, because there was no longer a need to attract foreign savings and, therefore, no need to issue the same amount of short-term public debt. After this first impulse, debt maturity was relatively stable until 2006, reflecting government efforts to obtain credibility to its economic policy and, at the same time, attract more investors to buy fixed rate linked securities. From 2007 on, when the share of floating rate linked bonds started to be reduced, and the share of fixed rate bonds started to increase, the average debt maturity reached 36 months (Pedras, 2009). In 2011, the lengthening of debt average maturity picked up again, in line with a more intense substitution of floating rate securities for fixed rate or inflation-linked bonds.

In summary, it can be noted that after going through periods of crises and instability, from 1998 to 2003, which made it difficult to manage the country’s public debt in the long-term, there was some improvement after 2003. In fact, the debt management strategy, taken by Brazilian Treasury and Central Bank, was focused on stabilizing the share of floating rate linked bonds (as % of total debt) and, at the same time, on increasing the share of fixed rate securities. The benefits were clear as, in less than a decade, the issuance of fixed rate linked securities increased, and so the average debt maturity. Finally, although we cannot yet say that there is a term structure of interest rates in Brazil, given the average debt maturity of about four years, the scenario is much better than in mid-2003 and 2004. At that time, the share of fixed rate linked securities was small and the average debt maturity was about two years. Thus, considering the debt management strategy described in this article, it is of utmost importance to analyze how agents respond to

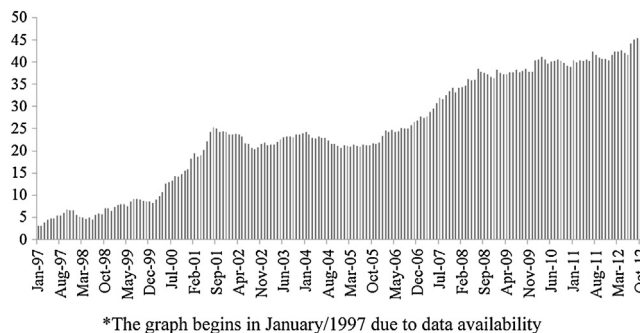


Fig. 3. Domestic federal public debt: average maturity (in months, Jan/1997–Dec/2012)\*.

Source: Central Bank of Brazil.

changes in the country's public debt composition, and how these possible changes can affect economic activity. The next sections will search for some answers.

#### 4. Econometric methodology, data and descriptive statistics

The econometric methodology applied in this article is related to state-space structural models and Kalman filtering, which is a recursive linear filter capable of predicting the unobservable variable, in the next period, based on the current observation. After that, the filter uses the realization to update the forecast.<sup>3</sup> The advantage of this method is the analysis of unobservable components, such the trend and cycle of a series, allowing them to be incorporated in the model. State-space models consist of two equations: measurement and transition. The former describes the relationship between observed and unobserved variables, whereas the latter describes the dynamics of the unobserved variables. Once the representation is set, the Kalman Filter is the statistical algorithm that will carry out the computation of the model (Pasricha, 2006).

A general univariate model can be described as:

$$y_t = \mu_t + \gamma_t + \psi_t + v_t + \varepsilon_t \quad \varepsilon_t \sim NID(0, \sigma_\varepsilon^2), \quad t = 1, \dots, T. \quad (1)$$

where  $\mu_t$  is the trend component,  $\gamma_t$  is the seasonal component,  $\psi_t$  is the cycle,  $v_t$  is the autoregressive component and  $\varepsilon_t$  is the error term.

The trend component can be defined as:

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t, \quad \eta_t \sim NID(0, \sigma_\eta^2) \quad (2)$$

$$\beta_t = \beta_{t-1} + \zeta_t, \quad \zeta_t \sim NID(0, \sigma_\zeta^2) \quad (3)$$

where  $\beta_t$  is the slope,  $\eta_t$  and  $\zeta_t$  are level and slope perturbations, respectively, and they are, together with  $\varepsilon_t$ , mutually uncorrelated.

As in Shumway and Stoffer (2000), suppose a univariate series  $y_t$  consisting of a trend component ( $\mu_t$ ), which follows a random walk process, and a noise component ( $\varepsilon_t$ ). We then obtain a local level model such that:

$$y_t = \mu_t + \varepsilon_t \quad \varepsilon_t \sim NID(0, \sigma_\varepsilon^2), \quad t = 1, \dots, T. \quad (4)$$

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

The aim is to produce estimators for  $\mu_t$ , given  $Y_S = \{y_1, \dots, y_S\}$ . This solution is given by the Kalman Filter. Suppose:

$$x_t^S = E(x_t | Y_S) \quad (5)$$

$$P_{t_1, t_2}^S = E\{(x_{t_1} - x_{t_1}^S)(x_{t_2} - x_{t_2}^S)'\} \quad (6)$$

When  $t_1 = t_2$ , we can define  $P_t^S$ . The initial conditions are:  $x_0^0 = E(x_0 | Y_0) = \mu$  and  $P_0^0 = \Sigma_0$ , for  $t = 1, \dots, n$ :

$$x_t^{t-1} = x_{t-1}^{t-1} \quad (7)$$

$$P_t^{t-1} = P_{t-1}^{t-1} + \sigma_\eta^2 \quad (8)$$

with:

$$x_t^t = x_{t-1}^{t-1} + K_t(y_t - x_{t-1}^{t-1}) \quad (9)$$

$$P_t^t = [I - K_t]P_{t-1}^{t-1} \quad (10)$$

Equation  $K_t = P_{t-1}^{t-1}[P_{t-1}^{t-1} + \sigma_\varepsilon^2]^{-1}$  is called the Kalman Gain and it is responsible for updating  $y_t$  when the information is updated.<sup>4</sup>

<sup>3</sup> See Harvey (1990) and Hamilton (1994) for more on the topic.

<sup>4</sup> See Shumway and Stoffer (2000) for more details. The SSF/Stamp software was used to run all the regressions in this article (Koopman et al., 2009).



Table 1  
Descriptive statistics (118 obs).

	Mean	Median	Maximum	Minimum	Std. Dev.
Yield spread (1 month)	0.03	0.005	1.50 Dec/2002	−0.84 Aug/2003	0.36
Yield spread (3 months)	0.08	0.01	3.47 Oct/2002	−2.07 Jul/2003	0.91
Yield spread (6 months)	0.21	0.06	5.68 Aug/2002	−3.18 Jul/2003	1.58
Yield spread (12 months)	0.51	0.12	10.01 Nov/2002	−4.31 Jul/2003	2.47
Yield spread (48 months)	1.73	0.66	22.41 Oct/2002	−3.83 Jun/2003	4.85
Yield spread (60 months)	1.90	0.92	24.38 Oct/2002	−4.00 Oct/2005	5.22
GDP gap	0.000348	0.00	0.05	−0.04	0.018
Monthly IPCA inflation	0.52	0.43	2.88	−0.03	0.38
Monthly Selic interest rate (annualized)	14.62	13.26	26.32	8.65	4.57
Floating rate linked bonds (%)	0.018	−0.005	7.94	−11.76	2.37
Fixed rate linked bonds (%)	1.40	1.09	12.77	21.19	3.88

Source: National Bureau of Statistics (IBGE), Bloomberg, Central Bank of Brazil.

The econometric estimations will be carried out by making use of monthly series for the period ranging from January 2002 to December 2012. The variables are defined as follow:

- Output (GDP) Gap, which is the log of monthly GDP (seasonally adjusted)<sup>5</sup> (Source: National Bureau of Statistics – IBGE);
- Monthly CPI (IPCA) Inflation (Source: National Bureau of Statistics – IBGE);
- Monthly Selic Interest Rate – Annualized (Central Bank of Brazil);
- Financial Treasury Bills – LFTs (in BRL) (Brazilian National Treasury);
- National Treasury Bills – LTNs (in BRL) (Brazilian National Treasury);
- Yield Spreads – Pre-DI Swap 1, 3, 6, 12, 48 and 60 months (Bloomberg);

Table 1 reports the descriptive statistics. As expected, the average yield spread increases over time, 0.03 (1 month) to 1.90 (60 months). The same upward trend is observed in the median and maximum values of the yield spreads, which occurred between August and December 2002. As for the minimum values, they are also located in a given period, between June and August 2003. The exception is for the 60-month spread (October 2005). Regarding the other variables, their maximums and minimums follow, basically, the same pattern found in the yield spreads.

#### 4.1. Measurement of yield spread and the Kalman Filter

It is important, at this point, to make an explanation about the procedure used to calculate the yield spread of all the series used in the article. In order to measure the effect of public debt management on the term structure of interest rates it is essential to decompose the yield curve in two components: level and spread. The latter can be defined as a proxy for the risk premium required by those investing in public securities. The spread  $\varphi_t$  between short-term and long-term interest rates can be decomposed in two equations (measurement and transition)<sup>6</sup>:

$$\text{Measurement equation : } i_{SwapPre,t} = i_t + \varphi_t + \xi_t \quad (11)$$

$$\text{State equation : } \varphi_t = \varphi_{t-1} + \varepsilon_t \quad (12)$$

<sup>5</sup> The monthly series was obtained via [Boot et al. \(1967\)](#) methodology. The authors make use of an *ad-hoc* mathematical procedure in order to construct synthetic quarterly data based on past annual data. The construction of the series is based on a least-square methodology, with the following steps: (i) based on the annual data, a forecast is made for the current year; (ii) An OLS technique is applied in order to derive a smooth continuous quarterly data from the annual data.  $X_t$  is the quarterly estimate for quarter 't';  $A_y$  is the annual estimate for year 'y';  $\beta$  is the last year for which there is available data. Thus:  $\min(x_1 \dots x_{4y}) \sum_{t=2}^{4y} [X_t - X_{t-1}]^2$ ,  $t \in \{1, \dots, (4\beta + 1)\}$ ,  $t \in \{1, \dots, (\beta + 1)\}$ , under the restriction that:  $\sum_{t=4y-3}^{4y} X_t = A$ . It means that the sum of the quarterly series is equal to the observed annual data ([Bloem et al., 2003](#)).

<sup>6</sup> The reader may refer to [Commandeur and Koopman \(2007\)](#) and [Asemota \(2010\)](#) for more details related to the procedure.

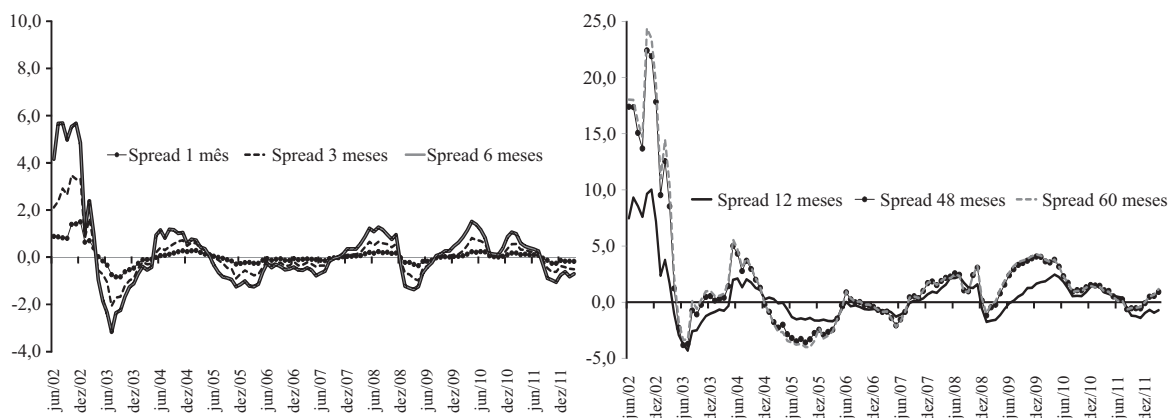


Fig. 4. Spreads over the treasury yield curve.

Source: Bloomberg.

where  $i_{Swap-Pre,t}$  is the Pre-DI Swap fixed rate, maturing on 1, 3, 6, 12, 48 and 60 months' time;  $i_t$  is the Selic interest rate;  $\varphi_t$  measures how the spread varies over time (the assumption is that it is a random walk process);  $\xi_t$  is the error term, with zero mean and constant variance, which captures the effects of disturbances on the slope of the curve;  $\varepsilon_t$  captures the effects of shocks on the yield spread, such as a change in investors profile or their aversion to risks related to inflation or interest rate.

Fig. 4 reports the behavior of the yield spread premiums over the treasury yield curve. One can notice that, as expected, the volatility risk premium is always higher on the long end of the yield curve. This shows that, in the long run, investors become more risk averse when there is expectation of a rise in inflation and interest rates, when compared to the short-run perceptions of aggregate economic conditions. As the short-term investor feels more protected by investing in short-maturity securities, the yield spread premium required to justify the risk of investing in such securities is less volatile. In this sense, it is worth mentioning the high yield spread volatility, observed in 2002 and 2003, related to the Pre-DI swap with longer maturities. This was in response to the perceived weakness of the Brazilian economy at that time. Another period of volatility, much less severe than what happened in 2002–2004, was observed in 2009, due to the global the financial crisis.

Fig. 4 also shows important information related to the relationship between debt management and the behavior of yield spread. In fact, after 2005, investors seemed to be more confident with the way the Brazilian government dealt with its public debt. At the same time, the reduction of floating rate linked bonds, especially after 2010, resulted in lower spread volatility, when compared to the previous period. This meant less variance of the term structure of interest rates and more public debt stability, due to the increase in the issuance of fixed rate linked bonds.

Moreover, the coordination between monetary and fiscal policies, with targets for both inflation and primary surplus, meant that even inflation indexed bonds were not able to bring volatility to the long-term yield spread after 2010.

## 5. Unit root tests

The next step requires the estimation of ADF and KPSS<sup>7</sup> unit root tests for all series. The results are reported in Table 2 and show that all variables are stationary, with some exceptions, such as the GDP gap and IPCA inflation rate. In relation to the latter, for instance, there is a sharp rise in inflation between 2002 and 2003, which could have influenced the outcome of its unit root test. Thus, in order to verify the influence of structural breaks we will make use of Clemente et al. (1998) procedure.<sup>8</sup>

Clemente et al. (1998), as argued in Baum (2005), propose a unit root test that extends Perron and Vogelsang's (1992) statistics and account for the possibility of two structural breaks within two types of events: either additive (AO)

<sup>7</sup> See Dickey & Fuller (1979) and Kwiatkowski et al. (1992) for more details.

<sup>8</sup> See Gomes da Silva and Vieira (2013) for more details related to the test.

Table 2  
Unit root tests.

	ADF			KPSS		
	Test stats	Reject H <sub>0</sub>		Test stats	Reject H <sub>0</sub>	
		Unit root			No unit root	
		5%	10%		5%	10%
GDP gap	−2.79	No	Yes	0.19	No	No
Monthly IPCA inflation	−3.57	Yes	Yes	0.44	Yes	No
Yield spread (1 month)	−4.26	Yes	Yes	0.14	No	No
Yield spread (3 months)	−6.04	Yes	Yes	0.14	No	No
Yield spread (6 months)	−4.98	Yes	Yes	0.15	No	No
Yield spread (12 months)	−4.26	Yes	Yes	0.16	No	No
Yield spread (48 months)	−3.73	Yes	Yes	0.27	No	No
Yield spread (60 months)	−3.56	Yes	Yes	0.29	No	No
Floating rate linked bonds (%)	−8.62	Yes	Yes	0.31	No	No
Fixed rate linked bonds (%)	−4.78	Yes	Yes	0.13	No	No

ADF critical values: −2.88 (5%); −2.58 (10%); KPSS critical values: 0.46 (5%); 0.34 (10%).

Note: Estimations with constant only.

or innovational (IO) outliers. The first one deals with a sudden change in the series, whereas the second one deals with a gradual shift in the mean of the series.<sup>9</sup>

The null hypothesis tested by Clemente et al. (1998) is given by:

$$H_0 : y_t = y_{t-1} + \delta_1 DTB_{1t} + \delta_2 DTB_{2t} + u_t \quad (13)$$

The alternative hypothesis is:

$$H_A : y_t = \mu + d_1 DU_{1t} + d_2 DU_{2t} + e_t \quad (14)$$

We can see that  $DTB_{it}$  is a pulse variable assuming the value 1 if  $t = TB_i + 1$  and 0 otherwise. Also,  $DU_{it} = 1$  if  $t > TB_i$  for  $i = 1, 2$  and 0 otherwise.  $TB_1$  and  $TB_2$  are the time periods when the mean is modified. The authors suppose for simplicity that  $TB_i = \lambda_i T$  for  $i = 1, 2$  with  $0 < \lambda_i < 1$  and  $\lambda_2 > \lambda_1$ .

The unit root hypothesis can be tested by estimating the following model for the case in which the two breaks belong to the innovational outlier (IO):

$$y_t = \mu + \rho y_{t-1} + \delta_1 DTB_{1t} + \delta_2 DTB_{2t} + d_1 DU_{1t} + d_2 DU_{2t} + \sum_{i=1}^k c_i \Delta y_{t-i} + e_t \quad (15)$$

The next step is to obtain the minimum value of the pseudo  $t$ -ratio for testing whether the autoregressive parameter ( $\rho$ ) is 1 for all the break time combinations. The derivation of the asymptotic distribution of this statistic, Clemente et al. (1998) assume that  $0 < \lambda_0 < \lambda_1$  and  $\lambda_2 < 1 - \lambda_0 < 1$ , implying that the test is not defined at the sample limits and it is necessary to choose some trimming value ( $\lambda_0$ ), and also  $\lambda_1$  and  $\lambda_2$  takes the values in the interval  $[(k+2)T, (T-1)/T]$ . The authors impose one additional restriction,  $\lambda_2 > \lambda_1 + 1$ , in order to eliminate cases of consecutive time breaks.<sup>10</sup>

The unit root null hypothesis to test for two structural breaks, when the shifts are better represented as additive outliers (AO), is developed by a two-step procedure. The first one is to remove the deterministic part of the variable and estimate the following model:

$$y_t = d_1 DU_{1t} + d_2 DU_{2t} + \tilde{y}_t \quad (16)$$

<sup>9</sup> See Perron (1989), Banerjee et al. (1992), Christiano (1992), Zivot and Andrews (1992), Perron (1997) or Vogelsang and Perron (1998) as part of the literature on structural break tests for breaking trend variables and Perron (1990) and Perron and Vogelsang (1992) when only a shift in the mean is present. See also Lee and Strazicich (2003) for an endogenous two-break LM unit root test.

<sup>10</sup> See Eq. (4) in Clemente et al. (1998) for further details on the expression for the distribution of the innovational outlier (IO) statistics ( $\min t_p^{IO}(\lambda_1, \lambda_2)$ ).

Table 3  
Unit root tests (two structural breaks).

	AR(k)	Test stats	1st break $D_{1t}$ (coefficient)	2nd break $D_{2t}$ (coefficient)
GDP gap	7	-0.214 <sup>a</sup>	Sep 2004 (-0.014) <sup>a</sup>	Oct 2010 (0.0089) <sup>a</sup>
Monthly IPCA inflation	6	-0.56 <sup>a</sup>	Mar 2003 (-0.87) <sup>a</sup>	Feb 2005 (-0.12) <sup>a</sup>
Pre-DI swap spread (1 month)	8	-0.23 <sup>a</sup>	Dec 2002 (-1.30) <sup>a</sup>	Apr 2004 (0.19) <sup>a</sup>
Pre-DI swap spread (3 months)	11	-0.25 <sup>a</sup>	Dec 2002 (-3.53) <sup>a</sup>	Jan 2004 (0.64) <sup>a</sup>
Pre-DI swap spread (6 months)	7	-0.11 <sup>a</sup>	Dec 2002 (-6.17) <sup>a</sup>	Mar 2004 (0.97) <sup>a</sup>
Pre-DI swap spread (12 months)	7	-0.10 <sup>a</sup>	Dec 2002 (-9.59) <sup>a</sup>	Mar 2004 (1.20) <sup>a</sup>
Pre-DI swap spread (48 months)	9	-0.20 <sup>a</sup>	Dec 2002 (-18.02) <sup>a</sup>	Oct 2007 (1.62) <sup>a</sup>
Pre-DI swap spread (60 months)	9	-0.18 <sup>a</sup>	Dec 2002 (-19.06) <sup>a</sup>	Oct 2007 (1.54) <sup>a</sup>
Floating rate linked bonds (%)	0	-0.88 <sup>a</sup>	Nov 2005 (-2.51) <sup>a</sup>	Sep 2006 (1.50) <sup>a</sup>
Fixed rate linked bonds (%)	4	-1.01 <sup>a</sup>	Feb 2003 (8.03) <sup>a</sup>	Apr 2007 (-2.71) <sup>a</sup>

Source: National Bureau of Statistics (IBGE), Bloomberg, Central Bank of Brazil.

Note:

<sup>a</sup> Rejection of  $H_0$  at 5%. “clemao2” command used (*Addictive Outlier*) – Stata 11.

The second step is to test the hypothesis of  $\rho = 1$  and search for the minimal  $t$ -ratio in the following model:

$$\tilde{y}_t = \sum_{i=1}^k \omega_{1i} DTB_{1t-i} + \sum_{i=1}^k \omega_{2i} DTB_{2t-i} + \rho \tilde{y}_{t-1} + \sum_{i=1}^k c_i \Delta \tilde{y}_{t-i} + e_t \quad (17)$$

where  $\tilde{y}_t$  are the residuals obtained from equation (15),  $DTB_{it}$  are dummy variables included in equation (16) to assure that  $\min t_{\hat{\rho}}^{AO}(\lambda_1, \lambda_2)$  converges to the distribution described in Eq. (4) of Clemente et al. (1998).<sup>11</sup> The idea is to run a regression of the residuals on their lagged values, a number of lagged differences, and a set of dummy variables needed to make the distribution of the test statistic tractable.<sup>12</sup>

Table 3 summarizes the results and shows that there is rejection of the null, i.e., all series are stationary. The two breaks estimated are located at the end of 2002 (first break) and beginning of 2004 (second break). As for the Brazilian GDP, the second break is in 2010, which coincides with the international financial crisis, which began in 2008. In the case of inflation, the first break coincides with the inflationary impact of the confidence crisis, between 2002 and 2003.

## 6. Determinants of yield spreads: model and results

Now, we can focus on the main purpose of this article, which is to analyze the effects of public debt on yield spread premiums required by investors, when purchasing (fixed and/or floating rate) bonds with different maturities, as a means of understanding how agents behave when debt composition changes. Given this scenario, we can think of possible effects of debt management on the country's economic activity.

The measurement equation can be defined as follows:

$$Spread_{i,t} = \beta_t GDP_{t-k} + \alpha_t IPCA_{t-k} + \delta_t FixedRate_{t-k} + \rho_t FloatRate_{t-s} + \varepsilon_{i,t} \quad (18)$$

where  $Spread_{i,t}$  represents the yield spreads related to 1, 3, 6, 12, 48 and 60 months. It means that for each yield spread, there will be an estimation with 2 lags<sup>13</sup> taking also into consideration the output gap, inflation (IPCA), and the interest rate on fixed and floating rate bonds.

The state equation can be defined as:

$$\beta_{i,t} = \beta_{i,t-1} + \varepsilon_t^{\beta_i}, \quad \sigma_{\beta_i} \equiv st.dev(\sigma_{\beta_i}) \quad (19)$$

where ‘ $i$ ’ represents the time-varying parameter to be estimated, which follow a random walk process.

<sup>11</sup> See Tables 1 and 2 of Clemente et al. (1998) finite sample critical values and the asymptotic distribution of the IO and AO statistics for 10,000 replications.

<sup>12</sup> The value of the minimal  $t$ -ratio is compared with critical values provided by Perron and Vogelsang (1992), as they do not follow the standard Dickey–Fuller distribution.

<sup>13</sup> Choosing two lags was necessary in order to solve the problem of autocorrelation found in the models estimated with only one lag.

Table 4  
Estimation results (final state estimates).

	Spread 1 month	Spread 3 2 months	Spread 6 3 months	Spread 12 12 months	Spread 48 48 months	Spread 60 60 months
GDP Gap <sub>t</sub>	0.00127 (0.94)	0.00275 (0.95)	0.03302 (0.63)	0.06494 (0.54)	-0.04861 (0.82)	-0.03418 (0.88)
GDP Gap <sub>t-1</sub>	0.00801 (0.66)	0.04383 (0.38)	0.09274 (0.22)	0.10841 (0.33)	0.05794 (0.80)	0.01151 (0.96)
GDP Gap <sub>t-2</sub>	0.05889 (0.00)	0.14719 (0.00)	0.20796 (0.01)	0.30568 (0.00)	0.46122 (0.04)	0.4867 (0.05)
IPCA <sub>t</sub>	0.06289 (0.11)	0.15176 (0.14)	0.42373 (0.01)	1.08817 (0.00)	1.99914 (0.00)	1.98233 (0.00)
IPCA <sub>t-1</sub>	0.21821 (0.00)	0.55486 (0.00)	0.72454 (0.00)	0.89065 (0.00)	2.25594 (0.00)	2.33705 (0.00)
IPCA <sub>t-2</sub>	-0.00888 (0.84)	-0.15918 (0.18)	-0.17133 (0.36)	-0.21239 (0.45)	-0.23244 (0.69)	-0.09529 (0.88)
FixedRate <sub>t</sub>	-0.00305 (0.37)	-0.00285 (0.74)	-0.0002 (0.98)	0.01371 (0.51)	0.06801 (0.12)	0.07018 (0.13)
FixedRate <sub>t-1</sub>	0.00585 (0.10)	0.02768 (0.01)	0.05605 (0.00)	0.09396 (0.00)	0.18797 (0.00)	0.20596 (0.00)
FixedRate <sub>t-2</sub>	-0.00008 (0.97)	0.00465 (0.56)	0.02038 (0.10)	0.02118 (0.26)	0.0031 (0.93)	-0.00172 (0.96)
FloatRate <sub>t</sub>	-0.01085 (0.04)	-0.01866 (0.17)	-0.02589 (0.23)	-0.07594 (0.02)	-0.2234 (0.00)	-0.23459 (0.00)
FloatRate <sub>t-1</sub>	-0.01031 (0.06)	-0.02012 (0.15)	-0.03406 (0.13)	-0.08353 (0.01)	-0.19986 (0.01)	-0.21483 (0.01)
FloatRate <sub>t-2</sub>	-0.01124 (0.02)	-0.01037 (0.41)	-0.0097 (0.62)	-0.04677 (0.12)	-0.17363 (0.01)	-0.18289 (0.07)
R <sup>2</sup>	0.899	0.893	0.903	0.907	0.898	0.898

Note: *p*-value in parenthesis. Number of observations = 118.

Table 4 reports the estimation results. First of all, we notice that both short-term and long-term yield spreads have a statistically significant relationship (in the second lag) with the Brazilian economic activity (measured by the output gap) and they increase as maturity increases. The same applies to the IPCA inflation, which is statistically significant with one lag. It means that changes in yield spreads can be explained by expected changes in economic activity, and the higher the gap between actual and potential products, the greater the demand for protection. The same reasoning applies to inflation: the more agents are inclined to believe that prices will go up, the higher the yield spread required.

Nevertheless, our main aim is to examine how agents respond to changes in the profile of government securities along the yield curve, i.e., the behavior of agents to changes in public debt. When we look at the fixed rate bonds, we notice that there is no statistical significance at lag 0 (FixedRate<sub>t</sub>) and lag 2 (FixedRate<sub>t-2</sub>). On the other hand, at the first lag the results show that an increase in issuance of fixed rate bonds may also increase the yield spread, and the longer the maturity the greater the effect. The coefficient ranges from 0.00585 for the one-month spread up to 0.20596 for the 60-month spread. As for floating rate securities, the effects are more significant for the yield spread at the first lag (FloatRate<sub>t-1</sub>), in which the coefficient ranges from -0.01031 to -0.21483. The negative sign is an indication that the effect is opposite to what happened with the fixed rate bonds, i.e., an increase in the issuance of floating rate bonds leads to a reduction of yield spread.

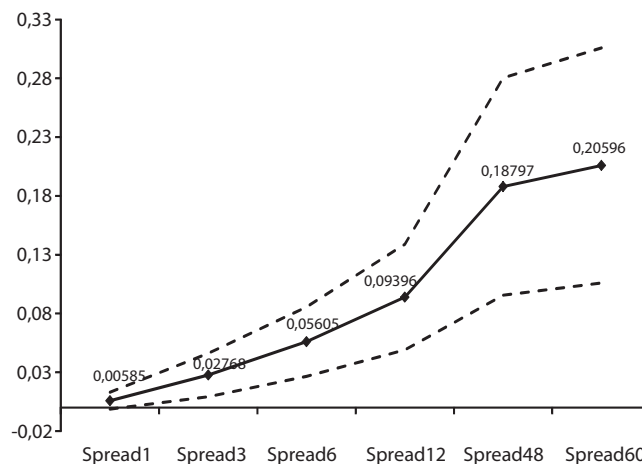


Fig. 5. Effects of securities issuance (fixed rate linked bonds) on yield spread premiums (final state - 1 lag).

Source: Results reported in Table 4.

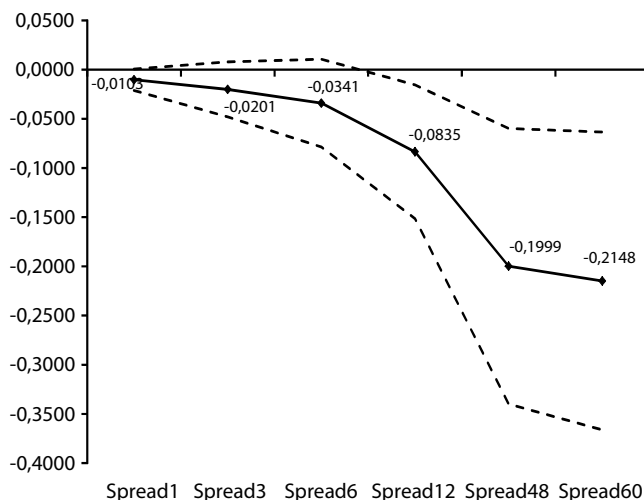


Fig. 6. Effects of securities issuance (floating rate linked bonds) on yield spread premiums (final state – 1 lag).

Source: Results reported in Table 4.

Figs. 5 and 6 summarize the main results reported on Table 4. In general, both in the case of floating rate and fixed rate linked bonds, yield spreads premiums vary the most for longer maturities. However, the most important difference relates to the sign of the yield spread required by investors: in the case of fixed rate bonds, the spread rises as maturity increases. As for the case of floating rate bonds the opposite occurs. This means that, for the former, the longer the maturity the greater the protection required against risks. As a result, the yield curve is ascending, as commonly observed in developed countries. On the other hand, floating rate bonds have a negative yield spread premium over time, as bondholders are immediately risk protected. These types of bonds have interest rates that are periodically reset and, therefore, a bondholder need not require a higher premium because, ultimately, it will come.

Hence, changes in debt structure characteristics are not neutral and, as a result, affect the country's yield curve and influence economic activity. Changes in the composition of public debt reflect in the way investors demand government bonds. This is so because agents change their portfolio over time in response to the opportunity costs that such new structure, with different maturities and indices bring to strategic financial asset allocation. The role of sovereign debt management and its transmission mechanism depend on the behavior of the yield curve and on how investors' demands are in relation to yield spread premiums.

For instance, spreads related to fixed rate bonds are higher on the long end of the yield curve, reflecting how agents determine the present value of each future value of those bonds. In order for the long-term interest rates not to exceed the opportunity cost related to productive investment, current measures are necessary to ensure inflationary and fiscal stabilities in the future and, therefore, provide reduction of premiums on the long end of the yield curve. With such a decrease, private funding, through debt issuance, becomes less burdened, making room for private investment to step-in and grow. This draws attention to the importance of implementing credible economic policies. In this sense, the recent public debt measures and management strategy are helpful because: (i) issuing fixed rate linked bonds allows for the construction of an ascending yield curve, improving the monetary policy transmission through the wealth effect; (ii) fixed rate linked bonds make fiscal policy more predictable, as debt service expenditures become less volatile, bringing more fiscal stability. Thus, the results expressed in Fig. 5 help us to understand Brazil's current debt management strategy, which is aimed at improving the efficiency of monetary policy and also aimed at making government spending more predictable. In both cases, there are important gains in terms of economic policy credibility and in terms of making the long end of the yield curve flatter.

As for the floating rate linked bonds, they require lower spread premiums along the term structure of interest rates, in line with the arguments found in Arida (2006) and Lara Resende (2006). These authors argue that floating rate debt securities protect the holder and have a short-term maturity structure once their return adjusts periodically according to the movement in the interest rates to which they are tied. Although the required yield spread premiums show that floating rate bonds reduce systemic risk, they tend to compromise capital market and productive investment. There are

two reasons for this. Firstly, private funding becomes more costly, in terms of intangible opportunity costs as well as operational borrowing costs. Secondly, floating rate bonds also replicate their short-term horizon to the economy as a whole.

Finally, it is worth mentioning that the recent management of the Brazilian public debt, with a greater share of fixed rate bonds and the attraction of a larger number of investors, can have a positive effect on economic activity. Surely, the progress made in Brazil's debt profile is highly beneficial to the dynamics of economic activity in the country.

## 7. Conclusion

The purpose of this article was to investigate the impact of the issuance of fixed rate and floating rate linked bonds on yield spread premiums required by investors, when purchasing bonds with different maturities. The goal was to have a better understanding of how debt management affects economic growth. The results showed that agents respond to changes in the composition of debt, meaning that its management can have real effects on the economy. The estimations made clear that the required returns increase over time for fixed rate linked bonds, but reduce for floating rate bonds, as there is no wealth effect.

There is no doubt that increasing the issuance of fixed rate linked bonds, along with robust and credible economic policies, is the best strategy for a sound relationship between debt management and economic activity. The worst-case scenario would be high levels of debt related to fixed rate linked bonds in combination with instability of macroeconomic variables, which could result in high interest rate variability and have an adverse effect on economic activity. That was the case in Brazil in 1999 and 2003, when economic growth reached 0.3% and 0.5%, respectively. In fact, since mid-2000 the Brazilian public debt management has gone through important improvements, from a debt profile likely to be deleterious for economic growth and development, to a more favorable one. Nonetheless, an optimal path of government debt has yet to be reached.

Last but not least, our analysis can help understand how the stance of monetary policy can influence the debt management process. On the one hand, the effect of lowering interest rates, which has been the case in Brazil until the beginning of 2013, can be compensated, in an intertemporal strategy of monetary tightening, by the issuance of fixed rate linked bonds with longer maturities. This would certainly promote more efficiency in the conduct of monetary policy, with the improvement of the debt's maturity profile by lengthening the average maturity of the country's public debt.

This opens up alternative investment options between fixed rate and floating rate securities, with different spreads and maturities that, in a way, would enhance the transmission mechanism of monetary policy in Brazil, via volatility and portfolio effects. Besides that, such strategy would also help the coordination between monetary and fiscal policy, as the latter would become more predictable and less subject to sudden fluctuations.

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