AMERICAN MONETARY POLICY NORMALIZATION AND ITS IMPACTS ON THE BRAZILIAN YIELD CURVE

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Abstract: This study examines the impact of a potential normalization of US monetary policy on the Brazilian fixed interest rates yield curve and discusses the available tools that may be used to mitigate this impact on the domestic fixed income securities market. The models used on the analysis include weekly data from the US Treasury, the Brazilian Credit Default Swap (CDS), the Non-Deliverable Forward (NDF) of the Brazilian Real versus the US dollar and Brazilian fixed interest rates. The sample period extends from September 2006 to January 2015. The study creates a single equation model and the expectations hypothesis to identify the increase in the 10 years US Treasury and a Switching Autoregressive Conditional Heteroscedasticity (SWARCH) model to estimate shocks in CDS and NDF. According to the results of these models and based on the Nelson and Siegel model (1987), the study analyses the effects of an increase in the US interest rates on the term structure of the Brazilian fixed interest rates. Particularly, we highlight the results obtained for 1, 5 and 10 year securities with estimated shocks of 96, 194 and 188 basis points; respectively. Given these results, the study identifies possible tools that the National Treasury may adopt in order to mitigate the consequences of raising US interest rates on the Brazilian fixed income securities market. A contingency plan considers five main tool possibilities: the adoption of extraordinary auctions; the cancellation of fixed-rate and price-indexed securities auctions; floating-rate securities emissions; short duration fixed-rate securities emission; and the cancellation of new auctions in foreign currency.

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1. Introduction

In response to the financial crisis of 2008/2009, central banks around the world have chosen, among other measures, the strategy of reducing their basic interest rates in order to stimulate their economies. This phenomenon has led some interest rates to be set at zero nominal levels (using as reference the American basic interest rate for the last 4 years) and even negative real levels in certain countries. Moreover, countries increased liquidity in the markets. The United States alone has injected more than 3 trillion dollars in its economy. As a result, there is a high level of liquidity reflected in various financial assets, including global foreign exchange markets and sovereign debt securities.

This trend led to a significant influx of capital into developing countries. Emerging markets, including Brazil, have experienced direct impacts of these "new" global monetary conditions because they created an increasing demand for assets with higher potential return allied with a better perception of risk, which caused an increase in the net flow of foreign capital into their economies. Consequently, there was appreciation of main developing countries' currencies against the US dollar and a strong demand for sovereign debt bonds. Demand pressures on sovereign debt bonds caused a reduction in rates due to a potential increase on its prices. Therefore, the beginning of the process of expansionary monetary policies by developed economies in response to the financial crisis of 2008/2009 has produced a sharp devaluation of the dollar against other currencies, as well as a reduction of the interest paid on government securities around the world.

Currently, this dynamic has changed because capital flows toward the opposite direction. Better economic prospects in the United States have led the Federal Reserve[2] to consider lessening its expansionary policy by raising the basic US interest rates in 2015. Recent perspectives show a reversion in capital movements observed in previous years: net flows of foreign capital should leave developing countries and may cause significant impacts on financial markets. There will be an increasing demand for dollar and asset sales in developing countries, with direct impacts on their exchange rates (depreciation) and sovereign debt bonds (higher interests). Governmental bonds could be affected both by the increase in sales by investors (price deterioration) and by a higher perception of the country´s risk. Consequently, the possibility of a normalization in the US monetary policy could lead developing countries to a delicate situation in terms of exchange rates and financing costs (debt management).

Regarding Brazil, it seems the expectation itself of an increase in US interest rates has already caused significant repercussions on both the exchange market (Real/Dollar) and sovereign debt bonds market. It becomes of paramount importance to estimate the effects of a change in the US policy in order to understand possible impacts on the Brazilian economy and prepare contingency plans to these repercussions. Therefore, the main objective of this study is to analyze the impact of a US monetary policy normalization on the Brazilian yield curve, as well as recognize the tools available to mitigate these impacts.

The paper is organized into five sections, including this introduction. Section 2 analyzes the potential effects of an increase in short-term US basic interest rates on its long-term yield. In theory, those work as a reference for the interest paid for the Brazilian governmental bonds. This section carries a literature review on this subject, as well as a construction of two models aimed at capturing those effects on the long-term yield. Section 3 presents some of the specificities of the methodology used to estimate the impacts on the Brazilian interest curve and comments on its results. Section 4 argues about different possibilities of measures that the country may adopt in order to cushion impacts and mitigate repercussions for the Brazilian economy. Special attention is given to impacts on the management of the Brazilian public debt. Finally, Section 5 concludes the present study, indicating the main results.

[2] The United States monetary authority.

2. US Monetary Policy Normalization

2.1 Relation between the change in the US basic interest rate and the 10-year Treasury

The Federal Reserve (Fed) may increase its basic interest rate in order to begin the "normalization" of its monetary policy in 2015. The Fed defines on each Monetary Policy Committee meeting a target for its benchmark interest rate – the Federal Funds Rate (FFR) – and reaches it through liquidity operations in the interbank market (Book, 2005). The Fed´s purpose is to guarantee price stability and an adequate level of employment in the economy. The FFR is a very short-term rate, able to change prices of other assets on the economy such as the US Treasury and bank credit.

The Fed has stipulated the FFR should remain at its minimum level (between zero and 0.25%) since the financial crisis in 2008. According to the latest disclosures on its Policy Normalization Principles and Plans – the Fed stated that it will begin the "normalization" of the US monetary policy by raising the FFR[3].

A few steps are necessary in order to understand the impact of this monetary normalization in Brazil. First, an increase of FFR causes an increase on the 10-year Treasury rates. The attempt to describe and quantify this impact is shown in a literature review (in section 2.2) and calculated on models (section 2.3) and exercises (section 2.4). The increase in the 10-year Treasury causes an increase on the Brazilian yield curve. Section 3 will analyze this impact.

Therefore, this section aims to measure the impact of an increase on the FFR on the US long-term rates. The main objective is to quantify with more precision the impact on the 10-year Treasury of an increase in FFR. Literature shows some interesting points, which are addressed in the following session.

2.2 Literature Review

Discussions regarding monetary policy transmission mechanisms are at the heart of the monetary authority activity and are recurrent in economic theory. Nevertheless, the specific impact of changes of the FFR on 10-year Treasury rates shows little consensus in literature[4]. Until the year 2000, studies indicated doubt about the direction of this impact. Although most authors argue that increases in FFR caused rises in longer rates, evidences were too limited (Akhtar, 1995) and the size and persistence of the effects varied according to the current economic conditions – economic cycles and main agents expectations (Roley & Sellon, 1995). During that time, the prevailing economic theory believed in the term structure of interest rates, by which the effect of a monetary tightening will depend on the expected future short-term interest rates and risk premiums embedded in long-term interest rates. This theory generated little reference to clarify the impact discussed in this study (Berument & Froyen, 2009).

Since the year 2000, studies of the impact of changes in the benchmark interest rate on longer interest rates focused on whether the initial shock was anticipated or not. Several authors argue that anticipated shocks are already priced in the longer interest rates. However, unanticipated shocks on the FFR should generate significant impacts in the same direction on the 10-year Treasury (Ellingsen & Söderström, 2004; Gurkaynak, Sack & Swanson, 2005; Beechey, 2007).

This argument about the significance of unanticipated shocks to measure the impacts on the Treasury seems to be a prevailing trend also in recent literature. Berument & Froyen (2009) analyzed 12 studies on this topic. They argue that the choice of the econometric model is important to the relevance and the degree of significance of the results for each study: econometric models of single equation and data at intervals after 1987 were able to present more robust results than those that used VAR[5] and longer

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[3] According to the Federal Open Market Committee - FOMC minutes on March, 2015, 15 of 17 members of the board expect a raise in the FFR until the end of 2015.

[4] Mervyn King, Alan Greenspan and Ben Bernanke and other presidents of important central banks are among authorities who publically questioned the reasons why long-term interest rates behave in a certain way; or remain in depressed levels for long periods.

[5] According to the authors, the ability of VAR models to capture changes in monetary policy, specially non-anticipated ones, is questionable. VAR models use monthly and quarterly data, therefore are less adequate than single equation models (they present more liberty degrees). Lastly, as the authors used long periods, the VAR models may not take into account the increase

periods[6]. Additionally, the magnitude of the impact varied across the studies. The impact of 100 basis points on the 10-year Treasury varied from 0.04 to 0.52 percentage points[7].

Models do not always reflect reality. In 2005, Fed Chairman Alan Greenspan wanted to understand the reasons why the 10-year Treasury interest rates retreated despite the FOMC had raised the FFR in 250 percentage points. Thornton (2012) observed that the relatively strong and statistically significant relationship between the Treasury and the FFR that existed during the beginning of the 80s disappeared after this period. He suggested that the relationship was broken because at the end of the 80s the Fed began to use the FFR as a political tool, removing its character of a fundamentally economic tool and considering possible monetary policy outcomes prior to determining its adequate level. The Treasury, in turn, remained essentially determined by economic variables, making the relationship between the two rates fade.

The present study found adequate to reproduce the forecast estimated by Reifschneider, Tetlow & Williams (1999), which is within the results of the models analyzed by Berument & Froyen (2009), that unanticipated changes of 100 percentage points in FFR generates an impact with approximate magnitude of 0.3 percentage points in 10-year Treasury rates. To corroborate this number, the present study created its own models trying to verify this relationship and the magnitude of the impact. Taking into account the technicalities identified by Berument & Froyen (2009), the first execise focused on a single equation econometric model.

2.3. Single Equation Econometric Model

While building the model, it became apparent that the inclusion of future rates usually made the variable effective FFR statistically insignificant. One possible explanation for this would be that the improvement of Fed´s communication with the market in recent years turned most of the monetary policy moves anticipated. This fact highlights that in recent years the Fed´s communication might have become more important to generate an impact on the 10-year Treasury than the raise of the FFR itself.

In order to capture the impact of changes of the FFR on the 10-year Treasury, this study tested the following models:

1. Model A: quarterly data of effective FFR and the 10-year Treasury, between the third quarter of 1992 and the last quarter of 2014. In order to control anticipated movements on monetary policy, the model included future FFR errors in relation to observed FFR for each month over the last 12 months.

2. Model B: quarterly data of the 10-year Treasury and future FFR rates, between the first quarter of 1998 and the last quarter of 2008.

Model A shows that each 1 percentage point raise on the effective FFR increases 0.33 base points on the 10-year Treasury rate, using the assumption of unanticipated raises on the effective FFR. Therefore, assuming no anticipation from the market, the impact of the normalization of the monetary policy would be a raise of 1.16 base points on the 10-year Treasury (350 points[8] multiplied by the coefficient 0.33).

Model B used the period from the first quarter of 1998 until the last quarter of 2008 because this timeframe comprises substantial improvement in Fed´s communication and because this timeframe excludes recent years when monetary policy was abnormally conducted in order to combat the economic crisis. The model shows impacts of future FFR rates (5 months and 8 months) because the effective FFR is not statistically significant. It suggests that, in case the market expects a raise of the FFR over the next

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in transparency of Fed´s more recent economic policy. Alternatively, single equation models present the disadvantage of not being able to capture other variables capable to affect the results, which occurred simultaneously to the change in monetary policy.

[6] The authors argue that the impact of unanticipated alterations of FFR on long-term assets was stronger during the Alan Greenspan mandate (1987 to 2006) and in mid-1960s. Since 1987, studies using VAR models could not capture unanticipated changes as it did in previous moments. One of the reasons to justify that may be the fact that the Fed substantially increased transparency in its statements, making the occurrence of the unanticipated component rarer.

[7] Available on Table 1, page 37 of Berument & Froyen (2009) study.

[8] Assuming 350 points is the difference of the current FFR and a long-term FFR of 3,75%.

quarter (and assuming increases of 0.125 base points on each FOMC meeting[9]), the 10-year Treasury rates would rise 0.81 base points. The model used a comparison for the Treasury rates with assumptions of rising and not rising future 5 and 8-month FFR rates.

Table 1 – Results of Econometric Models A and B

Model A explanatory variables	*coefficients*	*P-Value*
Efective Fed Funds Rate	0,33	0,02
First future FFR error	-0,55	0,01
Third future FFR error	0,53	0,00
Tenth future FFR error	-0,18	0,03
Constant	3,33	0,00
$10\ year\ treasury_{T-1}$	0,88	0,00

Model B explanatory variables	*coefficients*	*P-Value*
Future FFR rate (5 months)	-1,00	0,02
Future FFR rate (8 months)	1,55	0,01
Constant	2,63	0,00
$10\ year\ treasury_{T-1}$	0,82	0,03

The present study also adopted an alternative approach, which ratified the results of these single equation models. This approach uses a methodology based on the expectation hypothesis (Fisher, 1896).

2.4. Exercise with the FFR and FOMC member´s expectations for the 10-year Treasury

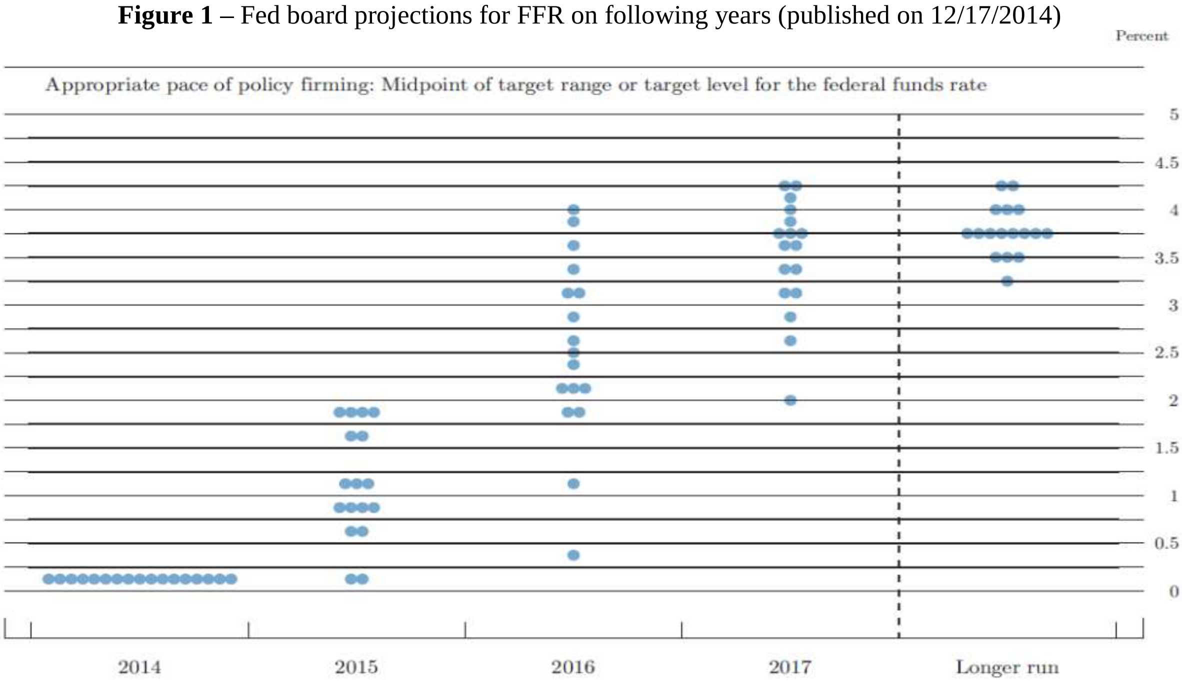
From the beginning of 2012, Fed has shown efforts to improve its communication with the Market and the transparency of its collegial decisions. It has started to publish opinions of each board director regarding the appropriate time to start the normalization of the monetary policy, as well as FFR end-of-term projections to the following 3 years, on a document named "Projection Materials".

This document is released on alternate FOMC meetings. The present study uses the publication of December 2014, considering the following parameters (our focus is on the FFR[10]):

[9] This is the pace the Fed has been announcing to be used on conducting its monetary policy normalization.

[10] Each point represents the projection of a FOMC member, and not only members with voting rights on that meeting. This publication does not identify members.

Figure 1 – Fed board projections for FFR on following years (published on 12/17/2014)

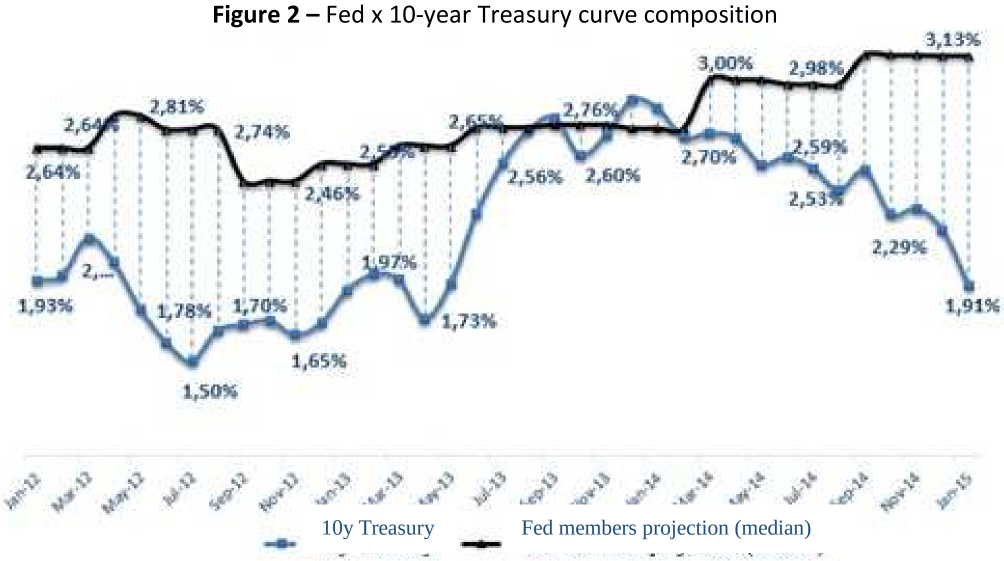


This execise consists of using the alternative approach known as "Expectation Hypothesis", described by Fisher (1896). The study used this approach as an additional source of information because of the multiplicity of results in literature regarding the connection between the FFR and long-term interest rates, especially the 10-year Treasury. It is an attempt to complement the results shown in Section 2.3 (single equation models).

The Expectation Hypothesis postulates the term structure of interest rates is equal to the average of the short-term interest rate (free of risk) plus a constant risk premium for each maturity. This risk premium is not considered in this exercise because its inclusion would only cause small shifts in the rate, which would be irrelevant to the exercise. As input, the exercise used the projections provided by the Fed, adopting as hypothesis the pace of increase in FFR will be extremely gradual (rise of 12.5 bps every opportunity), matching the end-of-period projections of the Fed.

It is possible to use this input and build a 10-year interest curve based on the Fed members' projections. The exercise compares this curve with the 10-year Treasury monthly average rate negotiated on the market. The following graph shows the result, which remains constant until the new Fed´s projections publication:

Figure 2 – Fed x 10-year Treasury curve composition



This procedure allows monitoring risks of sudden increases on the 10-year Treasury rates and quantifying input variables for modeling the Brazilian term structure in Section 3. Figure 2 shows that for the given period the market transacted the 10-year Treasury rates with a spread against the curve obtained by the Fed projections. In January, 2015, this spread amounted 120 basis points.

It is noteworthy that the market "used" the Fed´s projections as reference for a transaction rate for the 10-year Treasury during the last great volatility period caused by Fed´s miscommunication regarding the ending of the Quantitative Easing 3, during the summer of 2013. This episode is known as "taper tantrum". Therefore, this exercise presents evidence that the Fed´s projections and scenarios for the interest rates are relevant references to stablishing the 10-year interest rates. If the spread between the curve by which the market prices the 10-year Treasury and the curve built by the members´ projections is elevated, a shock of 100 basis points on the 10-year Treasury is plausible.

There are, however, some points to be made regarding the magnitude of the current spread on February 2015 (122 basis points). This exercise cannot capture all information by which the market operates, for instance a "dovish" position of voting members of the FOMC as compared to the full composition of the college, which may reduce the interest rate from the median obtained considering all members. Another fact is that the frequency of the board´s projections disclosure is only quarterly, leaving plenty of time for the market to price relevant macroeconomic variables in its projections for interest rates and especially employment levels, before Fed´s formal announcement of a tightening in the FFR.

This study does not intend to define the adequate level for bond market rates. It aims, though, to obtain a risk metric regarding the exposure to sudden shocks using as information a possible mismatch of interest rates. It serves as a basis and gives parameters to analyze the behavior of Brazilian interest rates depending on US interest rates.

3. Impacts on the Brazilian Interest Rate Curve

The study has inferred the impact of the increase of the FFR on the 10-year Treasury. This Section will comprehend the second step: to estimate the impacts of the normalization in the US monetary policy on the Brazilian interest curve (for the fixed income securities market[11]).

To achieve this goal, it becomes necessary to define the variables that might explain the magnitude of rates for the Brazilian fixed-rate securities and their respective weights. The study adopted the covered interest rate parity concept, which uses the international interest rate added by the country risk and the currency exchange exposure as a reference to determine the rate of a country's security. The following steps are necessary to achieve this purpose:

1. the scenario shows an increase on the FFR. Therefore, it becomes necessary to estimate possible raises/contaminations on the explanatory variables (international interest rate used as reference, country and currency exchange risks);
2. given the weight of those explanatory variables on the Brazilian securities, it is necessary to estimate the potential increase on these securities rates, the average duration of this effect (this phenomenon is denominated the shooting effect), and the new equilibrium levels for the rates as the volatility period due to the FFR chock finishes; and
3. given the results obtained for specific fixed-rate securities, it is possible to estimate an entire yield curve with different maturities considering the shooting effects and their new equilibrium levels.

Therefore, the results obtained by this fixed yield curve modeling will be able to answer which are the potential impacts of the normalization of the US monetary policy on the Brazilian interest rate curve.

3.1 The Brazilian Fixed Interest Rate Composition and the Interest Rate Parity Equation

As described in the introduction of this Section, it is relevant to define which variables are able to explain or justify the rates for the Brazilian fixed interest securities, or analyze the composition of this

[11] The fixed income securities market is relevant for the composition of the Brazilian Public Debt.

rate. The study focused on a 5-year fixed-rate security without coupon payment. The explanatory variables are the 5-year Treasury, the 5-year Brazilian Credit Default Swap (CDS) and the 5-year Non-Deliverable Forward (NDF) of the Real versus the Dollar. The 5-year Treasury is the reference of an international interest rate benchmark. The CDS is a financial derivative that measures the protection against a country's default. Hence, the study uses the CDS as a proxy for the country's risk. The value of a CDS is a spread measured in basis points. The NDF is a financial derivative that reflects the currency exchange rate expectations for a particular currency. In the current study, the value used for the NDF reflects the annual rate (yield) for the expected currency devaluation. Hence, the study uses the NDF as a proxy for currency exchange risk. The value of the NDF is calculated by the future negotiated exchange rate (NDF), divided by the spot exchange rate[12].

The study uses monthly data from January 2005 to April 2014. It assumes the parity framework, where the interest rate of a determined security is a simple composition of the amounts generated by each explanatory variable. In other words, it adds each variable premium in order to obtain the composition of the Brazilian security. Results are presented on Figure 3.

Figure 3 – Composition of the 5-year fixed interest rate

Figure 3 shows that the currency exchange risk seems to be structurally relevant to explain Brazilian 5-year security rates. Any inferences about Figure 3 inspire caution because it represents an arbitrary composition for explanatory variables. Nevertheless, the adoption of these variables as a possible composition for the Brazilian fixed interest rate seems appropriate.

The international finance literature refers to the Interest Rate Parity theory[13] as a relevant topic. According to Fischer (1930), the nominal yield of a country's security should be equal to that of a different country when measured in the same currency. Taking this as an assumption, the current analysis considers that the country risk will be the variable responsible for any deviation from the weighted international interest rate and the domestic one.

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[12] It is necessary to annualize this result.

[13] According to the Interest Rate Parity theory, the future Exchange rate is a function of the spot Exchange rate and the differential of interest rates of two countries.

To understand the distinct ponderations of those variables on the Brazilian fixed rate, it is useful to estimate a linear regression by Ordinary Least Squares (OLS) based on the interest rate parity equation, with the following configuration:

$$i_t = c + \alpha_1 i^* + \alpha_{2_t}\phi_t + \alpha_{3_t}\delta_t \qquad (1)$$

Where i_t represents the fixed security rate, c is an intercept, i^* is the 10-year US Treasury, ϕ_t is the exchange risk here defined by the NDF, and δ_t is the country risk defined by the CDS. In order to estimate Equation (1), it was necessary the use of two maturities: 5 and 10 years. The justification, which will be detailed more thoroughly in Section 3.4, rests on the fact that it is possible to model the whole yield curve for different maturities with just some points. In addition, regardless of the maturity of the fixed rate, the international reference for the interest rate is the 10-year Treasury rate. Aligned with the studies outlined on the IMF's Global Financial Stability Report (2014), this rate serves as a parameter for securities of emerging countries for both medium and long terms. The coefficients α_1, α_{2_t} and α_{3_t} represent the weights and are important to define the shooting potential effect for the fixed rate and the possible new equilibrium level.

Results of equation (1) are presented on Table 2:

Table 2 – Coefficient results for the Interest Rate Parity Equation

	Fixed Security Rate - Maturity (years)	
Coefficient	5	10
c	4,07	5,7
α_1	0,98	1,43
α_2	0,53	0,05
α_3	0,91	1,0

The following step is to calculate the increase potential on the three explanatory variables (US Treasury, CDS and NDF) of a normalization of the US monetary policy.

3.2 Impacts on the US Treasury, CDS and NDF

Section 2 pointed out that a possible raise on the Fed Funds Rate should increase the 10-year Treasury in about 100 basis points. Estimating CDS and NFD elevations require a different approach. As a hypothesis, it should be considered that stress scenarios in the financial markets might increase the magnitude of traded assets volatility. In this sense, this study adopted a methodology by which it was possible to measure volatility and, by this measurement, obtain possible impacts on both CDS and NDF.

In line with the IMF Global Financial Stability Report (2014), this study focused on the Switching Autoregressive Conditional Heteroscedasticity (SWARCH) model for analyzing volatility developed by Hamilton (1994). The model has 2 stages of volatility (high and low) and one order of autoregressive conditional volatility (called SWARCH (2.1)). The model adopted the same guidelines presented in Hamilton (1994) and summarized below:

$$r_t = a_0 + a_1 r_{t-1} + \varepsilon_t \qquad (2)$$

$$\varepsilon_t = \sqrt{\gamma_{s_i}} u_t \qquad (3)$$

$$u_t = h_t v_t \qquad (4)$$

$$h^2_t = \beta_0 + \beta_1 u^2_{t-1} \quad (5)$$

Where $\beta_0 \geq 0$, $\beta_1 \geq 0$ and $r_t = y_t - y_{t-1}$. y_t are the rates (yields) of the analyzed variable. The term γ_{s_i} is the volatility scale parameter for the stage s_i, with *i* assuming the value 1 when there is a state of low volatility and the value 2 in a state of high volatility. The volatility state is specified as a Markov chain with 2 stages, independent of the variable r process:

$$\mathbb{P}\{s_i = j \backslash s_{i-1} = k, s_{i-2} = k, \ldots, r_{t-1}, r_{t-2}, \ldots\}$$
$$= \mathbb{P}\{s_i = j \backslash s_{i-1} = k\}, \text{ for every } i, j, k. \quad (6)$$

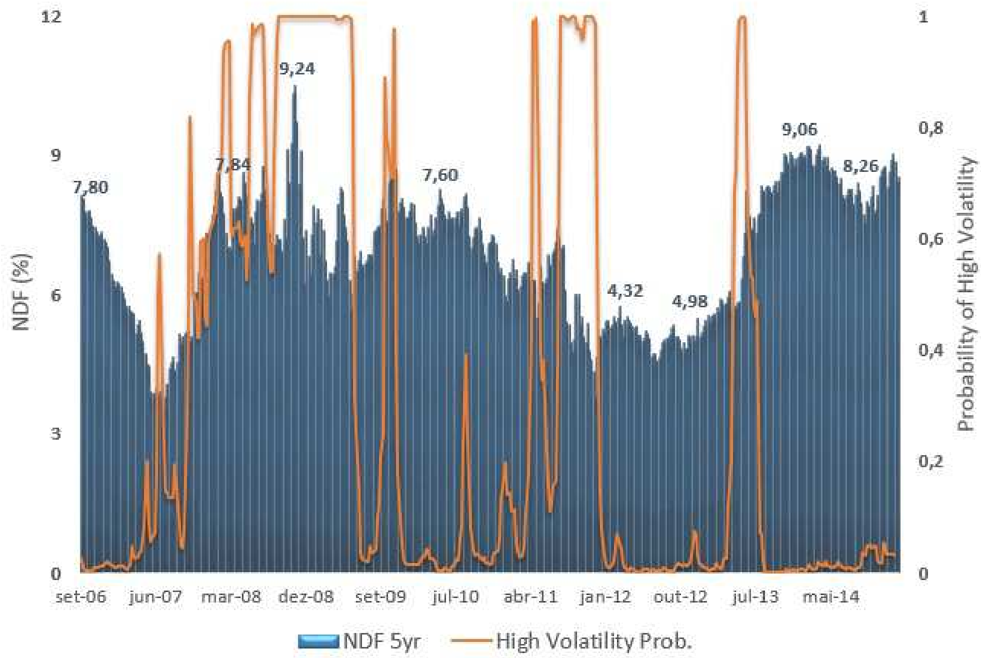
The adopted SWARCH model allows the calculation of the probability that the CDS (or the NDF) is in a low or high volatility state, for each period. This information is used in order to understand the potential magnitude of increases in rates of these variables in a stress scenario of the international financial markets.

The building of these volatility impacts on the CDS and NDF permits the estimation of a regression (using Ordinary Least Squares - OLS) for each variable using a function with an intercept and a dummy variable that takes the value 1 when the probability of a state of high volatility is greater 0.5 and zero otherwise (see Table 3). The coefficient of this dummy variable is the impact this study wants to estimate. This analysis was conducted for both 5 and 10-year CDS and NDF, which are able to trigger the potential shooting rate of the Brazilian fixed-rate securities with the same maturities (5 and 10-year). The model uses weekly data, obtained by the average of the daily data. The analysis for 5-year maturities has a sample ranging from September 2006 to January 2015. The 10-year maturity analysis has a sample that begins in March 2010 and lasts until January 2015. These sample periods differ due to the lack of data for the 10-year NDF. Figures 4 and 5 show the respective performance of NDF and CDS variables in level and the estimated probabilities (SWARCH model) of a high volatility state. Table 3 presents the estimation results.

The following graphs help understand the NDF and CDS modeling. They show two measures: the nominal value of the variable at any given time and their stage of volatility (high or low). Therefore, for each period there is a combination of these two measures. It is noteworthy that nothing prevents the occurrence of both high value of NDF or CDS and a low volatility stage, and vice versa.

Regarding the dynamics of the 5-year NDF, the current level is historically high (near the peaks of 2008-2009), which suggests that in the financial market is pricing significant currency devaluation. However, despite this historically high level, there is a low probability of this being a period of high volatility.

Figure 4 – 5-year NDF behavior and the probability of a high volatility state



Regarding the evolution of the 5-year CDS, its current level appears relatively far from the peaks traded during the financial crisis of 2008/2009. This allows us to infer that this variable has a high increasing potential in the case of a US monetary policy normalization. In terms of volatility stage, there is a likelihood of high volatility in the current scenario.

Figure 5 – 5-year CDS behavior and the probability of a high volatility state

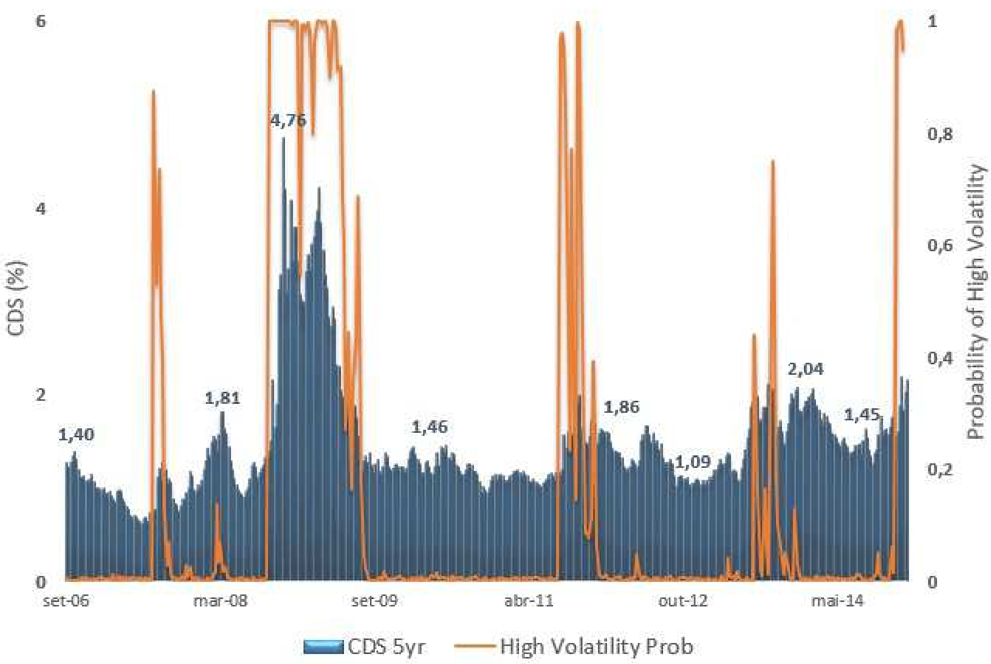


Table 3 presents the estimation results. They indicate that, in case of an activation of the volatility dummy variable[14], the 5-year CDS suffers a shock of 129 basis points while the 10-year CDS suffers a 41 basis points impact. The activation of the dummy would cause the 5-year NDF a shock of 26 basis points while the 10-year NDF would suffer a negative impact of 165 basis points. At first sight, the shooting statistics for the NDF seem discrepant because it indicates little or even negative effects on its rate due to high volatility scenarios. One possible explanation for this effect lies on the current behavior of the NDF. It is currently at a very elevated level, similar to those presented during the great crisis of 2008, and therefore the model suggests that a volatility increase would cause a reduction on its transaction rates.

Table 3 – Coefficient Results of the Dummy Variable (CDS/NDF)

	CDS		NDS	
Maturity (years)	5	10	5	10
explanatory variables				
c	1,3	1,66	6,78	13,30
volatility dummy	1,29	0,41	0,26	-1,65

This Section calculated potential impacts of a stress situation of the financial markets as a result of a US monetary policy normalization on the explanatory variables (US Treasury, NDF and CDS). The following step is to measure the magnitudes of the Brazilian fixed-rate securities based on these inputs.

3.3 The *shooting*, its duration and a new equilibrium for Brazilian fixed-rate securities

It is possible to measure the 5-year and 10-year shootings on the Brazilian fixed-rate bonds with no coupon payment by applying the values of the coefficients found on Table 2 on the potential impacts of the explanatory variables shown on Table 3. The two other relevant assumptions consist on the duration of this shooting and the new equilibrium obtained after this shooting occurred.

In order to obtain an estimative for the duration of the shooting on Brazilian securities, this paper analyzed the behavior of the volatility of the variables CDS and NDF. It considered the number of weeks in which high volatility states (probabilities above 0.5) were present for both variables during the analyzed period. The study used a SWARCH model with three volatility states: high, medium and low, because it would be more applicable to this type of analysis than other models. The use of three states rather than two, as used previously, is justified by the fact that with only two stages the periods of high volatility could be contaminated by volatilities of medium magnitude, which would overestimate the duration of these high volatility weeks.

Regarding the new equilibrium level, the study considered that after the stress period (if indeed it occurs), the new level for the US Treasury (increased by 100 basis points) is maintained while the volatility effect is dissipated. This means the model turns off the volatility dummies for the NDF and CDS variables. This scenario assumes, therefore, that after the announced increases on the FFR by the Federal Reserve, the 10-year Treasury would not only suffer an increase of 100 basis points, but also maintain this new level in the short and medium terms (a structural change in its magnitude). The CDS and the NDF, which in these models suffer the only influence of their respective volatilities, would return to the levels they were prior to the increase of the FFR. This return is justified by the short-term character associated with high volatility periods (market stress).

Table 4 summarizes the obtained results:

[14] As previously explained, the dummy is active every time the volatility state probability is higher than 0,5.

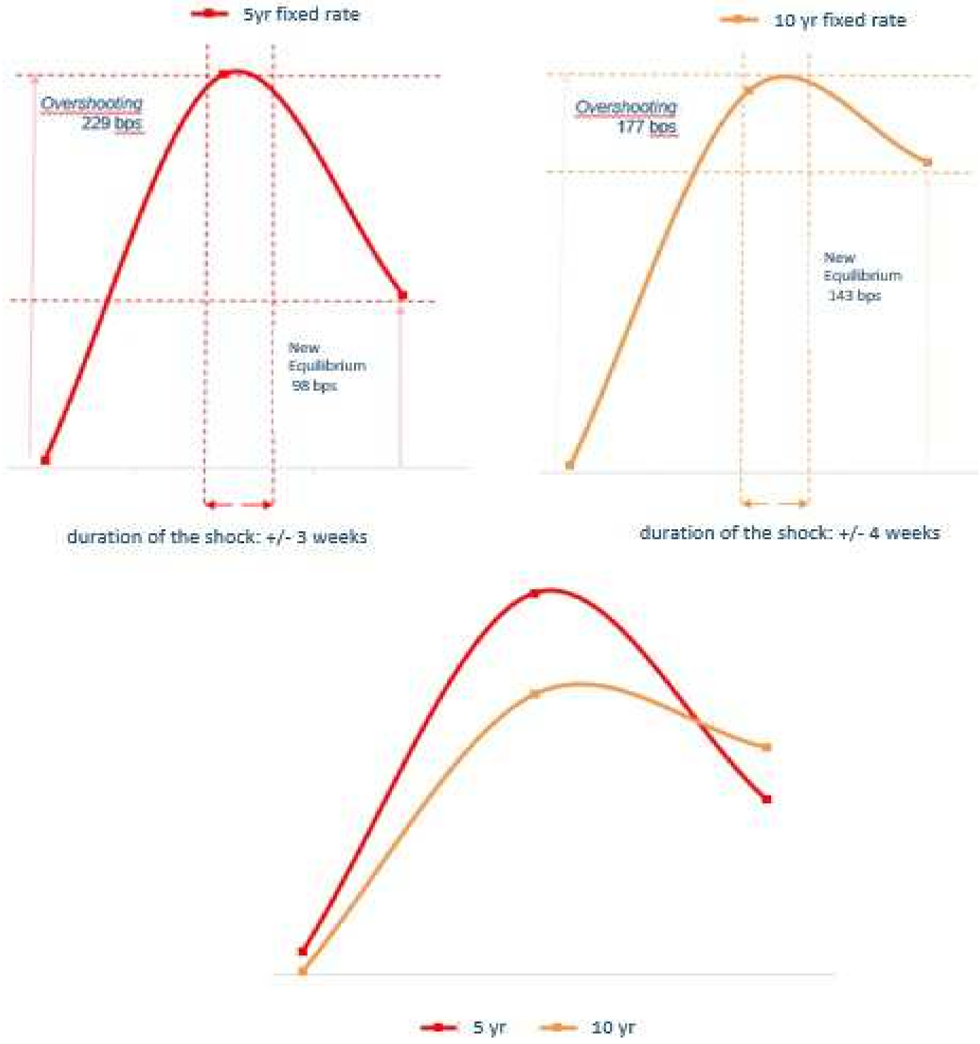
Table 4 –Results for the Shooting and the New Equilibrium

explanatory variables	Gross Shooting (base points)	Weight	Net Shooting (base points)	duration of the shock (SWARCH 3 stages)
10yr US Treasury	100	0,98	98	-
CDS 5yr	129	0,91	117	3 Weeks
NDF 5yr	26	0,53	14	3 Weeks
10yr US Treasury	100	1,43	143	-
CDS 10yr	41	1	41	4 Weeks
NDF 10yr	-140	0,05	-7	4 Weeks

Net effect	Shooting (base points)	duration of the shock (Weeks)	New Equilibrium
5-year fixed rate	229	3	98
10-year fixed rate	177	4	143

For 5-year fixed-rate securities, the raise of the Fed Fund Rate generates a potential increase of 229 basis points on the rate, with an average duration of three weeks and possible new equilibrium at 98 basis points above the level prior to the shock (after the stress peak). Regarding 10-year fixed-rate securities, the results are a shooting of 177 basis points, with an average duration of four weeks and a new equilibrium 143 basis points above current levels. It is noteworthy that the variable NDF presented a zero net impact for both 5 and 10-year securities. Variables CDS and US Treasury presented a similar shooting magnitude for the 5-year rate (a shock of 43% for the US Treasury and of 51% for the CDS), however for the 10-year rate the US Treasury presented an impact (81%) significantly greater than the CDS (23%). Figure 6 illustrates the shootings and equilibriums for the fixed-rate securities.

Figure 6 – Impacts on the Brazilian Fixed-Rate Securities



The figure shows that the security with lower maturity (5-year) presented a larger shooting and a lower equilibrium point than the security with higher maturity (10-year). This dynamic makes evident that changes originated by causes with short-term effects (e.g. high volatility due to stress on the financial markets) generate less impact on rates of longer maturity securities than on rates of shorter maturity securities. However, the new equilibrium setting, which assumes structural changes in the international benchmark rates, provides greater impact on longer maturity securities than those on shorter maturity securities. Therefore, it seems coherent to assume that the potential change of magnitude on the securities rates depends on the source (origin) of the causes. Short-term fluctuations in financial markets show greater impact on lower maturity securities rates, while medium and long-term elements of change influence higher maturity securities rates.

Section 3.4 will estimate the entire yield curve for different maturities using the obtained results for 5 and 10-year Brazilian securities. This will allow obtaining the shooting extent and the new equilibrium not only for specific securities, but also for the entire Brazilian fixed interest curve.

3.4 The Term Structure of the Spread

This paper has only focused on two fixed-rate securities so far. However, the main objective of the present analysis is the assessment of potential impacts of the normalization of US monetary policy on the Brazilian yield curve. The methodology adopted for this purpose consists of the model developed by Nelson and Siegel (1987) which, in short, has the following functional configuration:

$$y_t(m) = \beta_{0_t} + \beta_{1_t}\left[\frac{1-\exp(-\lambda_t m)}{\lambda_t m}\right] + \beta_{2_t}\left[\frac{1-\exp(-\lambda_t m)}{\lambda_t m} - \exp(-\lambda_t m)\right] \quad (7)$$

Where $y_t(m)$ represents the determined security for a given maturity (term), λ_t a time decay factor, β_{0_t} the level, β_{1_t} the slope e β_{2_t} the curvature. Using data for 3 different maturity securities it is possible to calculate the β's and the λ on equation (7) in order to estimate a yield curve with various other maturations. This study adopted the maturities of 1 month, 5 years and 10 years as proxies of short, medium and long-term, respectively. The λ possesses a particular dynamic and was defined as a constant. This configuration provides the following equations, where $y_t(0)$ represents the 1-month fixed-rate security and $y_t(\infty)$ the 10-year fixed-rate security:

$$y_t(0) = \beta_{0_t} + \beta_{1_t} \quad (8)$$

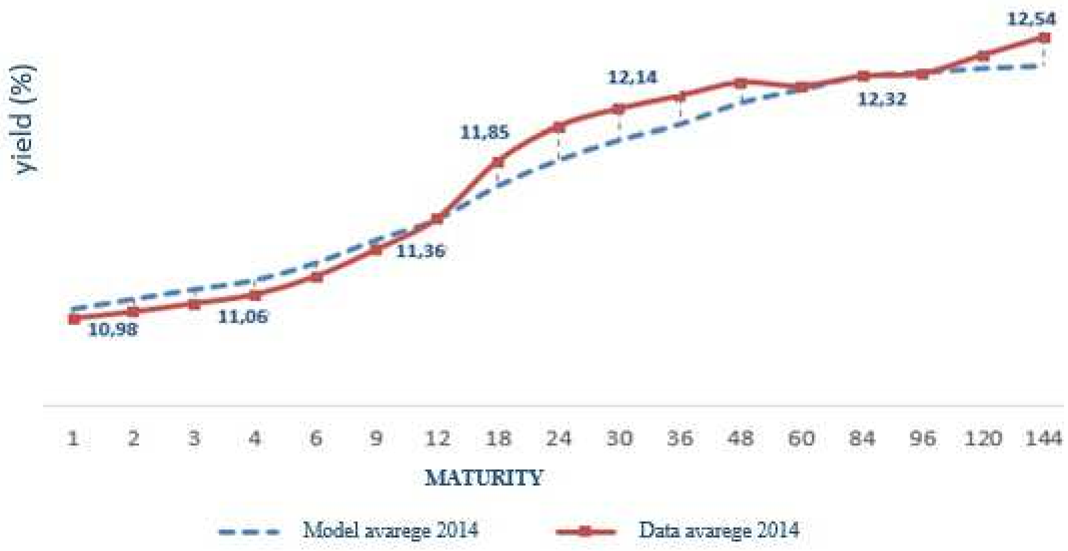
$$y_t(\infty) = \beta_{0_t} \quad (9)$$

$$\beta_{2_t} = \text{(1 month fixed rate + 10 yr fixed rate) - 2x(5 yr fixed rate)} \quad (10)$$

$$\lambda = \text{Mim} \sum (\, inicial\ model\ output_t \;-\; yield\ base\ on\ curve\ past\ data_t)^2 \quad (11)$$

Based on this structure, it was possible to obtain a curve based on past data and, subsequently, use the information obtained in Section 3.3 in order to draw the curve taking into account the shooting and new equilibrium effects[15] (Figure 7). This estimation used weekly data (obtained by a daily average) from fixed-rate securities from September 2006 to January 2015. In addition, it assumed maturities of 1, 2, 3, 4, 6 9, 12, 18, 24, 30, 36, 48, 60, 84, 96, 120 and 144 months (17 different maturities[16]). Figure 7 presents the shape of the curves with actual and model-estimated data for the weekly average of each maturity throughout the year 2014:

Figure 7 – The Brazilian Yield Curve



[15] Considering a peak stress due to the normalization of the US monetary policy.

[16] Over the considered period (2006-2015), interpolation techniques were necessary in order to obtain some security rates for certain maturities.

The next step consists on measuring the curves with the shooting effect and the new equilibrium in order to find the differences (spreads) in the rates in relation to the February/2015 curve. It uses as input the shootings and the new equilibrium shown in previous sessions for the 5 and 10-year fixed-rate securities. After that, it calculates new β's and adopts the same λ of the previous curve. It then estimates new rates in order to obtain a curve considering only the shooting effect and another curve considering only the new equilibrium state. It is noteworthy that for the 1-month fixed-rate no changes in magnitude should be applied (via stress in the financial market) because this rate's composition is influenced by daily rates with minor modifications. Hence, 1-month rates are independent of the scenario in examination. Figure 8 shows the main results:

Figure 8 – The Impact on the Interest Curve

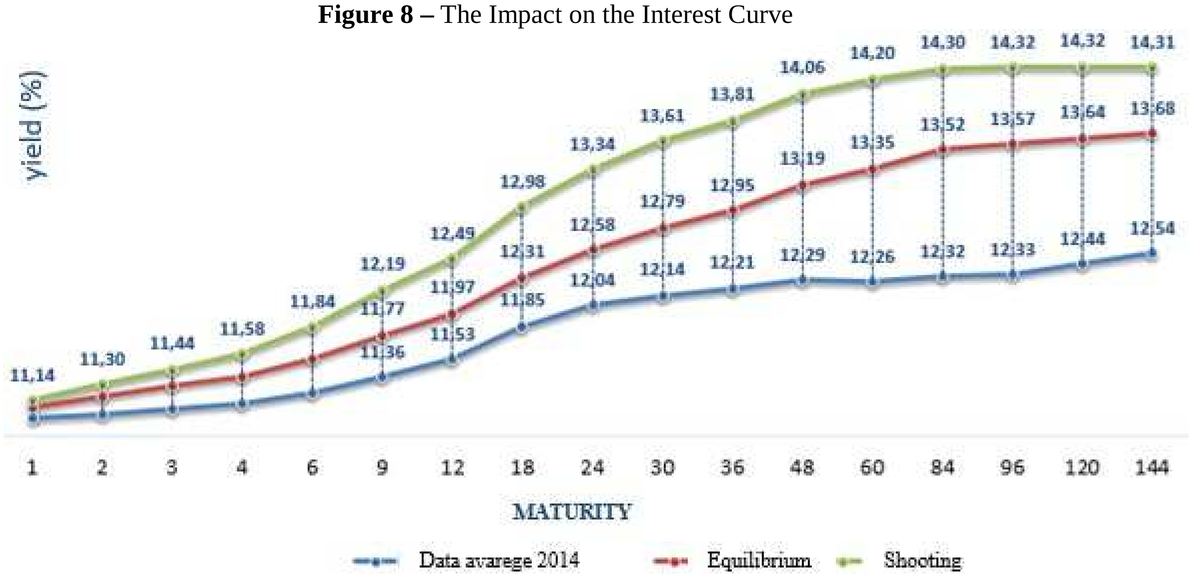


Figure 8 shows the behavior of the Brazilian fixed interest curve for 2 scenarios. The first, named "shooting", reveals the possible impact of the normalization of the US monetary policy during its first weeks. This scenario admits an increase of 100 basis points on the 10-year Treasury and an additional amount that considers the activation of the dummy variables of volatility for the CDS and the NDF. The second, called "equilibrium", maintains the hike of 100 basis points on the 10-year Treasury, but turns off the effects of the dummy variables of volatility, assuming that the stress peak passed and volatility tends to cool.

The behavior of the spreads on the graph, which represent the difference between the February/2015 curve and the shooting and equilibrium curves, is noteworthy because it presumes a steady rise until the securities with 60 and 84 months of maturation (5 and 7 years respectively), and stabilizes for securities with maturities between 120 and 144 months. Concerning the shooting spread, securities maturing in 84 months present the largest differential, an impact of 198 basis points. However, the security with 60 months presented a very similar spread (194 basis points), suggesting the rates begin to stabilize near maturities of 5 years. Regarding the equilibrium curve, securities with maturity of 96 months presented the highest spread, of 124 basis points. Starting from the maturity of 84 months, the spread remained fairly constant, near 120 basis points.

The following graph represents an additional tool that allows separating and identifying the origin of the shooting and its magnitudes. This alternative makes it possible to analyze with greater sensitivity the relevance of the variables used in calculating the shooting for the Brazilian fixed rates.

Figure 9 – The shooting decomposition in the Yield Curve

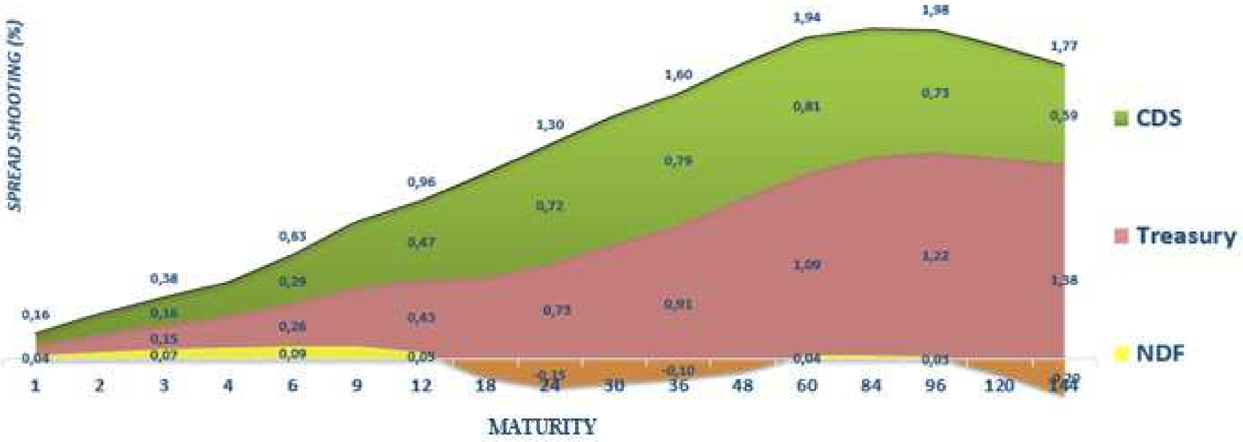


Figure 9 shows that the variables CDS and US Treasury have similar weights considering the net effect of raising rates for securities maturing within 24 months (2 years). However, as the maturity period increases from this point, the US Treasury becomes more relevant to explain the increase in rates of fixed-rate securities than the CDS. The latter continues with significant weight, yet smaller than the Treasury. Concerning the NDF, a possible explanation for the reduced significance on the shooting lies in the current stage of NDF rates (Figure 4), which are set at levels close to the period of great stress during 2008/2009.

4. Contingency Plan

Results of Section 3 display a possible shape for the Brazilian yield curve in the scenario of potential increases in US interest rates not anticipated by financial agents (otherwise the current configuration of the yield curve would already include these increases). They estimated the shooting, the duration and a potential new equilibrium.

Based on this information, this Section will highlight possible measures that could mitigate the effects on the Brazilian government securities market. In this sense, best practices in public debt management indicate the requirement of having in place a contingency plan that specifies how to act in a prolonged stress scenario.

The National Treasury Secretariat (STN) manages the Federal Public Debt (FPD). Its objective is to provide federal government borrowing requirements efficiently and at the lowest long-term cost, while maintaining prudent risk levels[17]. Parallel to this, STN conducts the debt management in order to contribute to a smooth operation of the Brazilian government securities market.

During situations of high stress in financial markets, the National Treasury possesses several active tools to grant an adequate management of the Brazilian public debt. These tools aim to stabilize the market and rebuild the debt management cushion, without exerting excessive pressure on the financing cost, or abandoning the principles highlighted as good practices. Some of the available tools are:

1) Extraordinary Auctions: in temporary events of scarce liquidity on the secondary market, STN may hold extraordinary auctions of repurchase and sale of inflation-linked and fixed-rate securities in order to grant price reference to the market. Extraordinary auctions are usually small and not significant in terms of consumption of the public debt cushion. Its objective is to provide a price reference for assets that may eventually suffer a temporary liquidity shortage.

[17] In order to achieve this objective, pursues the following guidelines, among others: gradually replacing floating rate securities for fixed rate instruments; consolidating the share of inflation-linked and exchange rate-linked instruments on the outstanding debt, in accordance with long-term benchmark; smoothing of the maturity structure, with special attention to the short-term debt; and lengthening of the average maturity of the outstanding debt.

2) Cancellation of fixed-rate and inflation-linked securities auctions: during periods of increased risk aversion, markets may only accept buying these securities at prices and interests that do not correspond to the fundamentals of the Brazilian economy. STN has the right to cancel scheduled auctions, disclosed in the Annual Financing Plan (PAF), at its own discretion. The extraordinary cancellation of auctions in moments of panic in the markets prevents the country from paying elevated costs for its issuances and from causing distortions in its yield curve. The existence of a public debt management cushion leaves STN in a comfortable condition; it allows the Secretariat to stay up to three months without holding any auctions.

3) Issuance of floating rate securities: one of the STN guidelines for managing the FPD is the replacement of floating rate securities for inflation-linked and fixed-rate securities. The objective is to protect the cost of the public debt against a rise in the Brazilian interest rate SELIC. However, during times of market turbulence, floating rate securities are important because they allow recovering the debt cushion and avoid putting pressure on the yield curve, since the risk of interest rate oscillation is not transferred to the market. The issuance of floating rate securities mitigates the refinancing risk and provides a maturity extension for the debt, since these securities hold a longer maturity than the FPD average[18]. Additionally, STN tries to be neutral regarding market liquidity. The issuance of floating rate securities allow STN to maintain the level of debt refinancing without contributing to raise market liquidity and the consequent increase in repurchase agreements from the Central Bank.

4) Issuance of short-term fixed-rate securities: the issuance of fixed-rate bonds with short duration is a complementary approach to the issuance of floating securities because they are similar on their good market acceptance without putting pressure on the yield curve. Its issuance presents little interest rate risk (low duration) and delivers a good return to security holders. Aligned with FPD management best practices, STN should use this kind of issuance with the precaution of observing the FPD refinancing risk limits in order to avoid excessive concentration of maturing bonds in the short term. Equally to the floating securities issuance, short-term fixed-rate securities avoid increasing repurchase agreements by the Central Bank.

5) Cancellation of external issuances: STN does not use issuances in Dollar or in currencies other than the Real as a funding source. It holds external issuances in order to diversify the investor base, consolidate Brazil in the international market and generate well-established price references (foreign sovereign yield curve) for Brazilian corporations access the international debt market. In times of market turbulence, external issuances are usually not favorable in terms of rates. Therefore, STN has the discretion to cancel their scheduled emissions, avoiding distortions on reference prices.

5. Conclusion

In order to combat the effects of the financial crisis of 2008/2009, countries around the globe adopted monetary policy measures, which increased considerably the international liquidity and presented a scenario of significant impact on the prices of assets in financial markets. In particular, exchange rates and sovereign debt securities suffered these impacts. However, the United States has been working with the possibility of reversing its expansionary monetary policy through gradual increases in its benchmark interest rate (FFR), given the recent improvement in its macroeconomic framework. This fact has drawn attention of financial agents for the potential impact on asset pricing and market volatilities. In a high liquidity scenario, a sudden (or unanticipated) change in such an important international reference rate can generate significant noise in the markets. Moreover, countries with the highest perceived risk (via more challenging macroeconomic environment) might have these effects amplified, with serious consequences for their real economies.

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[18] Today the issuance of the Brazilian securities “LFT” present a maturity of 6 years.

Considering this perspective, the objective of this study was to analyze the impact of the US monetary policy normalization on the Brazilian fixed yield curve, as well as discuss the available tools to mitigate its impact the country's markets. At first, on section 2, it tried to understand the potential increase on 10-year Treasury, due to its high importance in the interest composition of Brazilian securities. Through the construction of two different methodologies, a single-equation model and an approach that used the Expectation Hypothesis, it found similar results of a potential increase of 100 bps in the 10-year Treasury due to a possible reversal in the scenario of the US monetary policy.

Section 3 incorporated the results obtained in section 2 and analyzed the effect of two relevant variables to explain the rates of the Brazilian securities: CDS and NDF. It used a specific methodology to identify increases in the interest of 5-year and 10-year securities, and the Nelson and Siegel model (1987) to verify this impact across the Brazilian yield curve. Thus, it became possible to draw the term structure of the spread, which works as a reference for understanding the potential variation in Brazilian rates due to changes in the US Treasury. In particular, 1, 5 and 10-year securities presented estimated shocks of 96 bps, 194 bps and 188 bps, respectively. It also estimated the duration of the shooting, with results of around 3 to 4 weeks. Moreover, Section 3 introduced the decomposition of the term structure of the spread, in order to understand the driver of the shooting. It showed that the variables CDS and US Treasury have similar weights in the net effect on raising rates for securities maturing within 24 months (2 years). However, from 2-years to longer maturities, the US Treasury becomes more relevant, being the predominant asset to explain the increase in rates of fixed-rate securities, while the CDS continues with significant weight, though smaller.

Based on the results of Section 3, the study focused on identifying possible tools that the STN may adopt in order to mitigate the impacts on the sovereign securities rates. It identified five main possibilities as a contingency plan: implementing extraordinary auctions, cancelling fixed-rate securities and inflation-linked securities auctions, floating rate securities issuance, short-term fixed-rate securities issuance and cancelling external issuances. Despite the fact that the present study identified a possible challenging scenario for the country, STN, responsible for managing the Brazilian public debt, has at its disposal mechanisms to absorb impacts and thereby mitigate the effects on sovereign securities markets in Brazil.

There should be caution in interpreting the results of this study. However, there is no denying its conclusions are able to clarify relevant information that can help improve the current debate on the situation of emerging countries in a scenario of US monetary policy normalization.

Bibliography

Akhtar, M. A. (1995). Monetary Policy and Long-Term Interest Rates: A Survey of Empirical Literature. *Contemporary Economic Policy*, 13(3), 110-130.

Beechey, M. J. (2007). A closer look at the sensitivity puzzle: The sensitivity of expected future short rates and term premia to macroeconomic news.

Berument, H., & Froyen, R. (2009). Monetary policy and US long-term interest rates: How close are the linkages?. *Journal of Economics and Business*, *61*(1), 34-50.

Ellingsen, T., & Söderström, U. (2004). Why are long rates sensitive to monetary policy?.

Fisher, I. (1896). *Appreciation and Interest: A Study of the Influence of Monetary Appreciation and Depreciation on the Rate of Interest with Applications to the Bimetallic Controversy and the Theory of Interest* (Vol. 11, No. 4). American economic association.

Fisher, I. (1930). The Theory of interest rates. *New York*.

Frankel, J. A., & Froot, K. A. (1985). *Using survey data to test some standard propositions regarding exchange rate expectations* (No. w1672). National Bureau of Economic Research.

GFSR, I. (2014). International Monetary Fund, Global Financial Stability Report.

Gurkaynak, R. S., Sack, B., & Swanson, E. (2005, March). The sensitivity of long-term interest rates to economic news: Evidence and implications for macroeconomic models. American Economic Review, 95(1), 425–436.

Hamilton, J. D., & Susmel, R. (1994). Autoregressive conditional heteroskedasticity and changes in regime. *Journal of Econometrics*, 64(1), 307-333.

Nelson, C. R., & Siegel, A. F. (1987). Parsimonious modeling of yield curves.*Journal of business*, 473-489.

Reifschneider, D., Tetlow, R., & Williams, J. (1999). Aggregate disturbances, monetary policy, and the macroeconomy: The FRB/US perspective. *Fed. Res. Bull.*, *85*, 1.

Reserve, F. (2005). The Federal Reserve System: Purposes and Functions. *hp://www. federalreserve.gov*.

Roley, V. V., & Sellon, G. H. (1995). Monetary policy actions and long-term interest rates. *Federal Reserve Bank of Kansas City Economic Quarterly*,*80*(4), 77-89.

Thornton, D. L. (2012). Greenspan's conundrum and the Fed's ability to affect long-term yields. *FRB of St. Louis Working Paper No*.