EXTERNAL VOLATILITY AND EXCHANGE RATE MOVEMENTS IN BRAZIL

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ABSTRACT
This article investigates the relationship between external volatility and the dynamics of the Brazilian Real in the past 11 years. Our model suggests that a daily change of one standard deviation in the VIX led to an average daily depreciation of 0.135% in the Brazilian Real during this period. After endogenously allowing this effect to change over time and controlling for a series of market-related variables, results show that the Brazilian economy is more affected by external markets movements today than in the beginning of the decade. On average, a change of one standard deviation in the VIX led to a depreciation of 0.4% in the Brazilian Real during the Great Recession and was not significant in the beginning of the last decade, when Brazil experienced internal volatility due to the election period. While emerging economies have become less volatile in the recent past, their currencies are still vulnerable to external volatility.

Keywords: Emerging Markets; Exchange Rate; Structural Break; Volatility.

Área Temática: Mercados Financeiro, de Crédito e de Capitais.

1 INTRODUCTION

The volatility of international markets is a very important factor relating to exchange rates of emerging economies. Increases in volatility across international markets usually drive investors to buy U.S. bonds or other risk free assets. They tend to abruptly reduce investments in risky prone economies, depreciating emerging markets currencies (Calvo, Leiderman and Reinhart, 1993).

We analyse an 11-year period of exchange rate fluctuations in Brazil to measure how changes in international volatility levels, interest rates and other variables affected the currency. The advantage of using Brazilian data to investigate exchange rate movements is that it is a major emerging economy[1] and has a floating exchange rate regime, which is not the case in other emerging economies, like China for example.

[1] Brazil was the 6th biggest economy in the world in terms of GDP in 2011, according to the World Bank´s World Development Indicators dataset.

The economic theory suggests that the dynamics of exchange rates are driven by expectations about future prices and interest rates differentials (Dornbusch, 1976). Institutional changes like the ones occurred in Brazil in the late 90s and early 2000s (the end of inflation, switch to a free floating exchange rate and political maturity) tend to affect growth rates, volatility and financial market perceptions (Acemoglu et al., 2003). In this process, the effect of external volatility on exchange rates may vary across time. Brazil is an interesting country to study this possibility as it has passed by many institutional changes in the previous 20 years. In 1989, Brazilians voted for president for the first time after a long dictatorship regime. Inflationary problems ended after Plano Real in 1994 and the creation of a new currency, the Brazilian Real[2]. A long list of peaces of legislation was approved to balance the fiscal deficits, including changes in the public pension fund and detachment of revenues from expenditures, known as DRU. Finally, Brazil experienced a peaceful change in power in 2002, when President Lula, from the opposition, was elected after eight years of President Cardoso in power. All these changes certainly affected how the rest of the world views the Brazilian economy, the trade and investment flows of Brazil with other economies around the globe, and how the Brazilian economy responded to periods of crisis and high volatility in global markets.

The empirical literature shows that implicit volatility indexes contain relevant information about financial market sentiments, future prices and returns (Christensen and Prabhala 1998; Fleming, 1998; Blair, Poon and Taylor, 2001; Corrado and Miller, 2005). Results also show that volatility in financial markets may also affect other economic variables like total exports (Serenis, 2013) and influence how Central Banks decide to intervene in the exchange rate markets (Hoshikawa, 2008). It has been also reported that the effects of international volatility may vary substantially among countries (Kenen and Rodrik, 1986). A natural question is to ask if this important effect varies across time in a country facing many political and economic changes, like Brazil.

Previous results have shown that variation in the Brazilian Real is strongly influenced by external volatility recently (Schwartsman and Pinheiro, 2010) and that its implicit volatility is a key determinant of future volatility (Chang and Tabak, 2007). Studying how external volatility affects exchange rates variation is important as other studies have shown that exchange rate variation can have a significant impact on productivity growth and that this effect depends crucially on the level of financial development of the country (Aghion et al., 2009) and of its institutions (Acemoglu et al., 2003 and 2004) .

This article investigates the effects of international volatility, measured by the implicit volatility index of the S&P 500 index on the Brazilian Real exchange rate during in the past decade. We build our sample collecting daily data on the Brazilian exchange rate, the volatility index, interest rates and other financial variables from 2001 to 2012. The sample was restricted to days for which there were transactions in both markets (Brazil and U.S.) and with data available in the Bloomberg database. Our final sample consists of 2,734 daily observations.

We take advantage of our long dataset during a floating exchange-rate regime in this emerging economy and estimate the direct effect of the daily variation in the external volatility index on the variation of the Brazilian currency, while allowing this effect to endogenously change throughout this period. Our results show that the average effect of the volatility was to depreciate the Brazilian Real. Our model suggests that a daily change of one standard deviation in the VIX, about 6.53%, led to an average daily depreciation of 0.135% in the Brazilian Real during the past decade. However, this effect was not constant during the period of analysis. It was statistically insignificant in the beginning of the decade, when Brazil

[2] For a good review of the Plano Real see Franco (1995)

faced internal volatility. After that, it was positive and significant between 2004 and the initial months of 2008. On average, a change of one standard deviation in the VIX led to a devaluation of 0.4% in the Brazilian Real during the Great Recession and decreased to its pre-crisis level, showing that the Brazilian economy and its policies have improved in the past years, but it still is vulnerable to external shocks.

The remainder of this paper is organized as follows. The next section describes the exchange-rate regimes in Brazil since 1999. The data set, descriptive statistics, and the empirical strategy are presented in Section III, and the results are presented in Section IV. Section V concludes.

2 EXCHANGE-RATE REGIMES IN BRAZIL

In 1999, Brazil moved from a fixed exchange-rate to a floating exchange-rate regime, as a consequence of the Russian Crisis. In the same year, the Central Bank of Brazil started to implement a monetary policy based on inflation targeting. The floating exchange-rate regime and the inflation target policy are the main pillars of the Brazilian macroeconomic policy since then (Souza and Hoff, 2006).

Brazilian economic policies were first put on check in 2002, when Brazilian Real experienced a 42% depreciation in the months preceding the presidential election won by Luiz Inácio Lula da Silva, in October. The new president calmed down the markets by promising to keep the economic policies of his predecessor, and the Brazilian Real regained most of its value during the early 2000s (Souza, 2005). A second currency crisis was inevitable in the aftermaths of the Lehman Brothers bankruptcy in September of 2008. The Central Bank of Brazil intervened in the exchange-rate market, buying national currency in the spot market and through other financial instruments (futures and derivatives). One year later, the Brazilian Real was back to its market value before the crisis. The graph below shows the movements in the Brazilian Real since January 2001 until June 2012.

Graph 1: Brazilian Real Exchange Rate

Throughout the past 12 years the Central Bank of Brazil has intervened in the exchange rate market many times, for many different reasons, especially to reduce volatility

or short-run movements[3]. However, most economists agree it may still be considered a free floating exchange-rate regime.[4]

3 DATA AND EMPIRICAL STRATEGY

We collect daily data from different sources for the period from 3/1/2001 to 6/29/2012. After excluding dates when financial markets were closed, our final sample contains 2,734 observations.

In order to analyse the effects of the external volatility on exchange rate movements, we initially calculate the daily log-change in the Brazilian Real/USD exchange rate (BRL) and the daily log-change in the implicit volatility of the S&P 500 Index (VIX)[5][6].

Our initial method consists of estimating the relationship between the daily change in BRL and the VIX. The assumption is that increases in the external market volatility should drive investors away from a more risky market (Brazil), depreciating (increasing) the Brazilian Real.

Our empirical model derives from the interest rate parity model (no arbitrage condition) that states that no difference can exist between the expected returns on domestic and foreign assets (Feenstra and Taylor, 2008; Mishkin, 2006). If there are changes in the interest rate differentials, the there should be changes in exchange rates. Therefore, we included control variables that measure changes in the short-run interest rates in Brazil (BAZD) and in the United States (USS), as well as the long-run interest rate in the United States (GT10) in order to control for capital movements due to interest rate differentials.

Exchange rates are influenced not only by capital movements, but also by the flow of services and goods between countries. Movements in commodities prices, which are very important for both Brazil and the U.S., were taken into account using the daily change in the Reuters CRB Commodity Index (CRY). Also, as an attempt to control for movements in the U.S. Dollar relative to the world economy, we use the daily change in an index that measures the value of the U.S. Dollar against a basket of seven currencies (DXY). In our final specification, we also include the daily change in the Brazilian Stock Exchange Index (IBOV) to control for investment movements in the local equity market. Descriptive statistics are presented in Table 1[7].

Table 1: Descriptive Statistics

	Mean	Median	Std. Dev.	Min.	Max.
ΔBRL	0.00001	-0.00028	0.01174	-0.10344	0.06396
ΔVIX	-0.00021	-0.00529	0.06539	-0.35059	0.49601
ΔBZAD	-0.00029	-0.00049	0.01287	-0.08014	0.13658
ΔUSSW	-0.00090	0.00000	0.02868	-0.16582	0.23171
ΔGT10	-0.00040	-0.00046	0.02027	-0.17108	0.14304
ΔCRY	0.00014	0.00041	0.01213	-0.06878	0.07416
ΔDXY	-0.00011	-0.00013	0.00558	-0.02726	0.02520
ΔIBOV	0.00046	0.00104	0.01949	-0.12277	0.13678

Notes*:* Values are in log-differences. N = 2733.

[3] For a good review of the Brazilian history in the past 25 years please refer to Luna and Klein (2006).

[4] Brazil was not among the countries investigated by Calvo and Reinhat (2002).

[5] There are other important volatility indexes. The VXD measures the volatility index of the Dow Jones Industrial Index, the VXN measures the implicit volatility of the NASDAQ Index, and the VDAX measures the implicit volatility of the German index DAX-30 (Whaley, 2009).

[6] Flemin, Ostdiek and Whaley (1995) was one of the first articles to use VIX as a measure of volatility. Empirical works like the ones of Low (2004), Blair, Poon and Taylor (2001) and Becker et al. (2009) show that the index can be an efficient measure of information when predicting asset prices.

[7] Data for BRL and GT10 are from Bloomberg, VIX is from the Chicago Board Options Exchange, BZAD and IBOV are from the BM&F Bovespa, and CRY and DXY are from the New York Board of Trade.

The empirical model can be written in a regression form as:

$$\Delta BRL_t = \alpha + \beta \Delta VIX_t + \gamma \Delta X_t + \epsilon_t \quad (1)$$

where Δ is the log-difference of the variable, X_t is the set of control variables described above, ϵ_t is a normally distributed error term, and α, β and γ are the parameters of interest. The vector of control variables contains ΔBZAD, ΔUSSW, ΔGT10, ΔCRY, ΔDXY, and ΔIBOV.

Table 2 presents the correlations between control variables. There is not much evidence of high correlation between control variables. The highest correlation is between ΔGT10 and ΔUSSW, 0.395, but it is not much of a concern in terms of multicolinearity. The correlation matrix indicates that at there is no direct evidence of redundant variables in the model, although there might exist linear combinations of the variables that may still cause a reduction in efficiency.

Table 2: Correlation Matrix

	ΔBZAD	ΔUSSW	ΔGT10	ΔCRY	ΔDXY	ΔIBOV
ΔBZAD	1					
ΔUSSW	0.017043	1				
ΔGT10	0.002435	0.395084	1			
ΔCRY	-0.04144	0.026887	0.209571	1		
ΔDXY	0.022059	0.244349	0.05554	-0.36546	1	
ΔIBOV	-0.35375	0.043513	0.28471	0.326494	-0.16216	1

Note: 2733 observations.

4 RESULTS

We estimate the model (Equation 1) using three groups of control variables. Results are presented in Table 3. After controlling for interest rate differentials, movements in commodity prices, changes in the USD Dollar versus a basket of currencies and the dynamics of the Brazilian Stock Exchange, the coefficient β indicates a positive and significant relationship between external volatility and the exchange rate (column 3). Our model suggests that a daily change of one standard deviation in the VIX, about 6.53%, led to an average daily depreciation of 0.135% in the Brazilian Real during the past decade.

This initial model assumes that the effect of VIX on the BRL, captured by β, is constant over time. However, this relationship may not be true if in fact the floating exchange-rate regime suffered interventions designed to reduce the effects of external volatility movements in the Brazilian Real. Also, as well as many others developing countries, Brazil faced a strong depreciation during the first months of the Great Recession, which may have changed this effect during that unstable period.

Table 3: Effect of external volatility on BRL

	(1)	(2)	(3)
ΔVIX	0.0694***	0.0543***	0.0207***
	(0.0042)	(0.0040)	(0.0042)
ΔBZAD		0.3128***	0.2251***
		(0.0213)	(0.0228)
ΔUSSW		0.0344***	0.0172**
		(0.0086)	(0.0084)
ΔGT10		-0.0725***	-0.0433***
		(0.0135)	(0.0124)

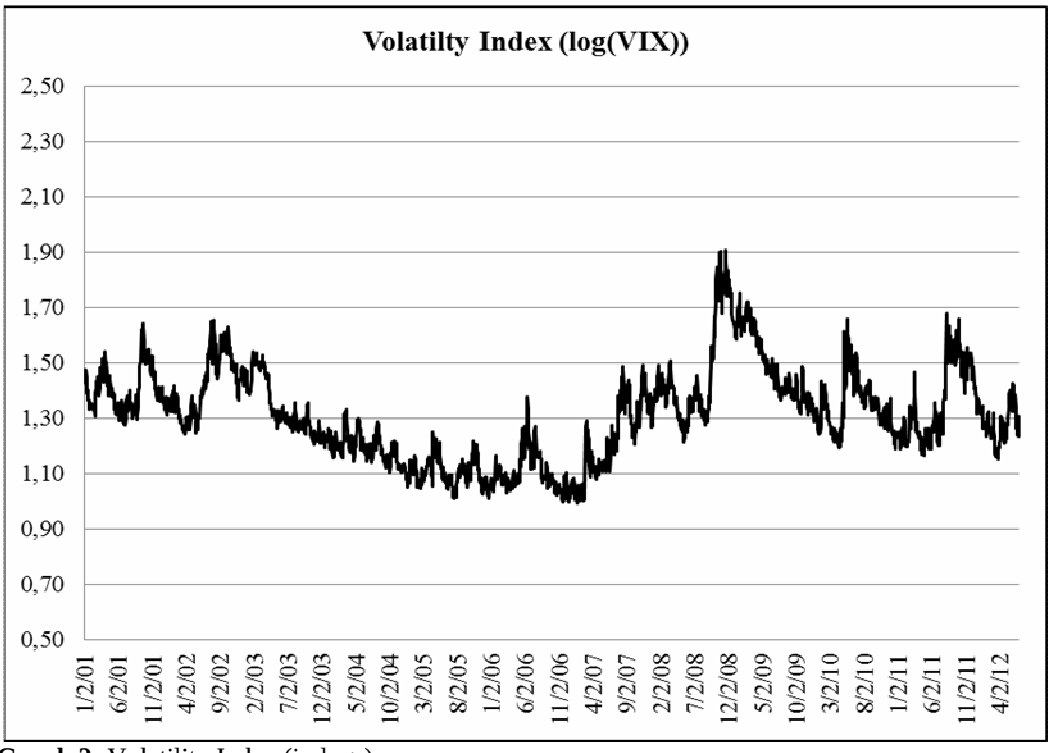
ΔCRY			-0.0894***
			(0.0209)
ΔDXY			0.2827***
			(0.0428)
ΔIBOV			-0.1917***
			(0.0181)
Constant	0,0000	0,0001	0,0002
	(0.0002)	(0.0001)	(0.0001)
F-statistic	479.68***	258.62***	246.13***
Adj. R^2	0,1491	0,2739	0,3858

Notes: Robust SE in parenthesis. N = 2733.
,* Statistically significant at the 5%, and 1% levels, respectively.

To analyse the dynamics of the BRL-VIX relationship through the decade, we allow β to vary over time. In order to find the periods for which this relationship may have changed, we investigate the dynamics of the external volatility index (VIX). It is important to notice that while this test identifies structural changes in the VIX level, it does not necessarily imply a change in the parameter β.

We perform the traditional Bai and Perron (1998, 2003) test for multiple structural break changes (using h = 0.125) and find five structural break dates in the log(VIX) series: 4/11/2003, 9/10/2004, 4/9/2007, 9/12/2008 and 2/12/2010, defining 6 periods for which the parameter may have changed.

This result is very interesting as it captures the Great Recession with anticipation of exactly three days while it also indicates a change in external volatility in the first couple of years of the decade, after the dot-com bubble break. The method also identifies two periods of relatively calm in external financial markets between 2004 and 2008, when emerging countries grew fast and improved their credibility (see Graph 2, next page). It was exactly during this last period before the Great Depression that Brazilian government bonds obtained the Investment Grade level from Standard & Poor's. The precise date was April 30, 2008.



Graph 2: Volatility Index (in logs)

Table 4: VIX Descriptive Statistics

Period	Mean	S.D.	Max.	Min.
1	26.915	5.804	45.080	17.400
2	17.676	2.158	23.410	13.760
3	12.900	1.932	23.810	9.890
4	21.179	4.651	32.240	11.980
5	35.684	14.147	80.860	17.550
6	22.563	6.627	48.000	14.260

Note: These statistics are for the VIX in level terms, not in logs.

Another interesting aspect of this procedure is that it captures not only the changes in the level of the VIX, but also in the variance. Table 4 presents the main descriptive statistics for each period. Notice that in period five, during the Great Recession, volatility attains its highest variance across periods. While the minimum, 17.55, is comparable to the one in the first period, the maximum is almost twice as big and the standard deviation is almost three times the standard deviation of the first period.

Table 5: Structural change regressions

	(1)	(2)
D1*ΔVIX	-0.0015	-0.0013
	(0.0136)	(0.0137)
D2*ΔVIX	-0.0011	-0.0008
	(0.0076)	(0.0077)
D3*ΔVIX	0.0183***	0.0184***
	(0.0052)	(0.0052)
D4*ΔVIX	0.0164***	0.0167***
	(0.0057)	(0.0057)
D5*ΔVIX	0.0617***	0.0619***
	(0.0121)	0,012108
D6*ΔVIX	0.0283***	0.0283***
	(0.0058)	(0.0058)
D2		0.0004
		(0.0003)
D3		-0.0001
		(0.0003)
D4		-0.0004
		(0.0003)
D5		0.0004
		(0.0006)
D6		0.0001
		(0.0003)
Constant	0.0002	0.0007
	(0.0001)	(0.0005)
Controls	Yes	Yes
F-statistic	149.79***	106.01***
Adj. R2	0.3952	0.3952

Notes: Robust SE in parenthesis. N = 2733.
*** Statistically significant at the 1% level.

When the relationship BRL-VIX is allowed to vary across time, we observe an interesting result (Table 5). In the first two periods determined by the structural-break test, there is no statistically significant effect of the changes in the external volatility over the BRL. This period is exactly the one in which the BRL was driven more by its internal political crisis, rather than by external shocks. This result shows that when internal volatility is more important, the relationship BRL-VIX is not important. Although it is important to notice that

periods one and two were also periods with relatively low variance in the VIX when particular when compared to period five, for example.

However, after this date, the effect of the external volatility index becomes positive and significant, reaching its peak during the Great Recession. On average, after controlling for the same group of variables, a change of one standard deviation in the VIX, led to a depreciation of 0.404% in the Brazilian Real during the recession (fifth period). The coefficient has almost two times the magnitude of its effect observed in the years preceding the crisis (third and fourth periods) and after the more turbulent period (last period).

This is a very interesting results, it shows that when the levels of external volatility increases, it becomes one of the driving forces of the changes in the Brazilian Real. While external volatility seen to be of less importance when the volatility is low, the magnitude of the effect increases during high volatility periods.

As a final robustness check, in the last specification we also allow both the intercept α and the coefficient β to be different among the five periods determined by the structural-break test. The results remain unchanged (column 2). The coefficient α is not statistically significant in any of the specifications.

These results highlight the variation of the direct effect of external volatilities on emerging market currencies over time. While emerging economies have recently become less volatile, their currencies are still vulnerable to external volatility, even after many institutional changes in the past 20 years.

5 CONCLUDING REMARKS

The present article measures how the relationship between external volatility and the Brazilian Real changed during the past 11 years, when Brazil was under a free floating exchange-rate regime and an inflation targeting regime. Using daily data from 2001 to 2012 we estimate that a change of one standard deviation in the VIX, about 6.53%, led to an average depreciation of 0.135% in the Brazilian Real during the past decade.

Our results suggest that, after allowing this effect to endogenously change over time, this relationship may vary substantially, especially during periods of extreme external volatility. On average, after controlling for the same group of variables, a change of one standard deviation in the VIX, led to a depreciation of 0.4% in the Brazilian Real during the recession.

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