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Title of paper: Nonlinearities in the Brazilian Yield Curve: before and during the global crisis

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Abstract:

This article investigates the effect of macroeconomic conditions on the term structure represented by the spreads of 1, 5 and 10 year term bonds; the database used contains monthly data for the period August 1997 to September 2011. The results indicate the presence of strong nonlinearities that may compromise the effectiveness of monetary policy. On the other hand, the effects of key macroeconomic variables, such as interest rate, output, inflation, and exchange rates, on the spreads during normal periods are consistent with expectations of coherent monetary policies.

Keywords: term structure, yield curve, monetary policy

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1. Introduction

The conduct of monetary policy is a recurring theme in studies and is at the center of important theoretical divisions in the history of economic thought.

Most modern monetary policy models are based on the assumption that the economy has a stable term structure. This is a key element for coherent monetary policy based on control of the short interest rate.

In some cases, monetary authorities seek to develop effective and direct communication with the agents who work in the financial market to reduce the uncertainty of its effect on interest rates in the short term and provide a clear understanding of short-, medium- and long-term interest rate trajectories. The hope is that short-term interest rates, which are the instrument of monetary policy, have the capacity to affect the long-term rate and thus aggregate demand.

In the Brazilian economy, due to confidence and external demand shocks, the risk of default has raised the long-term interest rate independently of monetary policy. This phenomenon was particularly noteworthy during both the currency crisis of the year 1999 and election cycle expectations in the year 2002. In both cases, the short-run interest rates jumped substantially without much effect on the long-run rates. During these events, there was an indication that monetary policy was endogenous, i.e., the long term may have affected the short term and not the other way around.

The aim of this paper is to examine the role of macroeconomic variables in determining the yield curve of the Brazilian economy.

Considering that the economy has suffered considerable confidence and external demand shocks in recent decades, the econometric methodology employed considers the presence of nonlinear relationships between the variables.

This article is divided into four sections. After the introduction, section 2 provides the rationale for the work by illustrating the relationship between macroeconomic variables and interest rates in the financial market. Section 3 presents the smooth transition regression model of the behavior of Brazilian interest rate, and section 4 presents the main conclusions.

2. Relationship between macroeconomic variables and interest rates in the financial market

Studies of the term structure of interest rates used to focus solely on the demand and supply behavior of bonds in the financial market. The works by Merton (1973, p.163) and Vasicek (1977) are examples of this type of study.

A newer line of research attempts to identify the macroeconomic forces that affect the movement of term structure. This research, such as that by Diebold, Rudebusch and Aruoba (2006), analyzes the role of the monetary authority ineffectively and efficiently influencing market expectations regarding the present and future trajectory of interest rates.

To clarify the statements in the preceding paragraphs, note that the possible explanations for the yield curve, particularly for movements in long-term rates, have opposite implications for the conduct of monetary policy. On the one hand, these explanations represent a traditional analysis of the term structure of interest that is centered on the risk premium; on the other hand, they constitute a new line of reasoning that addresses economic conditions and their effect on the interest rate path.

The possibility of substitution between bonds with different maturities ensures an arbitrage condition in which the rate of return on these bonds is equal. Campbell (1995) called this the “pure expectations hypothesis.” Accordingly, the rate of return of a bond with n periods of maturity is equal to the average of current and expected rates of bonds with maturities of one period.

$$i_{nt} \approx \frac{1}{n}(i_{1t} + i^{e}_{1t+1} + i^{e}_{1t+2} + \ldots i^{e}_{1t+n-1}) + e$$

where i_{nt} corresponds to the rate of return of a bond with n periods and i_{1t} is the rate of return of a bond with one period. The spread is the difference between the long-term interest rate and current short-term interest rate, as follows:

$$spread \approx \frac{1}{n}\left[(i_{nt} - i_{1t}) \approx (i^{e}_{1t+1} - i_{1t}) + (i^{e}_{1t+2} - i_{1t}) + ...(i^{e}_{1t+n-1} - i_{1t})\right] + \varepsilon$$

If the market expects the rate of return on short-term securities will rise in the near future, then the long-term rate will tend to increase. The difference between the long-term rate and the short-term rate, i.e., the spread, can be considered an approximation of the slope of the yield curve. This means that the slope of the yield curve depends on the expected behavior of short-term rates. The opposite occurs when it is expected that the rate of return will be reduced in the short-term future.

Therefore, the role of expectations is key to determining the long-term return rate and consequently the spread.

In addition to the average of the interest in the short term, an additional element explains the long-term rate. As long as the face value of the long-term bonds is only available in the future, they are subject to risks such as default and inflation. Thus, the yield of these bonds can embed a risk premium. This risk premium is represented as the factor ε.

The objective of this work is to explain the spread behavior according to macroeconomic conditions through their effects on both the short-term interest rates and the risk premium.

Stock and Watson (1989), Dombrosky and Haubrich (1995), Stock and Watson (2001), and Hamilton and Kim (2002) used term structure information to anticipate economic cycles.

Evans (1985) studied the effects of fiscal policy and showed that large deficits affect long- and short-term interest rates, changing the behavior of the yield curve. In another study, Evans (1987) found that the announcement of deficit has a temporary effect on short-term interest rates.

In Brazil, Rocha, Moreira and Magalhães (2002) highlighted the importance of foreign debt on the spread of foreign securities. Matsumura and Moreira (2005) studied the importance of macroeconomic variables in determining the spread.

The inclusion of macroeconomic variables in this work is based on a study by Diebold, Rudebusch and Aruoba (2006), who related the level, slope and curvature of the yield curve with macroeconomic variables: Capacity Utilization installed (UC), Selic[1], short-term interest (i_t^m) and inflation (π_t) rates.

3. Modeling the term structure of interest rates for the Brazilian economy

Term structure models exhibit nonlinearity, as shown by Tabak and Andrade (2001). However, the objective of this work differs from theirs. This model is not intended to estimate the yield curve model; rather, it is intended to assess the importance of the macroeconomic variables in the term structure represented by the spread.

The first aspect of the spread behavior that can be described for the Brazilian economy is the presence of substantial and rapid changes in the term structure.

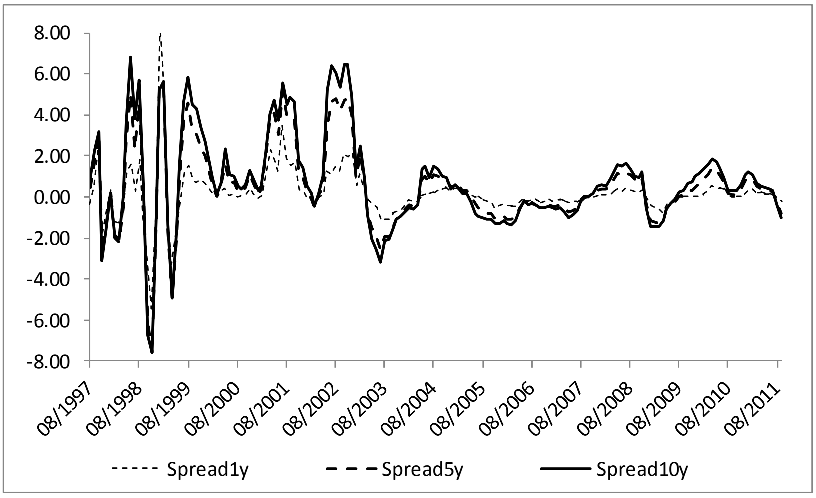

Figure 1: Spread of the Term Structure in Brazil.

The spread behavior in Brazil is depicted in Figure 1. We can observe that the term structure of interest rates in Brazil does not always have a positive slope. The spread is notoriously subject to abrupt changes, possibly reflecting confidence and demand shocks that affect the risk of default of public bonds. Note that the spread of the 1 year, 5 year and 10 year bonds have negative values in some years.

[1]The interest rate is controlled by Central Bank of Brazil.

Thus, the Brazilian economy has some characteristics that may indicate the presence of nonlinearity (regime change) in the term structure.

The model is based on the idea of "threshold", in which the dependent variable is a function of the independent variables in a peculiar way: the dependent variable is described by a linear process to a certain threshold, after which the coefficient of the variables changes.

The "threshold" approach is based on Hansen (2000), who suggested the possibility of splitting the sample and using an indicator function with observable variables. The use of the "threshold" variable is linked to the division of the sample into subgroups that can be considered classes or types of economic policy.

Teräsvirta (2007) showed that nonlinear models have gained importance in macroeconomics and financial modeling. Well-known categories of nonlinear models include the Switching, Markov-switching and the Smooth Transition Regression (STR) models. The STR model can be viewed as an evolution of the switching regression model.

The typical STR model is defined as follows:

$$y_t = [\phi + \theta G(\gamma, c, s_t)]' z_t + u_t \tag{1}$$

where $z_t = (w_t', x_t')$ is a vector of explanatory variables that contains a vector of lags of the dependent variable $w_t' = (1, y_{t-1}, \cdots, y_{t-p})'$ and a vector of exogenous variables $x_t = (x_{1t}, \cdots, x_{kt})'$. Note that j is the vector of the linear parameters and q is the parameter vector of the nonlinear estimation.

The transition function $G(\gamma, c, s_t)$ has a slope parameter γ, a vector of location parameters c ,where $c_1 \leq \cdots \leq c_k$, and a limit s_t. The transition function is a general logistic function:

$$G(\gamma, c, s_t) = \left(1 + \exp\left\{-\gamma \prod_{k=1}^{K} (s_t - c_k)\right\}\right)^{-1}, \gamma > 0 \tag{2}$$

where $g > 0$ is a constraint for identification.

The estimated model for the Brazilian economy follows equation (1), where

y_t = spread and z_t is the vector containing the exogenous macroeconomic variables $z_t = (RBrazil_t \quad UCI_t \quad Selic_t \quad IPCA_t)$ and the lagged dependent variable $w_t = (y_{t-1})$

Note that the linearity is tested against an STR model with a predetermined transition variable. As the theory does not specify the transition variable, the test is repeated for each variable in the set of potential transition variables. Thus, the STR model has the property of being identifiable under the alternative hypothesis instead of the null hypothesis of linearity.

When $\gamma = 0$, we have the transition function $G(\gamma, c, s_t) \equiv 1/2$,and the model is linear. Otherwise, when the model is nonlinear, we have to choose *K* restricted to *K = 1* or *K = 2*. For *K = 1*, the parameters $\phi + \theta G(\gamma, c, s_t)$change monotonically as a function of s_t from ϕ up to $\phi + \theta$. For *K = 2*, they change symmetrically around the midpoint $(c_1 + c_2)/2$, where the logistic function reaches its minimum value. The minimum value is between zero and ½, reaching zero when $\gamma \rightarrow \infty$ and ½ when $c_1 = c_2$ and $\gamma < \infty$. The parameter g controls the tilting, and c_1 e c_2 provide the location of the transition function.

Similar to the linear models, in the STR, their size must be reduced by the elimination of redundant variables in $y_t = [\varphi + \theta G(\gamma, c, s_t)]' z_t + u_t$.

3.1 Estimation of the Smooth Transition Regression (STR)

The database we used contains monthly data for the period August 1997 to September 2011 (169 observations). The historical series of Future Pre x DI transactions was obtained from the BM&F and was used for the construction of the interest rate term structure. The capacity utilization of the Brazilian industry (CUBI) in the last twelve months was obtained from the National Confederation of Industry (NCI), the rate of inflation measured by the National Index of Consumer Prices (IPCA) for the previous 12 months was obtained from the IBGE, and the Selic rate was obtained from the Central Bank of Brazil. The evolution of the EMBI + Brazil (Emerging Markets Bond Index) was obtained from Bloomberg (Rbrazil).

Considering the assumptions of economic theory, certain results are expected. Inflation (IPCA) is expected to have a positive effect on the interest rate term structure due to the risk of inflation embedded in the yield curve. In addition to this risk premium, there is another element, the expected increase in short-term interest rates bonds that is driven by monetary policy. Both factors tend to reinforce the positive effect of inflation on the long-term interest rate.

The coefficient of the annualized overnight rate of interest (Selic) in the spread equation depends on market expectations. If the market believes that an increase in the Selic rate is permanent, the effect on the long-term rate will be close to one and will therefore not significantly affect the spread. This result is crucial for the effectiveness of monetary policy. When the coefficient is equal to or greater than zero, the Selic rate changes will affect the long-term rate in equal or greater measure. However, when an increase in the Selic rate is understood by the market to be temporary, the effect on the long-term rate will be small and the spread will fall. In this sense, it is important to analyze the sign and value of the coefficient of the Selic rate in the spread equation.

The level of capacity utilization of the Brazilian industry (CUBI) is the ratio of the volume produced and the ceiling that the machines and equipment are able to produce. This variable can be considered a proxy for the output gap. It is important to note that a positive sign may indicate an increase in expected short-term interest rates (long-term yield curve). This can be understood as the expected response of the monetary authorities, who dislike inflation threats.

Something similar can occur due to the devaluation of the exchange rate (Dollar). An increase in the exchange rate indicates an improvement in export competitiveness, leading to future expansion. Another possibility is that devaluation may signal a future tightening of liquidity. In both cases, an increase in the short term interest rates is expected. This is reflected by a positive coefficient of the exchange rate on the spread.

To pursue empirical research on the Brazilian term structure based on the smooth transition regression model (STR), it is necessary to identify the variable responsible for regime changes and to determine the signs and magnitudes of the effects of macroeconomic and financial variables to explain movements in spreads measured by 1, 5 and 10 year bonds.

The STR model is estimated using the conditional maximum likelihood with Multi-J software.

The specification began with a linear model suggested by Diebold et al (2006) that include two additional variables; the exchange rate (Dollar), which accounts for the Brazilian dependence on foreign trade; and the so-called Brazil Risk (RBrazil) as proxy for dependence on international capital. RBrazil is the country's level risk measured by the EMBI + Brazil[2].The higher the price index of this bundle of assets is, the higher is the risk perception of the direction of the Brazilian economy by the international financial market will be.

The specification of the models was parsimonious, considered the problems of autocorrelation and heteroscedasticity in residuals, and obeyed the minimization of the Akaike information criterion (AIC), Schwarz criterion (SC) and Hannah-Quinn criterion (HQ).

Using the usual tests for unit root, in particular Elliott, Rothenberg and Stock's DF-GLS test, the existence of unit root was rejected for all variables except for the nominal exchange rate, Brazil Risk and the rate of inflation measured by IPCA. These variables that were unit root were considered using first differences.

The next step was to apply econometric tests that seek to ensure the correct specification of the model. Accordingly, the first step was to test for the existence of nonlinearity in the estimated model. If linearity was rejected, the choice was the

[2] EMBI+Brazil measures the price movement of securities from one day to the other. Its unit is the base point, i.e., 500 basis points, implying that Brazilian bonds pay 5% more than U.S. bonds, considering periodic interest payments, purchase price, redemption value and the time remaining until maturity obligations; this value is used by domestic and international investors

correct value K ($K = 1$ *or* $K = 2$). Table 1 indicates that the model is nonlinear and corresponds to the smooth logistic regression model LSTR1 with Rbrazil taken as the transition variable.

Table 1: Linearity Test against STR.

p-values of F-tests (NaN - matrix inversion problem):

transition variable	F	F4	F3	F2	suggested model	term model
RBRAZIL_d1(t)*	4.29E-42	2.44E-04	2.87E-03	2.60E-34	LSTR1	Spread1y
RBRAZIL_d1(t)*	2.72E-20	2.67E-01	9.79E+00	2.23E-17	LSTR1	Spread5y
RBRAZIL_d1(t)*	7.35E-18	2.75E+00	4.65E-04	3.09E-10	LSTR1	Spread10y

The grid was calculated to determine the value of the variable range that captures the type of gradient vector and the location represented by the variable c_1, the results for which are detailed in Table 2.

Table 2: Grid.

SSR	gamma	c1	term model
34.1199	0.5000	129.8276	Spread1y
72.7187	3.5593	24.7241	Spread5y
97.2578	4.8524	24.7241	Spread10y

transition function: LSTR1
grid c {-711.00, 813.00, 30}
grid gamma { 0.50, 10.00, 30}
transition variable: RBRAZIL_d1(t)

Given the specification of the model, in this case LSTR1, the transition variable *RBrazil*, the variable grid *c* {-711.00, 813.00, 30} and the function that corresponds to the range {0, 50, 10,00, 30}, it is possible to run the estimation algorithms and, through an iterative process, to estimate the nonlinear model to evaluate the behavior of the yield curve.

The tests for heteroscedasticity and autocorrelation of the residuals are shown in Tables 3 and 4.

The test for the absence of autocorrelation corresponds to the applied test used by Teräsvirta (1998) and to a special case of the general test described by Godfrey (1988). In this procedure, the estimated residuals are regressed on the lagged residuals and on the partial derivatives of the log-likelihood function with respect to the parameters of the model. The detailed results in Table 3 confirm the null hypothesis of no autocorrelation between the estimated residuals of the models for the 1, 5 and 10 year spreads.

Table 3: Model Specification - Testing for No Error Autocorrelation.

	Spread1y		Spread5y		Spread10y	
lag	F-value	p-value	F-value	p-value	F-value	p-value
1	0.2725	0.6024	0.1826	0.6698	0.1098	0.7408
2	0.7404	0.4788	0.1149	0.8915	0.2759	0.7593
3	1.2295	0.3014	0.0543	0.9833	0.2847	0.8364
4	1.2036	0.3121	1.7990	0.1325	0.6269	0.6441
5	1.0066	0.4163	1.7496	0.1275	1.0545	0.3885

The test used to determine heteroscedasticity was the ARCH-LM test, which is a statistical test similar to that described by Doornik and Hendry (1997) and is centered on multivariate LM statistics. Table 4 shows that the null hypothesis regarding the homoscedasticity of the residuals was not rejected for the models estimated for the 1 and 10 year terms. For the 5 year term, there is some probability of encountering this type of problem.

Table 4: Model Specification - Test of Heteroscedasticity.

	Spread1y		Spread5y		Spread10y	
lag	F-value	p-value	F-value	p-value	F-value	p-value
1	0.2725	0.6024	0.1826	0.6698	0.1098	0.7408
2	0.7404	0.4788	0.1149	0.8915	0.2759	0.7593
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5	1.0066	0.4163	1.7496	0.1275	1.0545	0.3885

The proper fit of the model to estimate a spread of 1 year is illustrated in figure 2, which shows the almost imperceptible difference between the original series and the series adjusted by linear and nonlinear components.

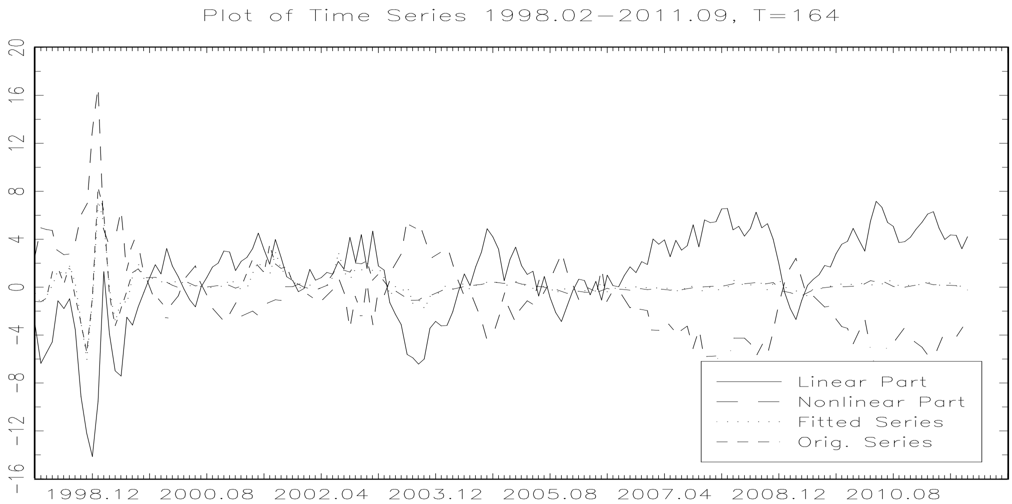

Figure 2: Set the STR model for a spread of 1 year.

The version of the estimated STR model is a generalization of the standard autoregressive model in which the autoregressive coefficient is a logistic function, where $G(\gamma, c, s_t) = \left(1 + \exp\left\{-\gamma \prod_{k=1} RBrazil_t - c_k\right\}\right)$ $, \gamma > 0$. Note that γ is the smoothing parameter. For spreads of 1 year, 5 years and 10 years, the γ values were 0.4986, 3.4501 and 4.7852, respectively; noting that the higher the value of γ is, sharper the S shape of the transition variable.

Analyzing the behavior of the transition function (the logistic function), a range of -800 to +1,000 points of variation in the Brazil risk (RBrazil) and values varying from 0 to 1 for the function G were considered. The S shape of the transition for the highest values of γ for spreads of 5 and 10 years is characteristic, as shown in Figure 3.

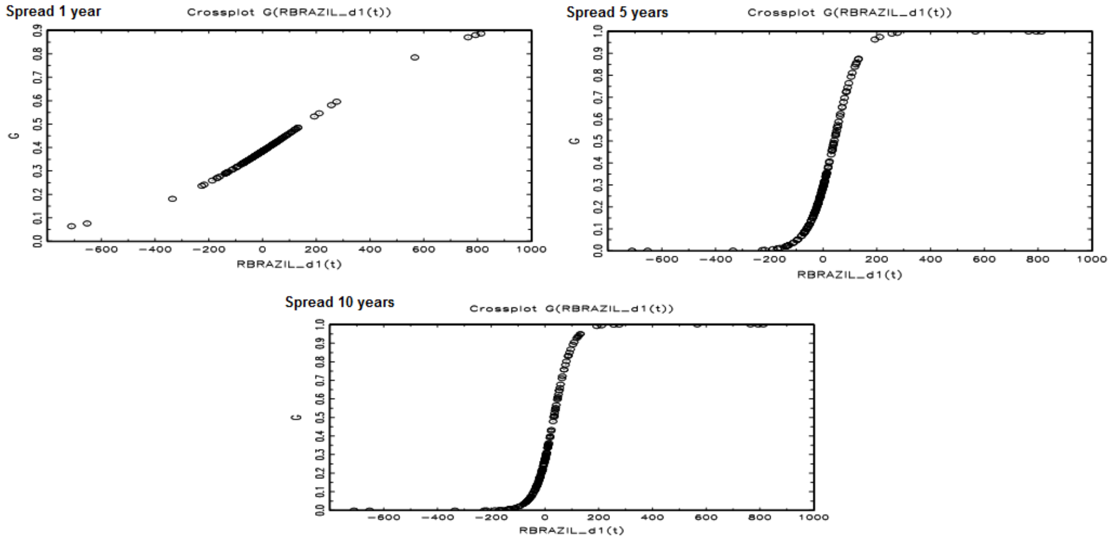

Figure 3: Values of γ (gamma) in the LSTR model.

The Brazilian economy has suffered in the last two decades due to severe confidence shocks that mainly affected foreign currency and long term government bonds. The variable chosen to define the transition and the threshold for the nonlinear model is the RBrazil.

As explained earlier, RBrazil satisfies the tests as a transition variable. Note that RBrazil is measured by the weighted average of the Brazilian securities traded abroad in relation to similar securities from the United States government. As such, this variable a very good proxy of country risk. It may directly affect the interest of the long term bonds; however, its primary importance is in explaining the main shifts of the whole term structure. The estimated thresholds of the change in RBrazil are 150.90, 41.34 and 32.88 for the spreads of 1, 5 and 10 year bonds, respectively (see Table 5 below). Its relationship with the nonlinear behavior of the term structure is illustrated in Figure 4, which presents the dRBrazil (first differences of RBrazil) results and the spreads of 1 and 10 year bonds.

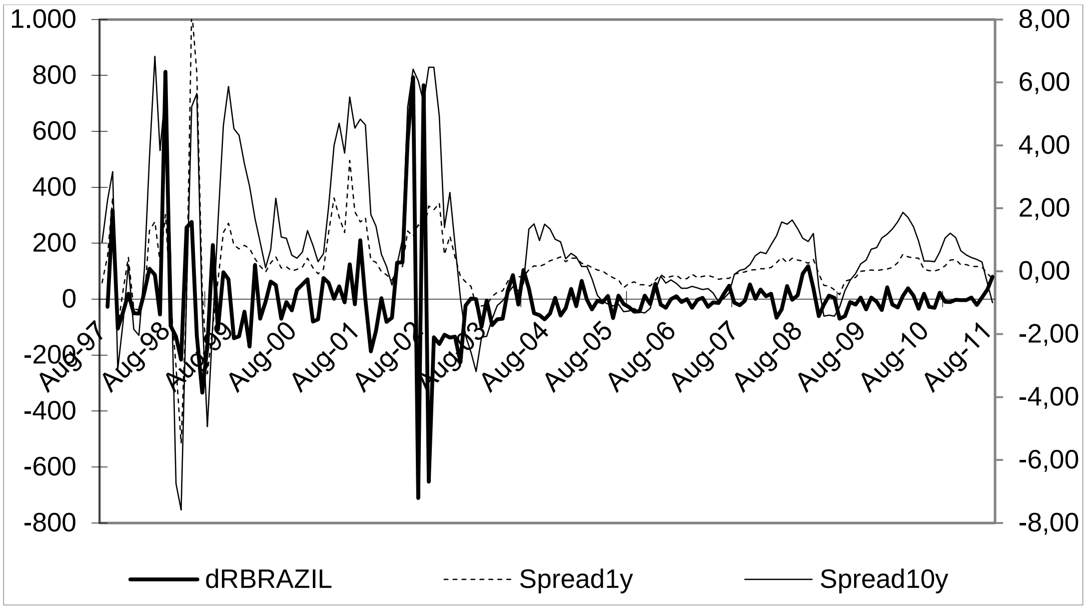

Figure 4: Risk Brazil vs. Spread.

3.2 Main Results of the Econometric Experiment

The estimation of the spread in the interest rate term structure supports the conclusion of Diebold, Rudebusch and Aruoba (2004).The results indicate that macroeconomic variables have significant explanatory power regarding the volatility of the spread in the interest rate term structure observed in the Brazilian financial market.

The importance of the spread of the previous period in the formation of the spread of the current period is positive and significant for all three terms analyzed (1, 5 and 10 years), as observed in the linear estimates described in Table 5. The coefficient is reduced by half when the term increases from 1 to 5 or10 years, with values of 1.34, 0.77 and 0.72, respectively. This reduction indicates that the memory of short-term maturity (1 year) tends to increase in volatility, while longer-term maturities (5 and 10 years) tend to smooth the spreads.

Table 5: STR Model Estimate.

variable	Spread1y estimate	Spread1y p-value	Spread5y estimate	Spread5y p-value	Spread10y estimate	Spread10y p-value
----- linear part ------						
CONST	-83.7388	0.0245	2.2772	0.7184	7.1330	0.2871
Spread(t-1)	1.3418	0.0000	0.7730	0.0000	0.7275	0.0000
Selicef(t)	-0.3016	0.0064	-0.1777	0.0000	-0.1831	0.0000
DOLLAR_d1(t)	0.9699	0.1977	1.6954	0.0448	1.9795	0.0383
CUBI(t-1)	1.4277	0.0306	0.2501	0.0222	0.1982	0.0856
DOLLAR_d1(t-1)	ND	ND	3.2809	0.0000	4.1788	0.0000
IPCA_d1(t-2)	ND	ND	ND	ND	0.6865	0.0002
IPCA_d1(t-3)	1.4493	0.0348	0.6726	0.0000	ND	ND
RBRAZIL_d1(t-4)	0.0014	0.1709	ND	ND	ND	ND
CUBI(t-4)	-0.3217	0.2129	-0.2462	0.0100	-0.2531	0.0132
---- nonlinear part						
CONST	222.9099	0.0111	17.5635	0.3339	11.8492	0.5253
Spread1y(t-1)	-1.5372	0.0213	0.1801	0.1010	0.2002	0.0273
Selicef(t)	0.7323	0.0164	0.4788	0.0000	0.4661	0.0000
DOLLAR_d1(t)	3.4834	0.0583	-2.0169	0.1176	-2.2947	0.0988
CUBI(t-1)	-3.8294	0.0101	-0.8453	0.0013	-0.7373	0.0074
DOLLAR_d1(t-1)	ND	ND	-2.0298	0.1422	-2.2711	0.1457
IPCA_d1(t-2)	ND	ND	ND	ND	-1.1850	0.0040
IPCA_d1(t-3)	-3.6467	0.0398	-1.3018	0.0005	ND	ND
RBRAZIL_d1(t-4)	-0.0073	0.0124	ND	ND	ND	ND
CUBI(t-4)	0.9007	0.1276	0.5488	0.0117	0.5154	0.0204
Gamma	0.4986	0.0121	3.4501	0.0000	4.7852	0.0000
C1	150.9090	0.2086	41.3459	0.0021	32.8777	0.0013
AIC:	-1.3508		-0.6080		-0.3082	
SC:	-1.0105		-0.2678		0.0320	
HQ:	-1.2126		-0.4699		-0.1701	
R2:	0.8597		0.8835		0.8888	
adjusted R2:	0.8606		0.8842		0.8894	
variance of transition variable:	25729.2447		25729.2447		25729.2447	
SD of transition variable:	160.4034		160.4034		160.4034	
variance of residuals:	0.2336		0.4910		0.6627	
SD of residuals:	0.4834		0.7007		0.814	

transition function: LSTR1

sample range: [1998 M2, 2011 M9], T = 164

Models: Spread1y(t) = CONST Spread1y(t-1) Selicef(t) DOLLAR_d1(t) CUBI(t-1) IPCA_d1(t-3) RBRAZIL_d1(t-4) UCI(t-4)
Spread5y(t) = CONST Spread5y(t-1) Selicef(t) DOLLAR_d1(t) CUBI(t-1) DOLLAR_d1(t-1) IPCA_d1(t-3) UCI(t-4)
Spread10y(t) = CONST Spread10y(t-1) Selicef(t) DOLLAR_d1(t) CUBI(t-1) DOLLAR_d1(t-1) IPCA_d1(t-2) UCI(t-4)

The Selic short-term interest rate had a significant negative coefficient, as observed in the linear part of the model, an indication of a temporary impact on the CDI financial market. However, in the nonlinear estimation, the signal was positive, indicating that the increase in the Selic rate had a positive effect on long-term rates. In other words, the negative effect on the spread of the Selic is cushioned and may even become positive in the periods during which the Brazil risk exceeds the threshold. This may indicate that various agents expect that the Selic rate will continue increasing in the future to circumvent the impact of shocks.

The exchange rate (U.S. dollars) had the expected positive sign, which is indicative of improved export competitiveness or devaluation involving a tightening of liquidity.

Both possibilities indicate an increase in the long-term interest rate (increased interest rate in the short term).

The analysis of the inflation rate is important because it is associated with the influence of the yield curve through the inflation risk premium. The expected positive effect is observed, but for longer terms, the effect is reduced substantially, possibly reflecting the ability of the Brazilian monetary authorities to control inflation. However, an alternative interpretation is that an increase in inflation indicates that the central bank will gradually increase the short-term interest rate. There is a negative cushioning effect on the nonlinear behavior, as before.

The coefficient of capacity utilization by Brazilian industry was positive in the linear part of the model, demonstrating that the yield curve behaves according to the cyclical dynamics of the Brazilian economy.

Brazil risk is extremely relevant as the transition variable for establishing the threshold of the nonlinear behavior of the Brazilian financial market. Its relevance with regard to explaining the magnitude of the spread in the nonlinear part of the model is noteworthy, which may explain why its contribution as an additional variable within the equation is weak.

4. Conclusion

The study of the term structure of interest rates and the behavior of the term spread, i.e., the difference between long-term rates minus the short- term rate, has puzzled monetary policy researchers because the expected effect of the actions of monetary authorities on long-term rates does not always prevail in the financial market.

The presence of strong nonlinearity in the term structure largely explains the pitfalls of monetary policy, e.g., its lack of effectiveness during certain periods, particularly in periods with nonlinear behavior.

The positive correlation between inflation and the spread is consistent with growing uncertainty but also seems to indicate that the financial community believes in the monetary policy of the Central Bank. This correlation was also observed for the capacity utilization rate and exchange rate.

Last but not least, it is possible to consider the inflation, capacity utilization and exchange rates as proxies for future expansionary cycles. In that sense, the spread could be considered a predictive factor of future expansion. This topic is reserved for future research.

Therefore, Brazilian economic policymakers must monitor the movements in the yield curve and analyze the information frequently to guide analyses and actions to be implemented and to interfere in a beneficial manner in the trajectory of the Brazilian economy.

In future work, we hope to explore the impact of term structure nonlinear movements in economic activity and at the same time, the effect of economic policy on the Brazilian yield.

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