The Influence of Public Bonds Indexed to Selic Rate in the Banking Spreads in Brazil After the Real Plan

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Abstract: Despite the sharp decrease observed after the implementation of the Real Plan, banking spreads in Brazil remained persistently large compared to those observed in countries at similar stages of development, including countries with incipient credit markets. This paper related the behaviour of the Brazilian public debt, which has been historically linked to an environment of macroeconomic instability, to large banking spreads in Brazil. The persistence of spreads in Brazil—the focus of this empirical study—is affected by a range of macroeconomic and microeconomic factors. Utilising a two-stage least squares (2SLS) model, the paper provides empirical evidence that both the SELIC rate and the issue of Treasury Financial Bills (LFTs) contribute to the large banking spreads observed in Brazil, and confirms the findings of previous research on this subject.

Keywords: Banking spreads; public debt; Brazilian economy

JEL Classification: G21, G28, H63

1. Introduction

After the implementation of the Real Plan (*Plano Real*) in 1994, Brazilian financial institutions were forced to reinvent themselves and discover new ways to obtain revenues. Inflationary revenues had provided an important share of total bank revenue. However, as inflation rates decreased, these earnings contracted and disappeared by 1996. Gains were achieved by maintaining bank liability in non-remunerated current accounts balances (sight deposits) while banks applied these balances to public bonds that yielded an equivalent value through monetary restatement. This income represented approximately 38.5% of bank revenues during the final period of high inflation in Brazil (Paula, 2011). With the end of inflationary revenues, banks were forced to obtain revenues from other sources to offset this loss, especially by increasing the revenues derived from bank credit portfolios, which were previously under emphasised by banks.

In the context of a changing banking landscape, Brazilian banking spreads were of great interest in analyses of banking sector performance during the post-inflationary

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period as lending became the main source of bank revenues. For this reason, since 1999, the Brazilian Central Bank (*Banco Central do Brasil*, henceforth, BCB) has conducted systematic studies of financial institutions to assess Brazilian bank performance and loan costs. Previous academic studies on this subject include Aronovich (1994) and Afainasieff *et al* (2002).

Banking spreads[1] can be analysed at the microeconomic and macroeconomic levels. At the microeconomic level, the spread can be determined along with other components of revenues and expenditures of a bank. After subtracting operating expenses, taxes, costs of default and compulsory requirement, the liquid residue or net interest margin (NIM) is obtained. Common macroeconomic variables, such as Gross Domestic Product (GDP), interest rates, inflation, etc., are discussed in the literature as the macroeconomic determinants of spread, which play unique roles in the behaviour of the same banking structure.

In the recent Brazilian experience, maintaining a relatively high basic interest rate, or SELIC rate,[2] stimulated banks to channel their resources towards public bonds indexed to that rate, or Treasury Financial Bills (*Letras Financeiras do Tesouro,* henceforth, LFTs). As a result, financial institutions obtained an important revenue source characterised by low risk and high returns to include in their portfolios. These LFTs competed with other sources of bank revenues, such as financial intermediation activities. The opportunity cost of new bank loans increased because there was no other revenue source of equivalent risk; therefore, banks charged higher risk premiums when providing new loans (Paula and Alves Jr., 2003). This phenomenon may have altered the composition of bank revenue and affected banking spreads in Brazil.

This paper analyses the determinants of banking spreads in Brazil and emphasises the contribution of SELIC indexed public bonds to the maintenance of large banking spreads in Brazil, which are among the largest in the world. Following this introduction, the remainder of this paper is divided into five sections. Section 2 provides a historical review of Brazilian public debt since the period of high inflation, which necessitated the creation of bonds indexed to the interest rate. Section 3 provides an overview of the spread after the implementation of the Real Plan between 1995 and 2011.Section 4 briefly surveys the literature on banking spreads, especially studies that

[1] In this paper, the banking spread is synonymous with the net interest margin.

[2] The *Sistema Especial de Liquidação e Custodia* (SELIC) (Special Clearance and Escrow System) is the Brazilian Central Bank's system for open market operations in monetary policy. The SELIC rate is the Central Bank's overnight rate.

utilise two-stage least squares (2SLS) models. Section 5 details the methodology and database used to assess the effect of indexed public bonds on Brazilian spread variation and evaluates the results. Finally, section 6 concludes.

2. Public bonds in Brazil: brief recent evolution

Since the establishment of the Readjustable National Treasury Bonds (*Obrigações Reajustáveis do Tesouro Nacional*– ORTN) in 1964, the Brazilian government began issue bonds to finance its debt. The basic function of a public debt program has been to allow state borrowing to fund public administration expenses or investment. Public bonds also allowed the BCB to adjust liquidity through open market operations.

Structural changes in the Brazilian economy, especially after the implementation of the Real Plan in 1994[3], substantially altered the use of various economic policy tools. To attract foreign capital and finance the current account deficit, the Brazilian government used interest differentials between the SELIC interest rate and offshore interest rates to encourage both portfolio investments and foreign direct investment (FDI) as part of the economic model adopted over the past two decades. Indeed, during the Real Plan period, the interest rate differential was crucial to attracting foreign capital in a context of fixed exchange rates. However, after the adoption of the inflation targeting regime in 1999[4], external capital inflows contributed to domestic currency appreciation, which was critical to the success of the BCB's anti-inflationary policies (Arestis *et al*, 2011).

However, the basic interest rate is also used as to index public bonds issued by the federal government to rollover and insure new debts. The LFTs are bonds indexed to the SELIC rate, which produce an ambiguous effect on the economy. On the one hand, more foreign capital enters to purchase LFTs, allowing increased public indebtedness when the SELIC rate rises. On the other hand, there is a growing cost of debt tied to LFTs when interest rates increase, which the country must bear. Moreover, indexing

[3]The Real Plan was similar to the stabilisation programs with exchange rate anchors that have been applied in Latin America since the late 1980s, which employ fixed or semi-fixed exchange rates in combination with more open trade policy. For a general analysis of the origins and development of the Real Plan, see Ferrari-Filho and Paula (2003).

[4] According to Fritz and Prates (2014), the Brazilian government responded to the 1999 currency crisis with the adoption of a new set of economic policies based on an inflation target system and a dirty floating exchange rate.

public securities to the interest rate, adjusted daily, causes the non-existence of the market risk because the coupon is a daily (Barbosa, 2006).

The link between the public bond market and central bank reserves is important because of the need to use reserves to sterilise operations with SELIC indexed bonds. If there is excess demand for public bonds, the BCB must ensure liquidity for constant means of payment held by the public and balance the monetary base. However, if there is an excess supply of public bonds indexed to the SELIC rate or if the holders of these securities choose to sell them, the BCB will have to buy these bonds and reduce monetary base.

Public bonds that were indexed to the prime rate were created during the period of high inflation experienced by Brazil during the 1980s. Before the creation of LFTs, Central Bank Bills (*Letras do Banco Central* - LBC) existed. These are described by Pedras (2009, 7; translation of the authors) as follows:

> *Given the difficulty of placing LTN, the impossibility of placing OTNs in the market,* due to the de-indexation of the economy after the extinction of the monetary restatement*, the Central Bank decided to create a bond for which it wasresponsible. Thus, in May 1986, the lack of instrument options led the National Monetary Council to authorize the monetary authority to issue its own bonds for monetary policy purposes. It then created the LBC (Central Bank Bills), which had the odd characteristic of being remunerated by the Selic rate with daily indexing.*

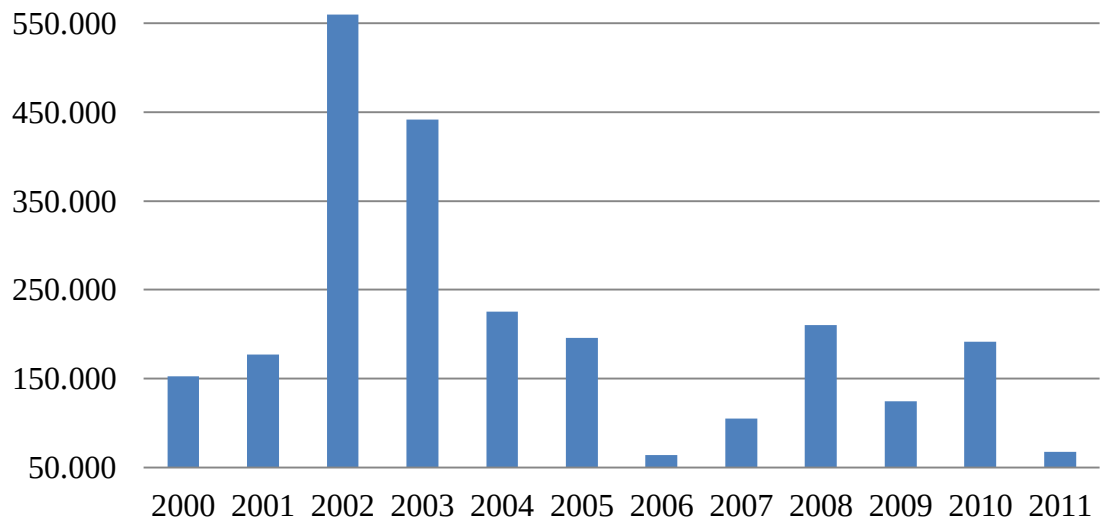
LFTs were created after the LBCs, which varied only inthat the National Treasury issued them rather than the BCB. Therefore, the creation of floating-rate securities met the needs of the Brazilian economy due to the high market risk of fixed rate bonds in the context of high inflation, but produced harmful effects on pubic indebtedness. After the implementation of the Real Plan, inflation slowed to levels at which maintaining a significant portion of debt indexed to the interest rate periodically adjusted by COPOM, the Monetary Policy Committee, was no longer required. These bonds now generate significant negative effects on the Brazilian economy because they inhibit the formation of a yield curve appropriate to long-term corporate bonds, which worsens the transmission of monetary policy and generates a reverse wealth effect because some financial wealth is pegged to the SELIC rate.

2.1 Recent issuance of Treasury Financial Bills (LFTs)

The issuance of LFTs has undergone major changes in volume as a part of public debt. National Treasury data indicate that there was a strong increase in issuance

in 2002 and 2003 and significant reductions since then. In 2000, the value of LFTs issued was BRL 152.5 billion, which increased to BRL 177.0 billion the following year.

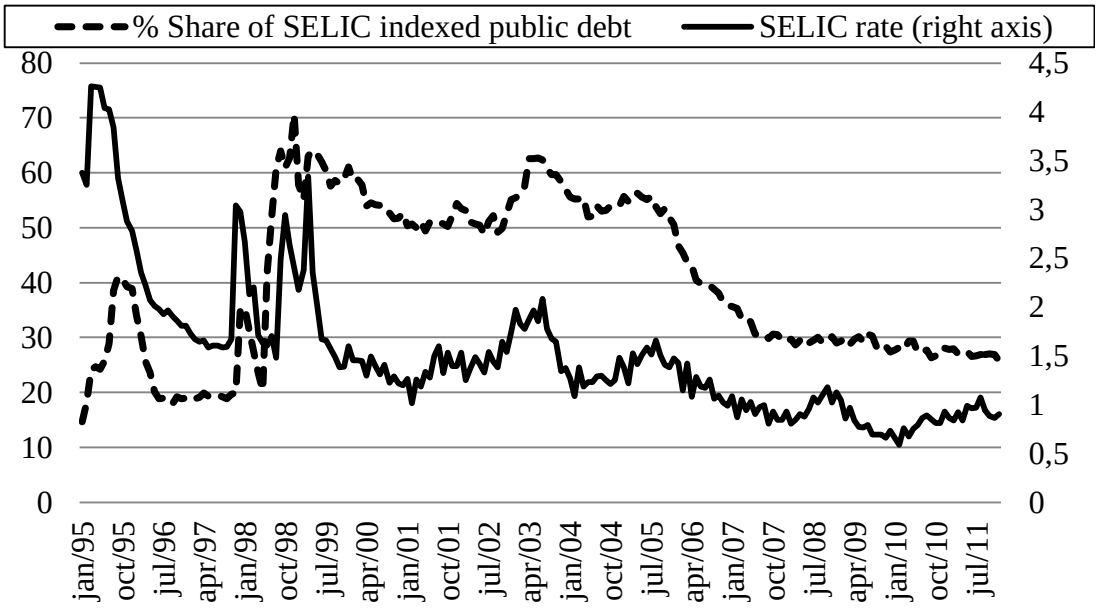
Figure 1. LFT issuances (in BRL million per year at 2000 prices)



Source: Brazilian National Treasury.

The share of securities indexed to the SELIC rate of total Brazilian public debt has varied significantly since 1995. In 1995, the beginning of the stabilisation period, the relative share of SELIC indexed bonds grew from 14.6% in January to 41.1% by August (Figure 2). The participation rate of debt indexed to the SELIC rate fell to 20.1% in May 1996 as these bonds were replaced by fixed short-term debt (with less than one year maturity). After the contagion of the Asian financial crisis in September 1997, the issuance of LFTs increased dramatically following the increase in the SELIC rate.Because Brazil needed to maintain a stable exchange rate - given the fixed currency scheme - monetary policy increased the basic interest rate spectacularly during periods of speculative attack on the Brazilian currency (Ferrari Filho and Paula, 2003). This period ended with the devaluation of the Real against the U.S. dollar in 1999. Beginning in mid-2002 until early 2003, the share of LFTs of total public debt increased from 50% to 60% following an increase in interest rates and a period of macroeconomic instability. The share of SELIC indexed bonds of total federal public debt was more than 50% from mid-1988 to early 2006 when participation began to decline gradually to less than 30% by mid-2007 following a decrease in interest rates and greater macroeconomic stability.

Figure 2.Share of SELIC indexed debt and SELIC rate (pp. per month)



Source: Central Bank of Brazil. Authors' elaboration.

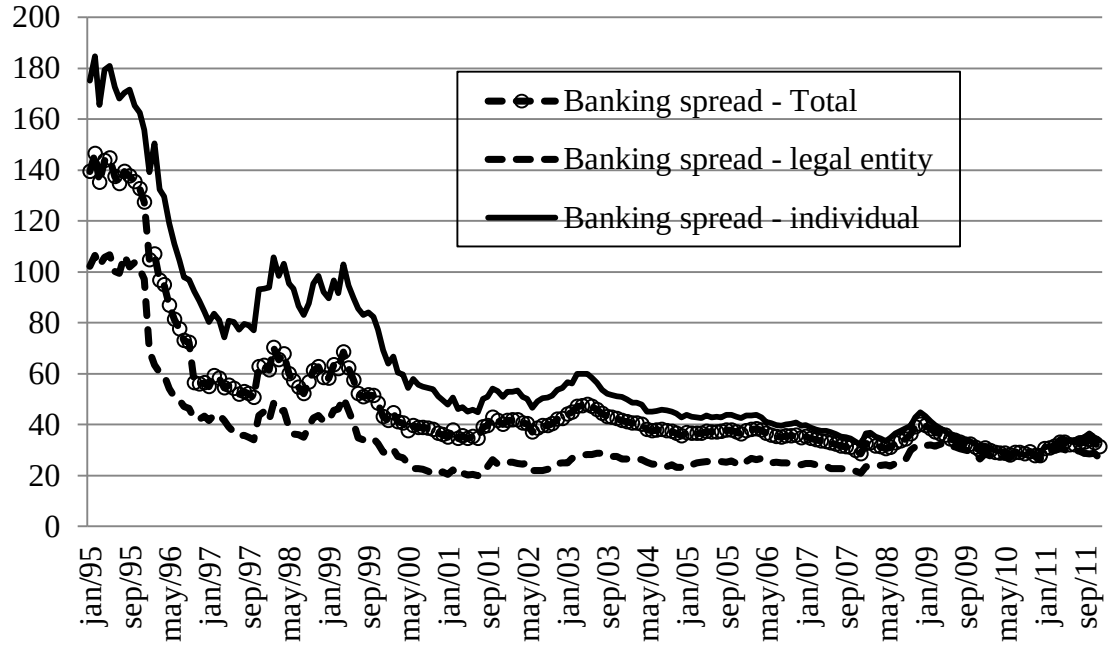
3. Evolution of banking spreads in Brazil between 1995 and 2011

After the implementation of the Real Plan, banking spreads remained at similar levels to those observed before the implementation of the price stabilisation plan. In 1995, the average (individuals and firms)[5], individual, and corporate spread rates were approximately 137%, 171%, and 103% p.a., respectively. Memories of inflationary revenues were remnants of the period of chronic high inflation. However, in 1996, there was a sharp decrease in banking spreads, which were approximately 50 pp. lower by the end of the year than those of previous years. Increases in the spread were observed from mid-1997 until early 1999 when the exchange rate transitioned to a floating regime. After this change, the banking spreads decreased but the change was of a smaller magnitude than that observed in 1996. In 2008, spreads were relatively high overall due to the international financial crisis that originated in the USA. Brazilian banking spreads subsequently fell in 2009 and remained at levels above 30 pp. per year[6]. Figure 3 displays the trajectory of the banking spreads during the period 1995-2011.

[5] We use the same definition as the BCB, which states,the "banking spread is defined as the difference between lending and deposit rates for CDBs (certificates of bank deposit). The average CDB rate for the set of financial institutions was calculated from the average of the individual rates weighted by each institution's net deposits" (Central Bank of Brazil, 2002b, 50).

[6] Reis Jr.*et al*(2013) analyze the evolution and structure of the banking spread in Brazil from 2000 to 2008 and conclude that"large retail banks" - public, private domestic and foreign - had higher spreads relative to other segments, and in particular has been the lowest spread of public banks.

Figure 3. Average banking spreads with free resources (pp. accumulated over 12 months)



Source: Central Bank of Brazil.

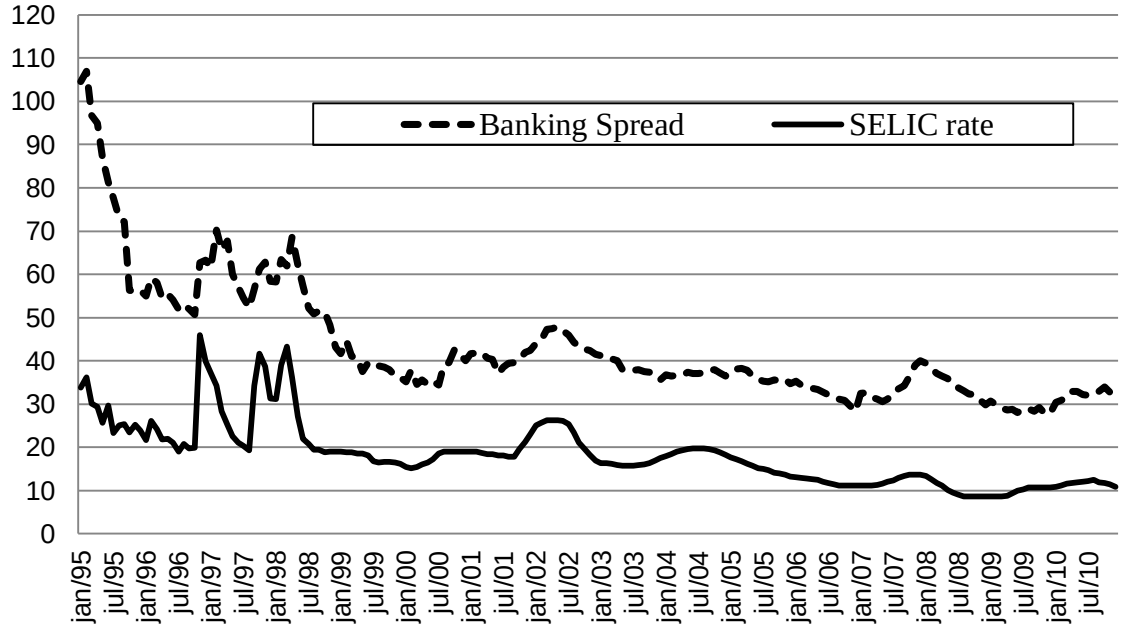
Since 2009, there has been some stability in the evolution of the banking spread. Government measures to increase credit supply rates to stimulate the economy after the 2008 crisis may explain, in part, this decrease. Since the end of 2010, the disparity between individual and corporate spreads has increased again; however, the levels are significantly lower than were those observed during the mid-1990s after the implementation of the Real Plan. This new gap indicates a closer connection to the endogenous variables of impact for financial institutions, such as varying default levels, than during the previous period when macroeconomic effects prevailed.

3.1 The relationship between the SELIC rate and Brazilian banking spreads

The macroeconomic instability observed in Brazil before the implementation of the Real Plan has been used to explain the high levels of Brazilian banking spreads. High inflation rates inhibited domestic financial institutions from granting loans because banks were obtaining revenues from other sources, such as public bonds that held overnight rates[7]. However, Brazil has undergone structural changes after the implementation of the Real Plan, including a significant reduction in inflation that contributed to reduced levels of spread during the first years post-Real (Figure 4).

[7] Financial bonds with a duration of one day.

Figure 4. Total banking spread and SELIC rate (in pp. per annum)



Source: Central Bank of Brazil.

Changes in banking spreads began to follow macroeconomic variables, such as the basic interest rate, after the price stabilisation period. According to several studies assessing the behaviour of banking spreads in Brazil (Afanaiseff *et al*, 2002; Silva *et al*, 2007; Manhiça and Jorge, 2012), the SELIC rate is the macroeconomic variable with the highest significance in explaining the level of the banking spread in Brazil. The rate reflects the operations of the Brazilian interbank market and underpins loan operations growth in the economy. Moreover, the SELIC rate increased in importance to the Brazilian economy after the implementation of the Real Plan because it effectively became an economic policy tool to attract foreign funds and, later, to regulate the demand for loans and level of inflation, the latter being a more explicit role since the implementation of the inflation targeting regime in mid-1999.

Decreases in the banking spread after the period of high inflation are accompanied by decreasesin the benchmark interest rate since mid-1997. However, by June 1999, a significant increase in the interest rate was not paralleled by the banking spread. This increase was due to contagion from the Russian crisis of 1998, and the BCB increased the SELIC rate to mitigate capital flight. After 1999, the spread and SELIC rate again exhibit similar paths.

Overall, the trajectory of the banking spread in Brazil over the first years after the implementation of the Real Plan produced consistent decreases soon after the economic changes were introduced, which happened to produce lower inflation.

However, further declines were not observed and the spread has been approximately 30% p.a. for over a decade. The persistence of spread levels in Brazil relative to those observed in other countries has not been fully explained.

4. Literature about banking spread: a brief and selected review

4.1. Empirical literature

There is an extensive international literature on banking spreads and, to a lesser extent, a literature analysing recent Brazilian banking spreads[8]. The seminal paper on banking spreads is by Ho and Saunders (1981), who analyse the net interest margin (NIM) of the top 100 U.S. banks in 13 quarters (1976 to 1979) considering the bank as a risk averse dealer (financial intermediary) in the credit market. This study does not consider the bank as an ordinary firm. As intermediaries between depositors and borrowers, banks are subject to two types of risk: risk generated by mismatches that can occur between the volume and the periods in which deposits and loans are made and risk related to the return on loans, which occurs when borrowers fail to honour their debts (delinquent loans). The authors estimated an econometric model using a two-stage least squares model, which implies that the expected utility of wealth earned by banks at end of period is the spread. The first stage of the regression model indicates that the intercept - the pure spread - is significant and positive about the explained variable and is in relation to an implicit variable, the interest payment. In the second stage regression, which includes the macroeconomic variables, significant volatility of interest rates (positive sign) is observed, i.e., greater the variation of base interest rates generate larger banking spreads.

Saunders and Schumacher (2000) analysed the determinants of bank net interest margins in six European countries and the USA from 1988 to 1995 for a sample of 615 banks. The authors decompose the NIM into three components: banking regulatory, market structure, and risk premium components. This model is based on Ho and Saunders (1981), which considers banks risk-averse conveyor agents and uses a 2SLS model. The results indicate that for the three control variables chosen (bank payments of

[8] In this brief review, we focus on studies that evaluated empirical determinants of banking spread level using the two-stage method originally developed by Ho and Saunders (1981) because several studies address the structure and decomposition of the spread..

implicit interest on deposits[9], bank opportunity costs of holding reserves at the central bank, and bank capital held to insulate themselves against credit risk), the implicit interest rate had the strongest impact. That is, to finance implicit interest payments, banks must increase the explicit NIM. The opportunity cost of reserves exhibited the expected relationship (positive), and the bank capital asset ratios were positively associated with NIM. In summary, the results indicate an important trade-off between bank solvency and the reduction of financial costs. The pure spread, which is obtained as the intercept of the regression during the first stage, explained 62% of the total spread compared to other control variables. The second-step panel regression results suggest that margins (or pure spreads) are sensitive to both market structure and interest rate volatility.

Brock and Rojas-Suarez (2000) analyse different measures of ex-post and banking spread and their behaviourin Argentina, Bolivia, Chile, Colombia, Mexico, and Peru utilising accounting data from a sample of banks from 1991 to 1996. This paper investigates the reason for constant banking spreads in these Latin American countries, which occurred during a period of deepening reform of the financial sector characterised by the reduction of reserve requirements and direct restrictions on credit and interest rates. These authors apply the model developed by Ho and Saunders (1981) to estimate the determinants of spread for each country except Mexico. The results of the first stage indicate that some countries exhibit positive and significant relationships with the banking spread for the following variables: capital-asset ratio (Bolivia and Colombia), cost (Argentina and Bolivia), and liquidity (Bolivia, Colombia, and Peru). Moreover, the risk of default did not produce the expected positive relationship with the banking spread (except for Colombia). The authors associate this result to inadequate provisions for losses on loans and growth strategies of high-risk banks. For the macroeconomic variables in the second stage, Brock and Rojas-Suarez observe that for most countries, macroeconomic uncertainty, represented by the volatility of interest (Bolivia and Chile) and inflation (Colombia, Chile and Peru) is related to the banking spread, corroborating the results of studies of developed countries (Saunders and Schumacher, 2000).

Subsequently, Maudos and Guevara (2004) analysed the European banking sector by considering five countries (Germany, France, United Kingdom, Italy, and Spain)for the period 1993-2000, applying the Ho and Saunders'model with adjustments

[9]Such implicit interest includes service charge remissions and other types of depositor subsidies due to regulatory restrictions on explicit interest payments.

for the structure of operating costs. Unlike other studies, this paper considers the Lerner index as a measure of competition in these banking markets. The most general results contradict other studies on the subject, revealing that recent banking sector concentration in the studied countries has reduced bank margins. One factor that must be considered given the unexpectedresult is that this sample of European countries has already a consolidated banking sector with lower net margins than other European economies (new participating countries and those desiringentry into the European Union).

Fungacova and Pohosyan (2011) analyse the determinants of net interest margin in the Russian banking sector using a dataset of quarterly balance sheet of banks during the period 1999-2007. Following the Ho and Saunders' (1981) model, the sample was divided by ownership structure (foreign and domestic banks) to examine the determinants of the net interest margin - NIM. Panel data are used with fixed effects estimator and separated into different capital structure regression. The dependent variable is the NIM (interest income less interest expense divided by total assets).The independent variables are the regional Herfindahl index, personal expenses over total assets, capitalisation ratio (equity to total assets), ratio loans in arrears over total assets, bank size (logarithm of total assets), and liquidity ratio (liquid assets on demand deposits). In the basic model, all estimated coefficients, except for the IHH, were significant. The NIM is not affected by changes in market structure. Operating costs are passed on to customers through higher margins charged on services. The significant positive coefficient of capitalisation ratio indicates that banks with higher risk aversion tend to charge higher margins. The size of the transactions confirms the presence of economies of scale (larger banks tend to have lower margins). Liquidity risk is significant and negative. Finally, credit risk has a negative coefficient, which contradicts the previous findings in this literature.

4.2. Empirical studies on banking spreads in Brazil

Afanaisieff *et al* (2002) investigate banking spreads through microeconomic and macroeconomic effects using the Ho and Saunders' model and panel data from 1997 to 2000 for 147 Brazilian banks. The following variables are used in the first stage regression: number of employees of institutions, operating costs, ratio of total deposits on assets, ratio of funds paid on assets, leverage, and liquidity. No significant results

were observed for these variables in the first stage regression. In the second stage, the pure spread (the intercept of the regression) was regressed with the volatility of market interest rates, GDP, and inflation. The results were significant for all variables, except GDP growth. In conclusion, thispaper indicates the importance of the dispersion of the banking spread among banks in Brazil, which can lead to the decreased importance of macroeconomic variables in the econometric tests and smaller effects of monetary policies (changes in the interest rates) with respect to the variation in the spread.

Nakane (2003) analyses the competitiveness of the Brazilian banking sector to explain the high rates of spread in the country. In a first part of the study, the author uses the Herfindahl-Hirschman Index for the period 1994-2003 for Brazilian banks and compares the results with the same index in other countries. This first stage indicates that the Brazilian banking sector is part ofa group of countries in which there is perfect competition during some years and imperfect competition during others, which suggests that the Brazilian banking sector cannot be considered a cartel, oligopoly, or other non-competitive market structure. In the second part, the author uses a microeconomic methodology developed by Bresnahan (1982) and Lau (1982), which employs a cartel market structure and includes Initial Demand, Marginal Revenue, and Marginal Cost Linear Functions. The test indicates that Brazilian banks have some market power but does not support the existence of extreme competitive structures (perfect competition or cartel). Finally, the study suggests that competition in the sector is high. These results indicate that high spreads are not be the result of a market structure that favours Brazilian banks because the results did not suggest the existence of a cartel or collusion.

Oreiro *et al* (2006) analyse the banking spread in Brazil using a multiple regression analysis to determine which macroeconomic variables determine, directly or indirectly, the banking spread during the period 1995-2003. They include the following variables in the model: interest banking spread, SELIC interest rate, volatility of interest rate (as a proxy of the bank's interest rate risk), industrial output (as a proxy of the GDP), extensive consumer price index (IPCA), and reserve requirements on demand deposits (a regulatory variable under BCB control). The results for the variance decomposition and impulse-response function indicate that the high volatility of the short-term interest rate (SELIC), its level, and industrial output are the main macroeconomic determinants of the banking spread in Brazil.

Silva *et al* (2007) use a Vector Autoregressive (VAR) model to assess the importance of macroeconomic variables in determination of the banking spread in

Brazil. The sample period dates from 1994 to 2005 and includes the following variables in addition to the ex-ante spread: basic interest rate (SELIC), industrial output, exchange rate, and rate of inflation (consumer price index). The results corroborate the findings of Afanaisieff *et al* (2002) and indicate that the effect of inflation and interest rates on banking spread was positive and persistent over time, while the output growth had a negative effect on the banking spread.

Finally, Manhiça and Jorge (2012) distinguish among measurements of the banking spreads, considering consider both ex-ante and ex-post spread in Brazil. The study aims to analyse the impact of macroeconomic variables, especially the prime rate of the economy (SELIC rate), on the interest margin (spread) charged by Brazilian banks from 2000 to 2010. To achieve this goal, the paper adopted the behaviour model of the banking firm developed by Ho and Saunders (1981), as well as, an econometric method, the system-GMM, based on panel data from 140 commercial banks.The econometric exercise is performed in two stages: the first considers the microeconomic effects, while the second step, the macroeconomic effects. The objective was to test whether the loan spread, after corrected through idiosyncratic differences between the banks, reacted to macroeconomic risk factors. Through empirical analysis focused on macroeconomic variables it was concluded that the spread responds to the level of the benchmark interest rates. Within the macroeconomic variables, the unemployment rate and the risk measured by the EMBI were also important in determining the loan spread. The volatility of interest rates, however, showed no significant results.

5. Empirical research: methodology, database, and results

5.1. Methodology

The methodology used in this study is based on Ho and Saunders (1981) with the updates suggested by Brock and Rojas-Suarez (2000) and Maudos and Guevara (2004). As we have observed, the bank is a financial intermediary, or dealer, and risk averse. The main variables, variances of risk capital and interest, indicate the willingness of the bank to perform new operations.

The econometric model used here is consistent with the existing research, namely, a two-stage least squares (2SLS) model. This method favours the separation of different effects in two groups of variables. In this case, the microeconomic and macroeconomic variables are separated by drafting two separate equations in two stages

of calculating the banking spread. The advantages of the two-stage model include allowing the estimation of the pure spread from the explanatory variables used in the first step and analysing the relationship between the pure spread and a set of variables postulated in a second step (Maudos and Guevara, 2004).

Johnston and Dinardo (1997), in turn, stress that the estimates produced by the first stage regression can be used as instrumental variables for the regression in the second stage. Nevertheless, Greene (2003) reports that a two-stage methodology allows replicate the unexplained part of the banking spread in a first OLS regression in the second stage part of the regression.

In the first step, the variables were extracted from the balance sheets of the leading Brazilian banks provided by the BCB for the period 2001-2011. These variables are microeconomic because they describe the behaviour of the banking firm, excluding exogenous effects caused by the external economic environment in which these banks operate. The purpose of this initial step is to capture the effects of microeconomic variables on the gross spread. The gross banking spread is the dependent variable in this first step, and the regression is performed with the independent variables that affect individual banks, i.e., the microeconomic variables, which are detailed in the next section. These variables are used in the first-stage calculation for a cross-sectional dataset, using an equation for each period. The estimate obtained during this first stage is used in the second stage from the intercept and residuals generated in each regression. The intercepts represent the pure spreads because they exclude the microeconomic effects. The residuals are widely interpreted in the existing research as proxies for the volatility of bank fees.

The *pure spread* is then used as the dependent variable in the second stage and is regressed with exogenous variables, that is, macroeconomic factors. The inflation rate, SELIC rate, and volatility are some of the macroeconomic variables that might affect the macroeconomic environment that can affect the banking spread in Brazil. The hypothesis is that these variables more accurately explain the banking spread, controlling for the effects of microeconomic variables.

The model is represented as follows:

$$S = \beta_0 + \sum \beta_i X_i + e \qquad (1)$$

The first equation represents each regression generated during the first stage of calculation. The coefficient $\beta_0$and residual *e* are used in the second step, as described below:

$$\beta_0 = \delta_0 + \sum \delta_i Y_i + \varepsilon \quad (2)$$

In the next section, we describe the two groups of variables used at each stage of the empirical analysis.

5.1.1. Microeconomic variables

The *gross spread*, the dependent variable of the regression, is defined as the ratio "gross operating expenses" over "banks' total assets", while the microeconomic variables to be regressed in the first step are described as follows:

$$\text{Cost} = \frac{\text{Operating cost}}{\text{Total assets}} \quad (3)$$

$$\text{HHI} = \sum s^2, \text{ where "s" is the individual bank market share} \quad (4)$$

$$\text{Provision} = \frac{\text{Provision}}{\text{Total assets}} \quad (5)$$

$$\text{Aversion} = \frac{\text{Return on equity}}{\text{Total assets}} \quad (6)$$

These variables are inserted in the regression equation as follows:

$$Gross\ spread = \beta_0 + \beta_1\, cost + \beta_2\, HHI + \beta_3\, prov + \beta_4\, aver + e \quad (7)$$

where *Cost* represents the operating cost, *HHI* is a Herfindahl-Hirschman Index[10], *prov* represents the provision of doubtful loans[11] *aver* represents risk aversion, and *e* capture what is not explained in this first stage. These variables were constructed according to the methodology described in Maudos and Guevara (2004) to capture how the intrinsic factors of each bank affect the level of the banking spread.

The expected behaviour of these variables is detailed in Table 1.

This first stage utilises cross-sectional data to capture the effects of the aforementioned variables for a sample of Brazilian banks.

[10] The Herfindahl-Hirschman Index (HHI) is used to measure the market concentration of firms.It is calculated by squaring the market share of each firm competing in a market, and then summing the resulting numbers. The result is proportional to the average market share, weighted by market share. As such, it can range from 0 to 1.0, moving from a huge number of very small firms to a single monopolistic producer.

[11] The provision of doubtful loans is the value that banks use to cover unpaid loans.

Table 1. Expected behaviour of microeconomic variables

Variable	Expected sign	Justification
Operating cost	(+)	The higher the operating cost, the greater the spread needed to operate the banking firm.
HHI	(+)	Greatermarket concentration allows monopolistic practices that can result in higher spreads.
Provision	(+)	The morecapital available for the provision of non-performing loans, the greater the spread due to the increase of such expenses.
Aversion	(+)	The more risk averse the bank, higher the spread due to a higher risk premium embedded in lending rates.

Source: Authors' elaboration.

5.1.2 Macroeconomic Variables

In the second step, we obtain the effects of macroeconomic variables on the banking spreads. Thus, the pure banking spread is regressed with the following independent variables: SELIC, IPCA, Volatility, Bond revenues, and LFTs. in the market. The first two variables, SELIC and IPCA, are indexes released by IBGE. *Volatility* is the variance of the interest rate during the period, while *Bond revenues* and *LFTs in market* are variables that seek to explain the influence of the share of public bonds indexed to the SELIC rate (LFTs) on the banking spread. These last two variableswere created from data provided by the BCB. The expected signs and behaviour of each variable are summarised in Table 2.

Table 2. Expected behaviour of macroeconomic variables

Variable	Expected Sign	Justification
SELIC	(+)	The higher the SELIC rate, the greater the opportunity cost of bank lending (compared to SELIC indexed bonds) and the higher should bethe spread due to higher risk premiums.
IPCA	(+)	Higher inflation increases the need for bank hedge due to the loss of loan value in real terms.
Volatility of interest rate (Volatility)	(+)	Greater variance in interest rates increases the interest rates risk. The spread tends to be larger to protect financial institutions from changes in the macroeconomic scenario.
Bond revenues	(+)	Larger earnings from public bonds would inhibit lending

(Bond Rev.)		(volume) and thus increase the spread for new loans.
LFTs in the market– (LFTIM)	(-)	The greater issue of LFTs by the National Treasury is associated with lower interest rates for public debt rollover, which would be in opposition to the banking spread behaviour.

Source: Authors' elaboration.

The inclusion of variables related directly to Brazilian public debt in a model of the spread has not been realised in previous research on this subject. This innovation aims to capture the deleterious effects of public bonds pegged directly to the SELIC rate on the increasing level of the banking spread. The issue of public securities indexed to the SELIC rate (LFTs) exempt the investor from interest rate risk and decreases the efficiency of monetary policy measures (Barbosa, 2006; Oreiro *et al*, 2012). Nevertheless, it is difficult to create variables that capture the effect of Brazilian public debt on the spread due to the limited availability of accurate information about Brazilian banks revenues from public bonds indexed to the SELIC rate.

However, from the government perspective, Treasury bonds pegged to the SELIC rate should be issued in an "ideal" situation where the basic interest rate exhibits a downward bias. That is, the largest volume of LFTs should occur opposite the SELIC rate behaviour. In this sense, this variable captures the behaviour that the Treasury/government should exhibit to offer new SELIC indexed bonds; hence, the inverse relationship with respect to the demand for such bonds.

The variable *Bond revenues* captures the revenues obtained by banks in buying and selling public and private bonds, which is a *proxy* variable of bank behaviour given higher or lower purchases and sales of SELIC indexed bonds, i.e., LFTs. Conversely, the variable *LFTs in the market* seeks to capture the behaviour of the Treasury as the issuer of bonds indexed to the SELIC rate.

However, the government impetus to issue LFTs occurs during periods of greater macroeconomic instability, such as the external crises that occurred between 1997 and 2003, to meet the demand for hedging interest rate risk by private investors. With the issuance of LFTs, the payment of the risk premium is less than would be required if they were issued with fixed rate bonds under conditions of strong risk aversion by investors. Thus, the interest rate is lower than would be the case given fixed rate public securities even if the counterparty risk of the interest rate were in government hands, resulting in a high fiscal cost of debt rollover.

The second stage regression equation is described as follows:

$$Pure\ spread = \beta_0 + \beta_1 Selic + \beta_2 Ipca + \beta_3 BondsRev. + \beta_4 Volatil. + \beta_5 LFTIM + e \quad (8)$$

Where the pure spread is the dependent variable, which is calculated from the first step as explained above; *SELIC* and *Ipca* are the basic interest rate and the inflation rate, respectively; *Bond Rev.* represents the revenues obtained by banks from bonds, and *LFTIM* represents the financial value of such bonds held by private agents.

5.2. Database

The database includes quarterly data from 2001 to 2011, or 44 observations. These data were collected from the 140 largest Brazilian banks each quarter ranked by theirtotal assets. This first step with cross-sectional data includes 6,160 observations. These data were obtained from the website of the Central Bank of Brazil (BCB), according to the headings and classifications extracted from the balance sheet of each institution. The IPCA (headline price index) series was collected from the IBGE website. In the second step, we utilise time series data, including 44 observations for each variable. All econometric tests were performed utilising Gretl 1.9 software (http://gretl.sourceforge.net).

5.3. Empirical results

Table 3 displays the results of the first stage that utilises cross-sectional data to capture the effects of the microeconomic variables on the banking spreads[12]. The values in bold were significant at the at least 90% level of higher and the numbers in parentheses are the t-statistics for each estimate. Among the variables with greater significance, *Operating cost* exhibited a degree of significance above 95% and the expected positive sign. The constant generated by the first stage was also significant and positive in the sub-periods in addition to representing large share of gross spread. This result indicates the importance of other factors in explaining recent banking spreads in Brazil. *Aversion* was positive and significant in most periods analysed in this study, i.e., over 90%. *Provision* exhibited instability, but was significant and positive in most quarters. The index of bank concentration, *HHI*, was not significant in this model and did not exhibit the expected sign.

[12] Statistical tests and regression with robust errors are included in the Appendix I.

Table 3. Results of the first stage calculation

Quarter	Constant (pure spread)	Operating cost	HHI	Provision	Aversion
2001.1	0.00437524	**0.643342**	-0.638573	-0.0084459	**0.0262014**
	(1.704)	**(6.954)**	(-1.012)	(-0.3472)	**(-4.701)**
2001.2	**0.014412**	**0,817877**	-1.9678	**0.0894334**	-6.3847e-07
	(3.261)	**(9.492)**	(-1.666)	**(2.241)**	(-0.06973)
2001.3	**0.0135777**	**9.492**	-1.24972	6.37422e-05	**-0.0063989**
	(5.913)	**(7.421)**	(-1.801)	(1.711)	**(-4.198)**
2001.4	**0.0147648**	**0.529723**	-1.38732	**0.278521**	**0.0344743**
	(2.418)	**(5.179)**	-0.9386	**(2.031)**	**(2.623)**
2002.1	**0.0110456**	**0.346302**	-0.520343	0.0494592	**0.0106528**
	(5.081)	**(4.371)**	(-0.9549)	(1.041)	**(2.170)**
2002.2	**0.0110456**	**0.346302**	-0.520343	0.0494592	**0.0106528**
	(5.081)	**(4.371)**	(-0.9549)	(1.041)	**(2.170)**
2002.3	**0.0237633**	**0.388609**	-1.48105	0.0193861	**0.0403267**
	(5.330)	**(4.340)**	(-1.331)	(0.2141)	**(3.949)**
2002.4	**0.0212143**	0.113626	-1.15076	-0.0793239	**0.0541429**
	(4.160)	(0.6835)	(-0.9546)	(-0.7528)	**(4.718)**
2003.1	-0.0097334	-0.240994	-3.0494	**3.68432**	0.100121
	(-0.3819)	(-0.6707)	(-0.592)	**(5.989)**	(1.995)
2003.2	**0.0134898**	**0.221643**	-0.522007	0.104958	**0.0191595**
	(5.795)	**(3.262)**	(-1.074)	(1.877)	**(3.889)**
2003.3	**0.026062**	**0.224445**	-1.03582	**0.277134**	**0.0239823**
	(6.109)	**(3.247)**	(-1.252)	**(2.874)**	**(2.843)**
2003.4	**0.0128791**	**0.260159**	-0.465325	**0.0997125**	**0.0230711**
	(6.772)	**(4.674)**	(-1.216)	**(2.872)**	**(5.835)**
2004.1	**0.0266938**	**0.314293**	-0.74031	0.0712131	**0.031787**
	(7.212)	**(5.714)**	(-1.036)	(1.100)	**(4.035)**
2004.2	**0.0052756**	**0.152187**	-0.499551	**0.564072**	**0.0106012**
	(2.270)	**(2.142)**	(-1.009)	**(19.960)**	**(2.048)**
2004.3	**0.0165705**	**0.175384**	-0.925937	**0.551843**	**0.0371829**
	(4.024)	**(2.876)**	(-1.118)	**(13.340)**	**(3.614)**
2004.4	**0.00957509**	**0.28253**	-0.334503	**0.133511**	**0.0123402**
	(4.072)	**(3.963)**	(-0.7415)	**(2.685)**	**(2.213)**
2005.1	**0.0198656**	**0.260643**	-0.728596	**0.350363**	**0.0293993**
	(3.706)	**(3.781)**	-0.7369	**(2.860)**	**(2.380)**
2005.2	**0.00733978**	**0.419754**	-0.357834	**0.166688**	**0.0145509**
	(2.600)	**(5.808)**	(-0.6666)	**(2.750)**	**(2.103)**
2005.3	**0.014571**	**0.398413**	-0.748365	**0.461544**	0.021984
	(2.872)	**(6.123)**	-0.7535	**(3.917)**	(1.796)
2005.4	0.00478928	**0.333343**	-0.342938	**0.322866**	**0.0223973**
	(1.564)	**(4.624)**	(-0.5641)	**(5.341)**	**(3.109)**
2006.1	**0.0136344**	**0.262166**	-0.921551	**0.498467**	**0.0625319**
	(2.215)	**(3.893)**	(-0.7637)	**(4.409)**	**(4.215)**
2006.2	**0.00877048**	**0.26543**	-0.48932	**0.244701**	**0.0192179**
	(2.8473)	**(3.985)**	(-0.7835)	**(4.3002)**	**(2.5953)**

2006.3	**0.015254**	**0.336041**	-0.991922	**0.42203**	0.029754
	(2.4697)	**(4.9255)**	(-0.806)	**(3.7226)**	(1.8881)
2006.4	0.00384786	**0.507202**	-0.497546	**0.274369**	0.0169304
	(0.9524)	**(6.4358)**	(-0.6262)	**(3.5881)**	(1.6793)
2007.1	0.0104049	**0.5221**	-0.994679	**0.454052**	0.025249
	(1.5299)	**(7.4469)**	(-0.753)	**(3.213)**	(1.466)
2007.2	0.00467342	**0.392223**	-0.502619	**0.287214**	**0.0179128**
	(1.6709)	**(5.829)**	(-0.8669)	**(4.4278)**	**(2.5068)**
2007.3	**0.0188816**	0.00273983	-1.45007	**0.73435**	**0.0530213**
	(2.9988)	(0.5555)	(-1.0013)	**(4.6582)**	**(3.1071)**
2007.4	**0.00756325**	**0.40981**	-0.32844	0.0593825	**0.0199715**
	(2.8104)	**(7.8165)**	(-0.561)	(1.2342)	**(2.6933)**
2008.1	**0.0168802**	**0.369935**	-0.829484	0.135616	0.0265256
	(3.6614)	**(7.5222)**	(-0.8223)	(1.7677)	(1.9897)
2008.2	**0.0110513**	**0.199497**	-0.408017	**0.0904573**	0.0102196
	(5.3635)	**(4.0592)**	(-0.9387)	**(2.0866)**	(1.8641)
2008.3	**0.0192252**	**0.172673**	-0.58357	**0.20205**	**0.0242317**
	(5.3787)	**(3.9138)**	(-0.7801)	**(2.6654)**	**(2.4824)**
2008.4	**0.0123231**	**0.185544**	-0.71962	0.0306312	0.00969408
	(3.8892)	**(2.5161)**	(-1.1676)	(0.4635)	(1.1325)
2009.1	**0.0121645**	**0.146226**	-0.86455	**0.406373**	**0.0525686**
	(2.0615)	**(2.2653)**	(-1.1615)	**(3.1389)**	**(3.4897)**
2009.2	0.00192656	**0.199076**	-0.110575	**0.171822**	**0.0313246**
	(0.5851)	**(2.4792)**	(-0.2672)	**(2.7993)**	**(3.8157)**
2009.3	**0.0179162**	**0.11566**	-0.386723	**0.162898**	0.0199563
	(4.6815)	**(2.3294)**	(-0.725)	**(2.5700)**	(1.8908)
2009.4	0.00404376	**0.13918**	-0.241655	**0.301454**	0.0110162
	(1.9146)	**2.6051**	(-0.8121)	**(13.0629)**	(1.8115)
2010.1	**0.0149239**	0.132256	-0.525523	**0.37377**	**0.0325549**
	(3.2899)	(1.2425)	(-0.8866)	**(8.3971)**	**(2.612)**
2010.2	**0.00710515**	**0.186003**	-0.161063	**0.0993496**	**0.013667**
	(3.4656)	**(3.9371)**	(-0.6383)	**(2.4397)**	**(2.7075)**
2010.3	**0.015601**	**0.219307**	-0.382867	**0.222898**	0.0189831
	(3.6317)	**(4.4734)**	(-0.7127)	**(2.2965)**	(1.8101)
2010.4	-0.00799359	**2.00451**	-0.149325	0.125198	-0.00136229
	(-1.5837)	**(13.6824)**	(-0.2266)	(1.0211)	(-0.1095)
2011.1	0.00253423	**1.24187**	-0.408566	0.182195	0.00607859
	(0.3059)	**(9.1438)**	(-0.3916)	(0.9585)	(0.2928)
2011.2	0.00456415	**0.425971**	-0.101889	**0.123243**	0.00707183
	(1.9697)	**(10.2685)**	(-0.3321)	**(2.215)**	(1.1219)
2011.3	0.00655983	**0.414605**	-0.0571725	0.202398	0.0193896
	(1.4624)	**(9.4641)**	(-0.1388)	(1.9164)	(1.6342)
2011.4	0.00820685	**0.325895**	-0.357265	0.0537371	0.00599505
	(3.2611)	**(6.1151)**	(-1.1203)	(0.8716)	(0.9237)

Source: Authors' elaboration.

These findings are consistent with the extant research reviewed in this paper (Saunders and Schumacher, 2000; Brock and Rojas-Suarez, 2000; Maudos and Guevara, 2004), which highlights the importance of operational costs. In the second step, time series data were used with 44 observations for each variable. All variables were significant except *Ipca*. The equation with the estimated results is the following:

$$Purespread = 0.008\beta_0 + 0.010Selic + 0.005Ipca + 2.266^{-10}BondRev. - 0.305Volatil. - 8.589^{-9}LFTs \quad (9)$$

Table 4 presents the results of the second step of the regression, which aims at capturing the possible effects of macroeconomic variables on the banking spreads in Brazil. The variable *SELIC* was significant and positive as expected consistent with the existing research. *Volatility* was negative contrary to the expected behaviour of the variance of the interest rate. *Inflation*, as measured by the *Ipca*, was not significant in this model. One possible explanation for this result is provided in the next section. The variables that explain the influence of LFTs on the banking spread were significant. *Bond revenues* were positive, while *LFTs in market (LFTIM)*, were negative, according to the expected behaviour of these variables described in the former section.

Table 4. Regression of the pure spread against macroeconomic variables

OLS using the observations 2001:1-2011:4 (T = 44)
Dependent variable: pure_spread

	Coefficient	***Standard Error***	***t-statistic***	***p-value***	
Const	0,00839495	0,00465322	1,8041	0,07914	*
SELIC	0,0099402	0,00382741	2,5971	0,01330	**
Ipca	0,00458842	0,0117398	0,3908	0,69810	
Bond Rev.	2,26636e-010	8,47891e-011	2,6729	0,01102	**
Volatility	-0,305025	0,0998139	-3,0559	0,00409	***
LFTIM	-8,58896e-09	4,89088e-09	-1,7561	0,08713	*

Dependent var. Mean	0,011142	S.D. dependent var.	0.007623
Squared residuals Sum	0,001695	S.E. of regression	0.006680
R^2	0,321530	Adjusted R^2	0.232257
F(5, 38)	3,601672	P-value(F)	0.009172
Likelihood Log	161,1752	Akaike criterion	-310.3505
Schwarz criterion	-299,6454	Hannan-Quinn criterion	-306.3805
Rô	-0,303909	Durbin-Watson	2.531773

Source: Authors' elaboration.
Note: *** to 99% of significance, ** to 95% and * to 90%.

5.4. Interpretation of the empirical findings

Most of the results obtained through the econometric regressions are consistent with the findings of the existing empirical literature. In the first step, the operating cost

is the most significant variable explaining the banking spread. Such behaviour is similar to that observed in the existing body of literature described in section 4.

Specifically, in Brazil, bank costs have become more important in the operation of financial institutions in recent years because the revenue sources created by high inflation vanished after the implementation of the Real Plan.

The constant generated, which is the pure spread, wasrelevant in explaining the spread as expected, which may be interpreted as the relevance of inertia on the banking spread levels over time. In empirical research, such as Silva *et al* (2007), when the spread is regressed against its own lags, the econometric tests exhibit a significant degree of relevance. That is, much of the trajectory of the variable can be explained by its past behaviour.

The index of market concentration, HHI, was not significant in the regression. This result is consistent with Nakane (2003), which analysed the empirical structure of the Brazilian banking market and concluded that banks compete without the existence of a non-competitive market.

All the macroeconomic variables behaved asexpected except the volatility of interest rate, which behaved opposite to the expected sign, given an economic environment of greater macroeconomic uncertainty during the analysed period with greater variance in the interest rate.

The SELIC variable was significant and exhibited the expected behaviour, which confirms its strong correlation with the banking spread based on the assumption of the opportunity cost of lending. As previously noted, the importance of the basic interest rate of the economy has beenreported in other empirical studies. The SELIC rate has remained high in Brazil despite a declining trend, which reflects the practice of requiring high rates of return for most lending operations. These practices produce a very high spread. In fact, financial institutions tend to use the basic interest rate as a price floor for lending operations by embedding a high risk premium. In the Brazilian case, the possibility of combining high yield, low risk investments through the purchase of public bonds indexed to the SELIC rate reduces partially the relevance of the revenue earned from the main activity of banks, that is, financial intermediation.

Note that the results are expressed by the variables created and related to the issuance of bonds linked to the SELIC rate, i.e., LFTs. Both variables reached the levels of significance required by econometric tests and exhibited the expected behaviour in relation to the banking spread. These results provide important empirical evidence in an

incipient literature on the relationship of banking spreads and public securities in Brazil. Considering these results, there is some evidence that public debt indexed to the basic interest rate harms both monetary policy and Brazilian credit markets.

Therefore, a consistent reduction of the stock of public bonds pegged to the SELICrate should be pursued by the government, encouraging their exchange for securities based on price indices and predetermined rates. Public bonds with these features already exist in Brazil but did not face, until recently, the same level of demand as LFTs because the latter were significantly more profitable during the analysed period. Some more recent measures taken by the Brazilian government, such as changing the composition of public debt (with a reduction in the relative share of LFTs), indicate government concern about the detrimental effects of LFTs on public debt. Sure measures should be continued until Brazilian public debt is independent of the basic interest rate.

6. Conclusion

This paper related the behaviour of the Brazilian public debt, which has been historically linked to an environment of macroeconomic instability, to large banking spreads in Brazil. This empirical study confirms the findings of previous research on this subject and measures the link between public bonds pegged to the SELIC rate and banking spreads in Brazil. Despite the sharp decrease observed after the implementation of the Real Plan, banking spreads in Brazil remained persistently large compared to those observed in countries at similar stages of development, including countries with incipient credit markets. The persistence of spreads in Brazil—the focus of this empirical study as well as the research that preceded it—is affected by a range of macroeconomic and microeconomic factors.

In Brazil, Treasury Financial Bills (LFTs) produces deleterious effects not only on the debt profile but also on banking spreads. The econometric models presented in this study corroborate the existing research on this subject. This relationship should be examined in future research to generate different methodologies to measure its effects on the Brazilian economy. The change in the profile of public debt to eliminate LFTs is similar to the reduction of public bonds indexed to exchange rate during the 2000s. Such change might positively affect the economy (in terms of public debt management, channels of transmission of monetary policy, term structure of interest rates, etc.).

During the study period, Brazilian inflation targeting monetary policy in a context of public debt indexed to the SELIC rate negatively affected public debt management as well as the Brazilian credit market due to large banking spreads. As long as the interest rate was high enough to encourage investment in public bonds linked to the SELIC rate, Brazilian banks possessed a low risk, profitable source of income. Recent moves by the Brazilian government to reduce the share of such bonds in the public debt improves the debt profile, improves the bank credit environment to increase the supply of new loans, and can, ultimately, benefit Brazilian economic development.

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Appendix I

A.1. White Test for Heteroscedasticity

OLS, using observations 2001:1-2011:4 (T = 44) / Dependent variable: uhat ^ 2

	Coefficient	**Standard Error**	**t-statistic**	**p-value**
const	-0.000228519	0.000228441	-1.000	0.3276
selic	0.000442031	0.000292621	1.511	0.1445
ipca	-5.76488e-05	0.000729424	-0.07903	0.9377
Bonds Rev.	1.01236e-012	6.12241e-012	0.1654	0.8701
LFTIM	-1.12981e-010	3.13535e-010	-0.3603	0.7219
Volatility	0.00918308	0.00839370	1.094	0.2853
sq_selic	4.66179e-05	8.26031e-05	0.5644	0.5780
X2_X3	-0.000639480	0.000783477	-0.8162	0.4228
X2_X4	1.03173e-011	4.16922e-012	2.475	0.0211 **
X2_X5	-1.88539e-010	2.46619e-010	-0.7645	0.4523
X2_X6	-0.0192786	0.00633748	-3.042	0.0058***
sq_ipca	0.00119519	0.00148681	0.8039	0.4297
X3_X4	-1.77233e-012	9.75599e-012	-0.1817	0.8574
X3_X5	-3.97015e-010	8.43605e-010	-0.4706	0.6423
X3_X6	0.00944503	0.0125175	0.7545	0.4582
sq_Bonds Rev.	0.00000	0.00000	2.041	0.0529 *
X4_X5	0.00000	0.00000	-1.470	0.1550
X4_X6	-4.84113e-010	2.02207e-010	-2.394	0.0252 **
sq_LFTIM	0.00000	0.00000	1.055	0.3025
X5_X6	1.65597e-08	9.48832e-09	1.745	0.0943 *
sq_Volatility	0.158722	0.115675	1.372	0.1833

R-quadrado não-ajustado = 0.494320

Test statistic: TR^2 = 21.750097,

with p-valu= P(Qui-quadrado(20) > 21,750097) = 0.354224

A.2. Normal Distribution Test of Residuals

Frequency distribution for uhat1, observations 1-44
Class number = 7, mean = -1.83329e-018 Std. deviation = 000667951

pt range	average	frequency	rel.	acum.	
< -0.011927	-0.014121	1	2.27%	2.27%	
-0.011927	-0.0075384	-0.0097325 3	6.82%	9.09%	**
-0.0075384	-0.0031502	-0.0053443 12	27.27%	36.36%	*********
-0.0031502	-0.0012380	-0.00095614 9	20.45%	56.82%	*******
0.0012380	-0.0056261	0.0034320 8	18.18%	75.00%	******
0.0056261	-0.010014	0.0078202 9	20.45%	95.45%	*******
>=0.010014	0.012208		24.55%	100.00%	*

Test for the null hypothesis of normal distribution:
Chi-square (2) = 0.769 with p-value 0.68085

A.3. Breusch-Godfrey Test for First-order Autocorrelation

OLS, using observations 2001:1-2011:4 (T = 44) / Dependent variable: uhat

	Coefficient	Std. Error	t-ratio	p-value
Const	0.000170837	0.00446361	0.03827	0.9697
Selic	-0.000577597	0.00368135	-0.1569	0.8762
ipca	0.00343772	0.0113806	0.3021	0.7643
Bonds Ver.	-5.38053e-011	8.53493e-011	-0.6304	0.5323
LFTIM	-8.84021e-011	4.69098e-09	-0.01885	0.9851
Volatility	0.0432897	0.0979745	0.4418	0.6612
uhat_1	-0.348425	0.167809	-2.076	0.0449 **

Unadjusted R-squared = 0.104357
Test statistic: LMF = 4.311090.
with p-value = P(F(1.37) > 4.31109) = 0.0449
alternative statistic: TR^2 = 4.591696.
with p-value = P(Chi-square (1) > 4.5917) = 0.0321
Ljung-Box Q' = 4.22245.
with p-value = P(Chi-square (1) > 4.22245) = 0.0399

A.4. Augmented Dickey-Fuller Test for pure spread

including 5 lags of (1-L) pure_spread
(the maximum was 9, modified AIC criteria)
Sample size 38
unit root null hypothesis: a = 1
test with constant
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
first order coefficient for e: -0.097
lagged differences: F(5. 31) = 0.923 [0.4795]
estimated value of (a - 1): -0.510485
test statistic: tau_c(1) = -1.14602
asymptotic p-value 0.6997
with constant and trend
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
first order coefficient de 1ª for e: 0.001
estimated value of (a - 1): -1.27419
test statistic: tau_ct(1) = -4.96751
asymptotic p-value 0.0001