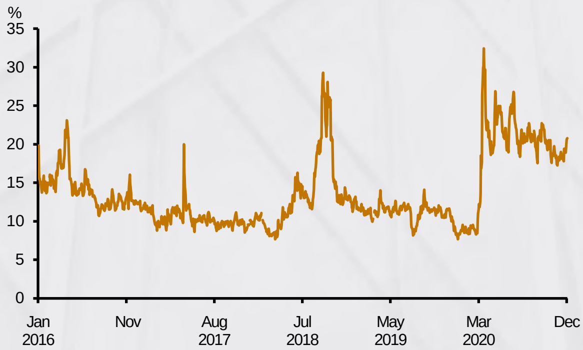
Foreign exchange rate volatility in Brazil

Since 2020, the volatility of the USD/BRL exchange rate has been above the historical average. Figure 1 shows the model-free implied volatility extracted from 1-month FX options.[1] Volatility sharply increases as of March 2020, when the Covid-19 pandemic started in Brazil. The high volatility persists until mid-2020 and declines afterwards, although not returning to pre-pandemic levels. For instance, the daily average volatility between October and December 2019 was 10.33% p.a., while in the same period in 2020 it was 19.42% p.a., almost twice as much. An increased FX rate volatility contributes to greater economic uncertainty, harming the formation of economic agents' expectations and the proper conduct of public policies. For example, a volatile FX rate discourages foreign investments and undermines the planning of importers and exporters. The aim of this box is to investigate the key factors underlying the USD/BRL FX rate volatility.

Figure 1 – Foreign exchange rate (USD/BRL) implied volatility



In contrast with what occurs with the FX rate level, the economic literature has not yet presented a consolidated structural model that explains volatility. The FX rate volatility is usually modeled by econometric models of the GARCH family (generalized autoregressive conditional heteroskedasticity), which reproduce some observed stylized facts.[2] However, one characteristic of this approach is the use of autoregressive terms in the conditional variance equation. These terms generally dominate the model fitting and leave no room for other explanatory variables. This motivates this investigation on the determinants of the FX rate volatility by means of a purely empirical methodology (kitchen sink like), which does not include autoregressive terms. Therefore, a group of potentially relevant variables chosen ad-hoc will be tested. Thus, this box should be seen only as a first step of investigating variables related to the USD/BRL FX rate volatility.

A lot of factors may explain volatility movements, varying from systemic factors – like the pandemic itself, that may be captured, for instance, by volatility indexes in currency markets, interest rates or stock prices – to idiosyncratic domestic factors – such as the Brazilian fiscal outlook or the FX market structure.

1/ Unlike the implied volatility extracted from option pricing models, this box uses the concept of model-free implied volatility because it does not assume a specific probability distribution for the price of the underlying asset. These volatilities are extracted directly from options prices. The model-free volatility concept used in this box was proposed by Bakshi, Kapadia and Madan (2003).

2/ For example, a significant variation in the FX rate has a strong impact on its volatility, which takes time to dissipate since volatility is predominantly inertial.

As systemic variables, the empirical strategy employs the VIX,[3] the Dollar Index of Emergency Currencies (DXY_EME)[4] – a basket of currencies of emerging countries against the US dollar –, the CRB index of commodity prices, and the first principal component of the model-free implied volatility extracted from a basket of emerging countries' currencies (VOL_IMP_CP_EME).[5] As local variables, the 5-year CDS-Brazil (CDS), the 1-year interest rate differential between Brazilian (in BRL) and US (in USD) securities (DIF_JUROS), and the number of mini US dollar futures contracts traded in the Brazilian stock exchange B3 (MINI_DOLAR) were used.

In addition to these variables, the model also uses the forward interest rate between 3 and 5 years from National Treasury securities negotiated in Brazil (TERMO 3_5) which, like CDS, tries to capture the fiscal risk. Supposedly, the FX rate volatility is expected to increase in periods of greater fiscal risk.

The use of a variable for the liquidity of the mini US dollar futures contracts becomes potentially relevant due to the sudden increase of transactions in this market in 2020 (Figure 2), which received a great number of individuals. This increase leads to the attraction of high-frequency funds, which may, theoretically, increase the FX rate volatility due to the way they work.[6]

Figure 2 – Number of mini US dollar futures contracts traded on the Brazilian stock exchange

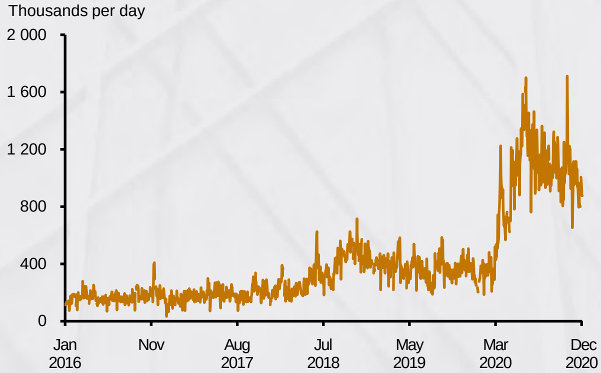


Table 1 shows several specifications of the FX rate volatility models, estimated by Ordinary Least Squares (OLS), in which the 1-month implied volatility is the dependent variable. Models were estimated using a sample ranging from 2011 to 2020, with daily frequency data.[7]

The systemic variables used in model 1 are VIX, DXY_EME and CRB, whereas the local variables are CDS and DIF_JUROS. In model 2, the variables DXY_EME and CRB are considered in terms of volatility instead of levels.[8] In model 3, the CDS variable is replaced by Termo_3_5, which generates a reduction in the adjusted R^2.

Models 4, 5 and 6 incorporate the volatility of emerging countries (VOL_IMP_CP_EME), which increases the adjusted R^2 and reduces the Schwarz Information Criterion (SIC). Models 5 and 6 add the MINI_DOLAR in the set of explanatory variables. The difference between them is that model 6 excludes the differential of domestic and external interest rate (DIF_JUROS), because MINI_DOLAR replaces that variable statistical

3/ Volatility index based on options, negotiated in the Chicago Board of Exchange (CBOE), concerning stocks belonging to the S&P500 index. For further details, see: https://www.cboe.com/tradable_products/vix/.
4/ Available in the Federal Reserve Bank of St. Louis homepage: https://fred.stlouisfed.org/series/DTWEXEMEGS.
5/ The currencies of the following countries are considered: India, Mexico, Russia, Chile, Singapore, South Africa, Colombia, Malaysia, Israel, Philippines and Thailand. The principal component is standardized to have a mean of 0 and standard deviation of 1.
6/ Despite the sharp increase in the number of individuals operating in the futures market of US dollar mini contracts, nearly 80% of this market is made up by institutional investors, such as investment funds and banks. Furthermore, more than 95% of transactions consist in day trade operations (as of June 2020), highlighting the great number of high frequency operations.
7/ The sample begins in 2011, when mini US dollar futures contracts began to be negotiated.
8/ Both estimated by econometric models of the GARCH family.

Table 1 – Estimation results of USD/BRL FX volatility models

Dependent variable: USD/BRL volatility	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C	9.511 **	3.020 ***	0.515	6.486 ***	2.947 **	3.082 **	-3.060	-3.047
	(4.751)	(0.801)	(1.596)	(1.374)	(1.460)	(1.323)	(2.032)	(2.022)
VIX	0.285 ***	0.230 ***	0.203 ***	0.165 ***	0.142 ***	0.148 ***	0.134 ***	0.137 ***
	(0.034)	(0.032)	(0.034)	(0.034)	(0.036)	(0.036)	(0.034)	(0.032)
DXY_EME	-0.012							
	(0.024)							
VOL_DXY_EME		4.260 *	14.836 ***	1.720	1.173			
		(2.432)	(2.143)	(2.263)	(1.708)			
CRB	-0.010							
	(0.007)							
VOL_CRB		0.395	-1.296 ***	0.695	1.387 **	1.525 **	1.730 ***	1.715 ***
		(0.437)	(0.372)	(0.447)	(0.592)	(0.595)	(0.584)	(0.583)
VOL_IMP_CP_EME				16.145 ***	12.438 ***	13.071 ***	15.297 ***	14.715 ***
				(4.897)	(4.420)	(4.008)	(4.398)	(3.714)
CDS	0.030 ***	0.029 ***		0.024 ***	0.014 ***	0.015 ***		
	(0.005)	(0.004)		(0.004)	(0.004)	(0.003)		
TERMO_3_5			0.644 ***				0.794 ***	0.753 ***
			(0.208)				(0.165)	(0.129)
DIF_JUROS	-0.307 ***	-0.313 ***	-0.215 *	-0.422 ***	0.038		-0.045	
	(0.103)	(0.074)	(0.111)	(0.079)	(0.100)		(0.106)	
MINI_DOLAR					6.3E-06 ***	6.2E-06 ***	8.9E-06 ***	9.1E-06 ***
					(0)	(0)	(0)	(0)
Adjusted R^2	0.61	0.62	0.54	0.65	0.68	0.68	0.69	0.69
SIC criterium	4.98	5.01	5.18	4.91	4.82	4.81	4.78	4.77
Observations	2 578	2 578	2 502	2 430	2 231	2 231	2 222	2 222

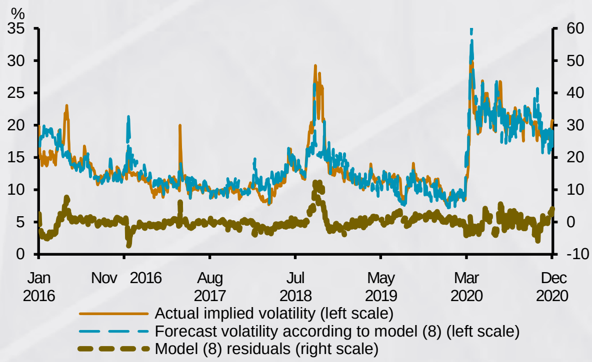
Standard-errors in parentheses.

*** p < 0.01, ** p < 0.05, * p < 0.10.

significance of DIF_JUROS.[9] Finally, models 7 and 8 are similar to models 5 and 6, respectively, except for the replacement of CDS by Termo_3_5.[10]

Among these specifications, model 8 stands out, with higher adjusted R^2 (tied with specification 7) and lower Schwarz Information Criterion (SIC), with the aim of investigating each variable contribution in the changes of the 1-month implied volatility of the FX rate. Figure 3 shows that model 8 is well adjusted to movements of FX rate implied volatility.

Figure 3 – Actual and forecast implied volatility according to model 8



9/ All variables in the regressions are contemporary in respect to the dependent variable. Due to endogeneity issues, the models with one day lagged independent variables have also been tested, with no significant changes in results.

10/ Other models have also been tested such as threshold models and models with interaction terms, but with unsatisfactory results.

The variables with greater relevance for FX rate volatility are the local variables MINI_DOLAR and Termo_3_5. One additional standard deviation to the number of FX rate mini contracts (303 transactions) and to the forward interest rate (1.99 p.p.) generates respective volatility increases of 2.76 p.p. and 1.50 p.p. One additional standard deviation to systemic variables – implied volatility of other emerging countries, VIX, volatility of the commodity index – generates, respectively, positive changes of 1.30 p.p., 1.00 p.p. and 0.59 p.p. in FX rate volatility.

With the same specification, a simple exercise has been carried out for estimating the weight of each variable in the volatility increase during the pandemic. The mean of variables from 3.2.2020 to 12.30.2020 (218 observations) and immediately before the pandemic (with the same sample size) were calculated. Table 2 presents these means.

Table 2 – Mean of variables before and during the pandemic

Variable	Before the pandemic	During the pandemic
USD/BRL FX volatility (% p.a.)	10.53	21.02
VIX (% p.a.)	15.50	31.57
VOL_CRB ((% p.a.)	1.47	1.76
VOL_IMP_CP_EME (s.d. from the mean)	-0.07	0.07
TERMO_3_5 (% p.a.)	7.50	8.16
MINI_DOLAR (number of trades in thousands)	344.11	1 009.51

With the difference of variables before and during the pandemic and the coefficients of regression 8, the expected increase in FX rate volatility is calculated by the following equation:

$$E[\Delta Volatilidade\ do\ Câmbio\ BRL - USD] = 0.137(\Delta VIX) + 1.715(\Delta VOL_{CRB}) + 14.715(\Delta VOL\_IMP\_CP\_EME) + 0.753(\Delta \text{TERMO\_3\_5}) + 9.12 \times 10^{-6}(\Delta MINI\_DOLAR) = 11.29$$

As the increase in the volatility mean was 10.54 p.p., the model 8 error was only 0.75 p.p. in this exercise. Figure 3 shows a lower magnitude of the residual in model 8 in more recent periods when compared to its full time series, indicating that this model presents a good fitting for the recently observed data. Finally, by dividing each term of the equation by the expected variation of the FX rate volatility, the weight of each variable in the volatility increase is estimated.

Table 3 – Weight of each variable for the increase of volatility during the pandemic

Variable	Weight
VIX	19%
VOL_CRB	4%
VOL_IMP_CP_EME	18%
TERMO_3_5	5%
MINI_DOLAR	54%

Therefore, the increase in FX rate volatility observed in Brazil since the end of February 2020 largely reflects both domestic factors – such as the sharp increase of US dollar mini contracts transactions –, and external factors – such as the rise of VIX and the increase in FX rate volatility observed in emerging countries.

The interest rate differential in some specifications is statistically significant, but only explains a relatively small part of the volatility increase. When MINI_DOLAR is inserted in the regression, DIF_JUROS is not statistically different from zero and it changes its signal depending on the specification. According to model

4, which does not include MINI_DOLAR, one standard deviation less in DIF_JUROS (3.81 p.p.) generates an increase in volatility of 1.61 p.p. Considering only the pandemic period, by using the same specification, the contribution of the interest rate differential in the increase of volatility is small. From the eve of the pandemic (2.28.2020) to the end of the sample (12.30.2020), period in which the Selic rate dropped from 4.25% p.a. to 2.00% p.a., the decline of the 1-year interest rate differential was 0.32 p.p. (from 3.03% to 2.71%), which would generate an increase of only 0.13 p.p. in the volatility. However, in this period, the FX rate volatility rose 9.77 p.p., from 10.98% to 20.75%.

References

Bakshi, G., Kapadia, N.; Madan, D. (2003). “Stock return characteristics, skew laws and the differential pricing of individual equity options” The Review of Financial Studies, 16, 101-143.