A macroeconomic perspective on Brazilian FX swaps*

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Abstract
This paper takes a macroeconomic perspective on Brazilian foreign exchange swaps. It was found that foreign exchange swap shocks lower inflation, ease financial conditions by reducing the risk premium, are associated with temporarily higher economic activity and lower interest rates in the medium run. After a swap shock, the impact on the exchange rate is at best short-lived. A counterfactual exchange rate without the contribution of swap shocks shows periods when the Real would be almost 4 percent weaker.

Keywords: FX interventions, swaps, exchange rate
JEL Codes: E58, F31, F62

1 Introduction

This paper takes a macroeconomic perspective on Brazilian foreign exchange (FX) swaps,[1] aiming to understand whether these instruments have an impact on macroeconomic variables such as inflation, economic activity, current account balance and interest rates since their introduction in the early 2000s.

The large size of FX swaps interventions in Brazil, either as a share of GDP or as a share of international reserves, raises the possibility that these instruments can have macroeconomic effects, deserving a specific investigation. For instance, considering the period after 2005, swap balance reached a peak of 31.4% of international reserves and 6.0% of GDP in March 2015 and February 2016,

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★ The views in this paper are solely the responsibility of the author and should not be interpreted as reflecting the views of the National Treasury. (STN Directive 833, November 28, 2018)

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[1] Brazilian FX swaps are similar to non-deliverable futures. They do not involve exchange of the notional principal and settle in local currency (Garcia & Volpon, 2014; Nedeljkovic & Saborowski, 2018). In the so-called traditional swap, the Central Bank takes a long position in the Selic rate and short position in onshore dollar rates plus the exchange rate variation. In reverse swaps, the balance sheet of the contract is the opposite, i.e., the Central Bank assumes a long position in dollars.

respectively. In June 2020, the corresponding figures were 16.3% of international reserves and 3.5% relative to GDP.[2]

Despite being often used by the Central Bank of Brazil to contain depreciation pressures, some raise doubts about the effectiveness of FX interventions through swaps to contain long standing depreciation pressures, since its primary purpose is to provide hedge to the private sector.

This paper seeks to answer these questions, looking at the impact of FX swaps on a medium-term perspective, in contrast to prevailing studies, that focuses on the immediate impact of these instruments.

Three econometric methods are used: local projections, VAR under the recursiveness assumption and VAR with sign restrictions. These methods allow the dynamic feedback between the variables, typically of macroeconomic time-series. Local projections have been increasingly used, as it imposes fewer restrictions than VAR models, consisting of a regression of the variable of interest on the variable subject to the shock, in this case a swap shock. VAR under the recursiveness assumption is standard in several applications, and is equivalent to the imposition of timing restrictions, i.e., some variables react only with a lag to the shock. Finally, VAR with sign restrictions was used in order to impose that the Real appreciates after a swap shock, which is not always the case in the other models. This paper also tries to answer the question of what would be the Real-Dollar (USDBRL) exchange rate without the interventions, through a historical decomposition.

FX interventions through swaps were introduced in 2002,[3] with the goal of providing hedge to the private sector. The hedging nature of these instruments, and the role of the Central Bank as provider of hedge of last resort is discussed in Bevilaqua and Azevedo (2005) and Gonzalez, Khametshin, Peydró, and Polo (2019).

In advanced economies, FX interventions are thought to operate through two main channels. The first is the portfolio balance channel, in which the assets are not considered perfect substitutes, and then the relative supply of a currency changes the composition of agents' portfolios. The second mechanism is through the signalling channel, in which interventions provide information to the market

[2] One may argue that, since FX swaps are derivatives, the information content of notional values should be relativized. But one of the main assumptions for the effectiveness of interventions through swaps is that they are backed by the international reserves. Otherwise, interventions through swaps could spark convertibility risk (Garcia & Volpon, 2014; Nedeljkovic & Saborowski, 2018).

[3] They are regulated by Resolution 2,939 of the National Monetary Council.

about the future actions of the monetary authority (Sarno & Taylor, 2001). The provision of hedge to the private sector is typical of emerging economies.

This paper is organized as follows. In addition to this introduction, section 2 presents the related literature. Section 3 lays out the data and empirical approach. Section 4 shows the results. Section 5 presents the contribution of swap shocks in highlighted episodes. Section 6 displays the counterfactual USDBRL exchange rate without swap interventions. Section 7 concludes.

2 Literature review

There is now vast evidence that FX swaps used by Central Bank of Brazil affects the level and the conditional volatility of the exchange rate, considering daily or high-frequency data.

Meurer, Teixeira, and Tomazzia (2010) use a Markov Switch model to analyze spot interventions between 1999 and 2008. They split the analysis in interventions in favor or against the tide, finding that prolonged interventions, i.e., those that last more than one day, can affect the volatility and the direction of the exchange rate. They associate this result to the fact that prolonged interventions are more likely to influence expectations in FX markets.

Based mainly on E-GARCH models estimated on daily data from 1999 to 2006, Oliveira and Plaga (2011) study the effects of different types of FX interventions—spot, FX-linked bonds, and swaps—on the conditional volatility of the Real, assuming that these types of interventions are exogenous to the exchange rate. They find that interventions through spot auctions and FX-linked bonds affected FX volatility in the currency crisis of 1999 and 2002, respectively. For the first crisis period (1999), spot interventions increased the conditional volatility of the exchange rate, with a small estimated coefficient (0.000245), statistically significant at the 10% level. They attribute this result to massive capital outflows in the aftermath of the change in the exchange rate regime. For the second crisis period (2002), they find that FX-linked bond successfully affected the conditional volatility of the exchange rate, with negative estimated coefficient (−0.000165), statistically significant ate the 10% level.

Janot and Macedo (2016) find that swap interventions with large sizes affect the USDBRL exchange rate, using intraday data from 2011 to 2015. They regress the returns and squared returns of the FX on their own lags, and indicator variable for buying or selling interventions, a vector of macroeconomic surprises and a dummy variable associated with the opening hours of trading. Surprise swap auctions are associated with an impact of 0.5% on the returns, while

surprise spot auctions impact returns by a lower magnitude (0.2%) which they associate to larger average swap relative to spot interventions—US$ 14 billion of the former in comparison to US$ 300 million of the latter. They also find that surprise swap auctions increase the exchange rate volatility, opposite of what would be expected.

Oliveira (2020) specifies the dynamics of the nominal exchange rate as a continuous process. Assuming that the intervention policy in the FX market is known by the market participants, he finds that both spot and swap interventions reduce the depreciation of the Real, using daily data from 2006 to 2016.

Using daily data from 2008 to 2013 and an instrumental variables setup, Nedeljkovic and Saborowski (2018) find that FX interventions through spot or derivatives are effective in affecting both the level and the volatility of the exchange rate in Brazil, provided that there is no convertibility risk, in which case FX swaps become less effective. They find that US$ 1 billion in spot and swap interventions are associated with an effect on the exchange rate of around 1 and 0.7%, respectively, having similar impacts on the exchange rate. In turn, the impact of US$ 1 billion spot intervention on the implied volatilty is a reduction of 2.5%.

Employing a synthetic control approach to deal with endogeneity issues, Chamon, Garcia, and Souza (2017) found that the first round of the FX swap program announced after the Taper Tantrum of 2013 managed to appreciate the Real by a cumulative effect of more than 10% on the first weeks after announcement, although the impact on implied volatilities was weak. They associate the large results on the level of the exchange rate to the surprise effect of the program on the market. Subsequent extensions of the program were not effective.

Kohlscheen and Andrade (2014), applying a GARCH (1,1) model with high-frequency data from 2011 to 2013 as baseline, find that FX swaps affect the exchange rate, and the impact is greater for swaps in which the Central Bank takes a short position in dollars, with an average estimated effect of 71 basis points on the log returns, relative to an impact of 20 basis points when the Central Bank took long positions in dollars.

There is also evidence that foreign exchange interventions are effective on affecting the real exchange rate (RER). Adler, Lisack, and Mano (2019) investigate the effects of foreign exchange interventions on exchange rate levels in an instrumental-variables panel approach, encompassing 52 countries and monthly data from 1996 to 2013. In their study, a 1 pp FX intervention relative

to GDP leads to a depreciation of the nominal and real FX close to 2% and 1.5%, respectively. They also find that interventions have a persistent effect on exchange rates, with the shocks dissipating only after 36 months, but the paper is silent on the impact of interventions on other macroeconomic variables.

Along the same lines, Daude, Levy Yeyati, and Nagengast (2016) test the effect of interventions on the RER rate in an error correction model that controls for RER dynamics, fundamental determinants, and short-term financial variables. They find evidence that FX interventions in emerging markets are generally effective in the short-run, with a 1 percentage point increase in the intervention variable being associated with a 0.18% depreciation of the real exchange rate. But the paper is focused on the impact of FX interventions on the RER, rather than on other macroeconomic variables.

Less is known, however, about the specific macroeconomic effects of FX swaps. One exception is Gonzalez et al. (2019), who find that the swap program announced after the Taper Tantrum shock in 2013 attenuated by around half the negative impact of the shock on credit supply and employment by firms exposed to banks with large foreign exchange debts at the time. They conclude that FX swaps can mitigate the spillovers from monetary policy in advanced economies to emerging markets as Brazil. Gonzalez et al. (2019), however, is focused on the Taper Tantrum episode, whereas the purpose of this paper is to investigate the macroeconomic consequences of swaps since their introduction.

Macro-inclined papers of FX intervention include Tobal and Yslas (2018), Kohlscheen and Andrade (2014), Blanchard, Adler, and Filho (2015) and Menkhoff, Rieth, and Stöhr (2020). All these papers use some version of the vector-autoregressive (VAR) approach.

Blanchard et al. (2015) find that countries that intervene in their exchange rate display a smaller appreciation in response to gross capital flows, with a 1.5 percentage point differential in appreciation between interveners and floaters over the 3-4 quarters. Brazil is an outlier in their results, in the sense that it is the only currency intervener whose exchange rate appreciation is not reduced in response to a global capital flow shock, which would imply that FX interventions are not effective.[4]

Tobal and Yslas (2018) argue that the Brazilian model of FX intervention entails inflationary costs, with the response of the inflation rate following an FX intervention shock peaking at months 2 and 4 with significant increases of 0.074pp and 0.086pp, respectively. The result in their view stems from the

[4] See Figure 7 of the paper.

discretionary behavior of interventions by the Central Bank of Brazil. But in their paper, there is no differentiation between the various instruments,[5] while this paper is concerned only with interventions through swaps.

Distinguishing between different instruments of intervention is important because they have different consequences for the economy. While non-sterilized dollar purchases (selling) by the Central Bank expands (reduces) the monetary base, FX swaps do not involve foreign reserves.[6] But FX swaps have fiscal consequences on the nominal balance through margin payments, which are considered as interest expenses(receipts) in fiscal accounts, in case the Real weakens (strengthen) against the dollar (Gonzalez et al., 2019).

Kohlscheen and Andrade (2014) is another paper that uses standard VARs to investigate the impact of intervention through swaps. In their model, traditional swaps impact exchange rate movements contemporaneously, but only react to them with a lag. In contrast with Tobal and Yslas (2018), who found interventions to have short-lived effects, an exogenous swap shock is found to have prolonged effects on the exchange rate. But Kohlscheen and Andrade (2014) do not investigate the impact of swap shocks on other macroeconomic variables.

In a recent paper, Menkhoff et al. (2020) use a structural VAR with external instruments approach to study the dynamic effects of FX interventions in financial markets. Using daily data and focusing on the Yen-Dollar exchange rate, they find that a surprise foreign currency purchase depreciates the yen significantly and is highly persistent. A one standard deviation intervention shock, leads to a depreciation of about 0.2% relative to the US-Dollar, Pound and Euro, lasting from one to up to four quarters.[7]

3 Data and empirical approach

In order to analyze the effects of FX swaps interventions in the economy, the main problem for identification is the endogeneity of movements in the exchange rate and the interventions. This paper uses several identification strategies to overcome this issue, namely local projections, VARs with sign restrictions and VARs under the recursiveness assumption.

[5] For Brazil they include interventions in forward and spot markets, repo lines of credit and foreign currency loans. See footnote 11 of the paper.

[6] Tobal and Yslas (2018) included the monetary base in their VAR models, despite the different implications for this variable of FX interventions through spot and swaps.

[7] They attribute this result to some reasons: i) previous papers have focused on emerging markets, not genuine floaters; ii) imprecise measures of FX interventions, derived from changes in reserves and iii) disputable identification strategies.

The swap balance data comes from the Central Bank of Brazil.[8] There were three large build-ups in swaps balance over time, highlighted in grey in Figure 1.

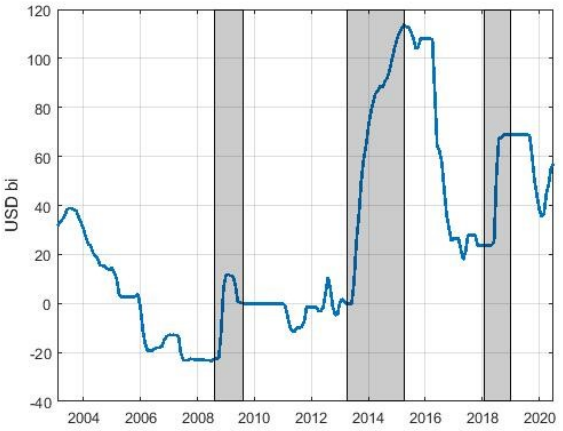


Figure 1. Swap balance

The first large build-up happened after the financial crisis of 2008. The balance climbed from −US$ 22 billion in September 2008 to US$ 11 billion in December 2008. Mesquita and Torós (2010) provide details about this episode. Problems in the non-financial corporate sector spilled over to the FX market. In October 2008, the Central Bank announced a program to sell up to US$ 50 billion in FX swaps, which corresponded at the time to 25% of the foreign reserves. In the view of the authorities, a larger number relative to the international reserves could have signalled the intention to avert the adjustment of the exchange rate, which could have had a negative impact, by triggering speculative attacks on the Real.

The second build-up took place in the aftermath of the Taper Tantrum of 2013. In May 2013 the Central Bank of Brazil had a net zero position in swaps. After the Taper Tantrum episode, and the subsequent programs announced by the Central Bank, the balance reached a peak of US$ 113 billion in March 2015. Chamon et al. (2017) describe this episode. In August 2013 the Central Bank announced a program, intending to sell FX swaps. This program was extended three times, the first one in December 2013, second in June 2014, and the third time in the end of 2014, lasting until March 2015. The total amount sold, in

[8] Publicly released at Nota à imprensa do mercado aberto, Table 12A: https://www.bcb.gov.br/estatisticas/mercadoabertoswaptitulos

notional value, reached US$ 113 billion.

The third large build-up happened in 2018, when the Central Bank sold US$ 45 billion from May to September, with the balance raising from US$ 24 billion in April 2018 to US$ 68 billion in September 2018. This episode is noteworthy because it includes the largest expansion in swap balance on record in a single month, US$ 27 billion in June 2018. The background of this build-up in swap balances was volatility in financial markets stemming from Turkey and Argentina.

The literature relative to emerging markets shows that authorities and market participants regard sizeable interventions as effective in influencing the level and volatility of exchange rates, through the portfolio balance channel, due to thinner and iliquid markets. Other factors that contribute are the relatively large size of central banks in the market, information advantage over private actors and the potential use of regulation (Menkhoff, 2012).

Table A1 in the Appendix A presents the description of the data and the transformations used for the estimations, if any.

Figure 2 depicts the data used in the estimations. The current account data is accumulated in 12-months, due to the high volatility at the monthly frequency. The data originally comes from the SGS database of the Central Bank of Brazil. The Selic rate, monthly activity index IBC-Br, IPCA inflation rate, nominal

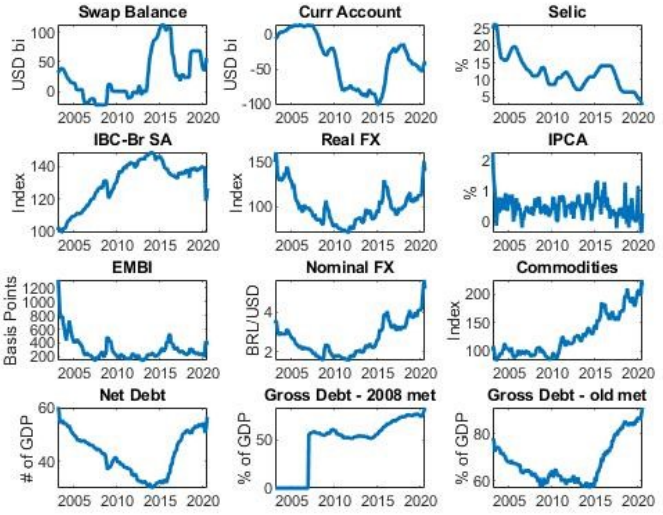


Figure 2. Data

and real exchange rate and commodity prices in local currency also comes from the SGS database. Previous research has found that commodity prices are an important determinant of the Real (Kohlscheen, 2013), hence the inclusion of this variable in the models. The risk premium measure used is the EMBI, since CDS data starts only from 2007 onwards, while swap transactions have occurred since 2002. Unlike the other series, this comes from Ipeadata database.

4 Results

4.1 Local projections

This section tries to answer the question of what happens to the economy after an exogenous swap shock, represented by an increase in the FX swap balance. The estimation is done using local projections, based on Jordà (2005). As Ramey (2016, p.40) explains, local projections put fewer restrictions on the impulse responses, because rather than estimating impulse responses based on nonlinear functions of the reduced form parameters, local projections estimate regressions of the dependent variable at horizon $t+h$ on the shock in period t and use the coefficients on the shock as impulse response estimates. The general form of local projections is

$$z_{t+h} = \alpha_h + \theta_h shock_t + control\,variables + \varepsilon_{t+h}, \tag{1}$$

where z is the variable of interest (either the shock itself, nominal and real exchange rate, inflation, current account, Selic policy rate, economic activity measured by the IBC-Br, risk premium, commodities prices measured in local currency, measured by the IC-Br index and a public debt variable), and θ_h is the estimate of the impulse response of z at horizon h to a $shock_t$. In the estimations, $h = \{1,2,\ldots,18\}$. All impulse responses displayed show 95% confidence intervals.

The control variables in this case are the contemporaneous value and ten lags of the variables current account, log(`ibc-br`), log(`rer`), log(`fx`), log(`ic-br`), `ipca`, `embi`, `grossdebt`, `selic`, `swaps`, where `fx` and `rer` stands for the nominal and real exchange rate, respectively.

According to Adämmer (2019), the local projections approach does not overcome the problem of identification, being necessary to impose restrictions to estimate the structural form. The most common approach is to use the Cholesky decomposition of the covariance matrix of the reduced form residuals. This approach is also called the recursiveness assumption, as it implies that the first variable in the system responds to its own exogenous shock, the second variable

responds to shocks to the first variable and its own exogenous shocks, and so on and so forth. This means that how the variables are ordered in the model matters for the estimation. The recursiveness assumption in the context of estimation through local projections is also discussed in Ramey (2016, p.40).

The public debt variable is to take into account the fact that results from swap operations have had a significant impact on public accounts in the past. Losses from these operations due to a weaker FX translated into higher nominal deficit and higher debt, which likely affected the decision-making process of monetary policymakers. Even tough swaps do not involve international reserves, since they are settled in Reals, they affect the net FX position of the Central Bank, which can have repercussions in terms of risk perception, through higher net debt. Commitment of international reserves can also impact the effectiveness of swap operations, as they are supposed to back them, i.e., there is low convertibility risk (Garcia & Volpon, 2014; Nedeljkovic & Saborowski, 2018). Other papers that touch on the potential fiscal costs, or the cost-benefit relationship of FX interventions, include Gonzalez et al. (2019) and Oliveira (2020).

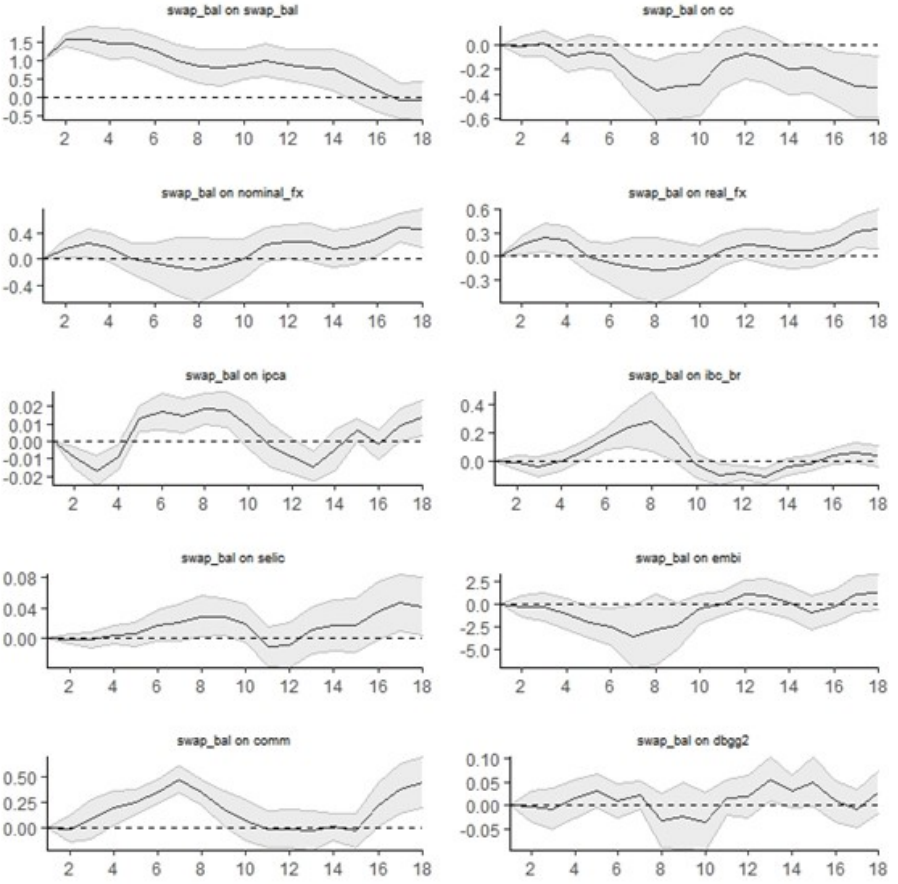
Figure 3 depicts the response of the variables to a swap shock, obtained through local projections.[9] The sample period runs from January 2003 to June 2020, comprising 210 observations.

After a swap shock, the nominal exchange rate actually depreciates a little bit. This movement is followed by the real exchange rate. This happens because inflation measured by the IPCA declines after a swap shock, and this response is statistically significant, contributing to a weaker real exchange rate. Between the 5^{th} and 10^{th} month after the shock inflation increases, driven in part by higher commodity prices in Reals.

After a period of stability immediately after the impact, the current account (accumulated in 12 months) deteriorates between the 10^{th} month after the shock, and this response is statistically significant.

The swap shock allows a modestly lower Selic rate around one year after the shock. This is consistent with the view that financial market participants often consider FX interventions and the interest rate setting as substitutes. According to this interpretation, an FX intervention that sells dollars contain depreciation trends for a while and reduces inflation, allowing interest rates to be lower. Curiously, this is also consistent with early evidence that FX interventions signal future monetary policy in the opposite direction, i.e., interventions to raise the

[9] I used the R package `lpirfs` (Adämmer, 2019) to select the appropriate lag length and estimate the model. The optimal lag indicated by the AIC and BIC criterias was 10.



Note: swap_bal: swap balance; cc: current account; nominal_fx: nominal exchange rate; real_fx: real exchange rate; ipca: IPCA inflation rate; ibc_br: IBC-Br economic activity index of the Central Bank of Brazil; selic: Selic policy rate; embi: EMBI risk premium; comm: commodity price index of the Central Bank of Brazil; dbgg2: gross debt. Sources of the series are in Table A1 of the Appendix A.

Figure 3. Swap shock

value of the domestic currency are associated with expansionary monetary policy in the future (Kaminsky & Lewis, 1996).

The response of economic activity and the risk premium are mirrored. The risk premium is lowered after the 5^{th} and 10^{th} months after the shock, and this is coupled with temporarily higher economic activity. The reduction in risk premium also enables a lower public debt around the 10^{th} month after the shock.

4.2 Recursive VAR

This section presents the results based on recursive VAR, with the following ordering: current account → log(`ibcbr`) → log(`realfx`) → log(`nominalfx`) → log(commodity prices) → `ipca` → `embi` → `selic` → `swaps`. The model was estimated with 2 lags, as indicated by the AIC and BIC criteria. The sample period runs from January 2003 to June 2020, encompassing 210 observations.

The assumption is that when the Central Bank auctions swaps, it observes macroeconomic and financial variables, i.e., these variables are on the information set of the Central Bank. The ordering implies that the first variables impact the others contemporaneously, while swaps only affect the previous variables with a lag. The rationale behind the ordering was to place macroeconomic variables first, followed by financial variables and policy variables at last in the model.

Figure 4 shows the impulse response functions. After a swap shock, there is no impact on the nominal exchange rate. Inflation measured by the IPCA falls, and the response is statistically significant. Commodity prices measured in local currency also drop in the short run. The decline in inflation contributes to the depreciation of the real exchange rate. The weaker real exchange rate improves the current account, with a peak effect on around 5 months after the shock. The fall in inflation allows a modest cut in the Selic in the medium run. Finally, the swap shock eases financial conditions through lower risk premium, which contributes to a higher economic activity.

Overall the results are consistent with the ones obtained on subsection 4.1. More specifically, the responses of the nominal exchange rate seem to be very muted after a swap shock. In some sense this could be viewed as positive, with FX interventions implying reduced volatility and calming down markets. There may also be an association between the responses and the average maturity of the swap operations.[10] The real exchange rate actually seems to depreciate following the shock, helped by the lower inflation rate. There are also similarities

[10] The average maturity of the swaps was about one quarter as of March 2021, considering data from the Central Bank of Brazil.

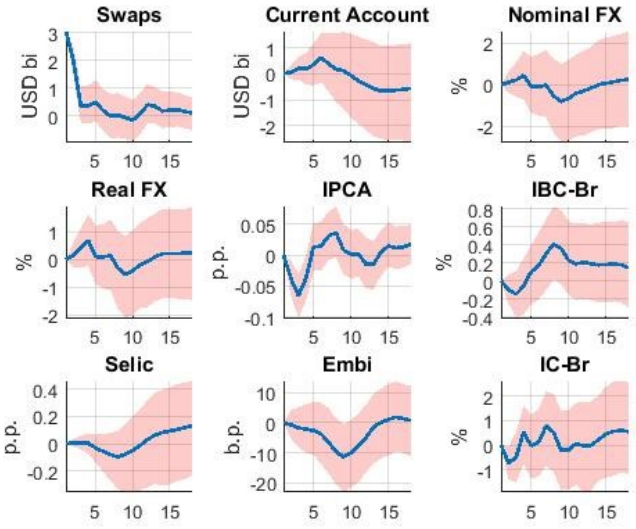


Figure 4. Swap shock

in the response of the risk premium, economic activity and policy rate to the shock, providing robustness to the results.[11] The lower Selic rate could be interpreted through the lens of the signalling channel.

4.3 VAR with Sign Restrictions

The lack of response of the nominal FX to swap interventions in previous sections might also be driven by endogeneity between FX interventions and the nominal exchange rate. The primary interest of the work lies on the effects of the interventions on exchange rates, but there can be a simultaneous reaction of FX interventions to movements in the exchange rate. For instance, the central bank may sell reverse swaps (buy dollar futures) during periods when the Real

[11] One may question the ordering of the model used here. I also estimated models that include public debt variables, namely the gross and net debt, with the following ordering: current account – log(IBC-Br) – log(real FX) – log(nominal FX) – log(commodity prices) – IPCA – Embi – DLSP or DBGG variable – Selic – Swaps. After a swap shock, the nominal FX barely moves, inflation declines, the real FX depreciates, and over the medium term the swap shock is associated with lower risk aremium, wider current account deficit, higher economic activity and lower Selic rate, depending on the specification. In another specification I placed financial variables (Embi and nominal FX) after the Selic rate: current account – log(IBC-Br) – log(real FX) – log(commodity prices) – IPCA – Selic – Embi – log(nominal FX) – Swaps. The main results remained: after a swap shock inflation and the risk premium declines, allowing a cut in the Selic rate, while economic activity improves. Results are available under request.

is appreciating and sell traditional swaps (sell dollar futures) when the Real is depreciating, which could blur identification of the interventions, as interventions would tend to be associated with estimated coefficients of the "wrong" sign. This issue is pervasive in the literature of FX interventions, and has been dealt with using different approaches, ranging from different econometric methods (instrumental variables, event studies, synthetic control approach, etc.) to high-frequency data.[12]

Given this possibility, and the macroeconomic focus of the paper, I estimated a Bayesian VAR model with sign restrictions. The idea to use sign restrictions was to impose the expected effect of the interventions. Since other methods showed negligible effects following swap shocks on the FX, the effects obtained through sign restrictions would actually act as an upper bound of the impact of interventions through swaps on the FX.

The reduced form of the model is

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + u_t, \tag{2}$$

where y_t is a $n \times 1$ vector containing the endogenous variables in the model and u_t are reduced form residuals with zero mean and variance-covariance matrix given by Σ. The reduced form can be expressed as

$$y_t = Bx_t + u_t, \tag{3}$$

where $B = [cA_0 A_1 A_2 \dots A_p]$ and $x_t = [1 y'_{t-1} y'_{t-2} \dots y'_{t-p}]$. The structural form is given by

$$A_0 y_t = k + A_1^* y_{t-1} + A_2^* y_{t-2} + \cdots + A_p^* y_{t-p} + \epsilon_t, \tag{4}$$

where A_0 is an $n \times n$ matrix with the contemporaneous reactions of the variables to the structural shocks, A_p^* are $n \times n$ matrices of structural coefficients of the system, ϵ_t is a $n \times 1$ vector of shocks with $\mathbb{E}(\epsilon_t \epsilon'_t) = I$. The structural form and the reduced form are related through $A_0^{-1} A_0^{-1\prime} = \Sigma$. The standard technique for imposing sign restrictions is to randomly draw orthogonal matrices Q, such that $A_0^{-1} Q' Q A_0^{-1\prime} = \Sigma$. By replacing A_0 with QA_0 in the structural form of the model, the researcher has another model that is observationally equivalent to the reduced form but with different impulse responses. If the responses from

[12] Neely (2005) and Fratzscher, Gloede, Menkhoff, Sarno, and Stöhr (2019) discuss several methods used to tackle endogeneity of FX interventions.

the new model satisfy the sign restrictions, the model is kept, otherwise it is discarded.

The algorithm consists in drawing the reduced form parameters B and Σ from the posterior distribution of the reduced forms, draw a rotation matrix Q and keep the draw if the sign restrictions are met. These steps are repeated until a sufficient number of draws from the posterior distributions are collected, conditional on the sign restrictions.

The model was estimated with 6 lags. The endogenous variables were the same as the ones used in the recursive VAR of subsection 4.2. The only difference is that the nominal exchange rate, the real exchange rate, commodity prices and the economic activity index enter the model in changes, rather than in log levels. Entering these variables in changes reduces the sample by one observation, running from February 2003 to June 2020, encompassing 209 observations. The only restriction placed is that after a swap shock, the nominal exchange rate must appreciate on impact, reflecting the results based on high-frequency data. The other variables are left free after the shock. The model accepts this restriction only 44% of the times. The other restrictions are that the endogenous variables in the model respond positively to a shock on itself. Table 1 shows the restrictions.

Table 1. Sign restrictions

	Swaps	CC	Selic	IBC-Br	IPCA	EMBI	Nominal FX	Real FX	Comm
Swaps	+								
CC		+							
Selic			+						
IBC-Br				+					
IPCA					+				
EMBI						+			
Nominal FX	–						+		
Real FX								+	
Comm									+

Figure 5 depicts the impulse responses. The real exchange rate also appreciates after the swap shock, alongside the nominal exchange rate. The current account deteriorates in the medium run, reflecting the movement in the real exchange rate. Commodity prices also drop after the shock. Inflation and the Selic rate barely move. Finally, the shock lowers the risk premium and leads to higher economic activity in the short run, although in a small magnitude.

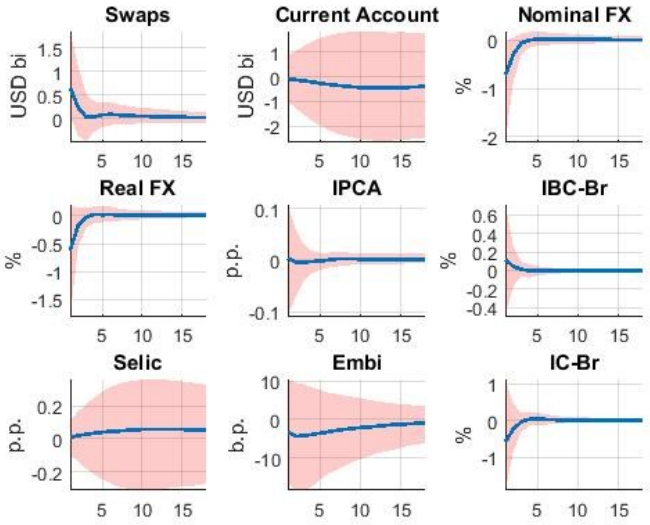


Figure 5. Swap shock

5 Historical decompositions

Figure 6 presents the historical contribution of swap shocks to each endogenous variable in the VAR model of subsection 4.3. The main highlights are the negative contribution of swap shocks to the current account and to the risk premium during the FX program in response to the Taper Tantrum in 2013. Put differently, swap shocks contributed to improve financial conditions but prevented some adjustment in the current account.

Figure 7 depicts the contribution of swap shocks to the behavior of the nominal exchange rate. The main contributions of swaps shocks to the appreciation of the Real occurred in 2009, in the aftermath of the global financial crisis of 2008, during the swap program in 2013, in the aftermath of the Taper Tantrum, and during the massive intervention in June, 2018. Periods in which the Central Bank was not rolling over its position, with the ultimate impact of reducing the balance, also impacted the exchange rate, weakening the Real.

The largest contribution of swap shocks to appreciate the Real took place in June, 2018. In that month the Central Bank sold US$ 27 billion, the largest intervention on record in a single month. Despite the large size of the intervention, the Real weakened 3.8% in that month. The model indicates that swaps contributed to the appreciation of the Real by 1.1%. In the following month,

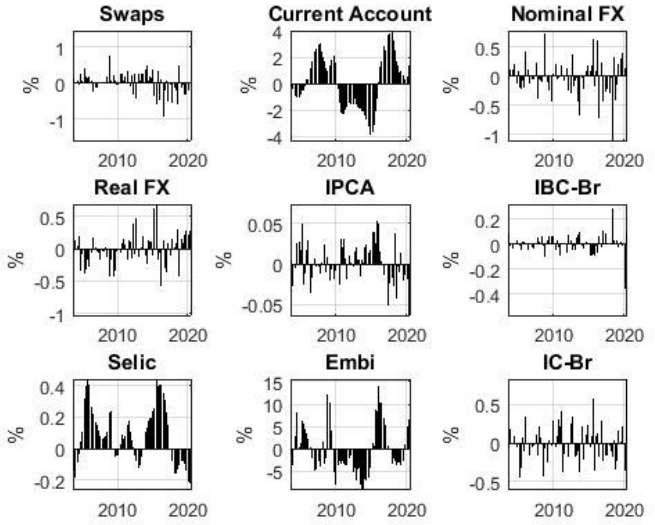


Figure 6. Contribution to each variable due to swap shocks

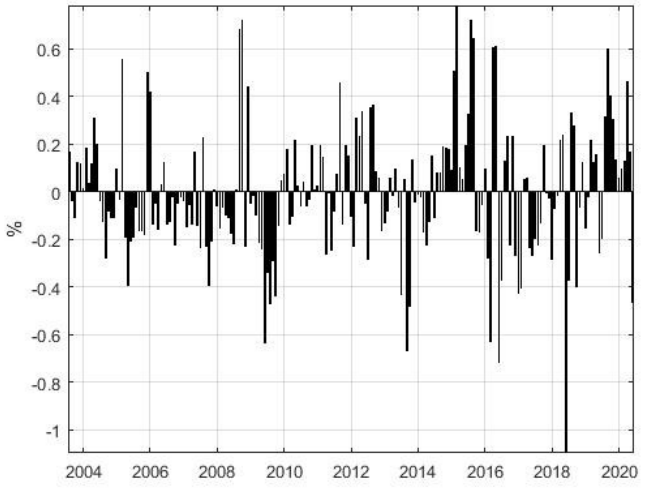


Figure 7. Contribution of swap shocks to monthly change in USDBRL

the intervention continued, with the swap balance increasing by US$ 15 billion. Even with this intervention, the Real weakened 1.5%, with the model showing that swaps shocks contributed to strengthen the Real by 0.37%. To sum up, even a model that imposes the condition that the exchange rate must appreciate after a swap shock shows a quite modest role for swaps in the dynamics of the exchange rate. The massive FX intervention between June and July 2018 contributed little to appreciate the Real.

Figure 8 shows the contribution of swap shocks to the nominal exchange rate and the evolution of the swap balance. The main pattern is that immediately after a build-up in swap balance, there is a significant negative contribution of swap shocks to the appreciation of the nominal exchange rate, as one would expect. This happened in the 2008, 2013 and 2018 episodes. But this negative contribution is not very persistent. Once the balance has stabilized after the build-up, the contribution of swap shocks fluctuates around zero. The most striking feature is that even with a large balance, the contribution can be positive, i.e., swaps shocks contributed to the depreciation of the exchange rate. This was the case during the first months of 2015, when even with the balance at its peak of more than US$ 113 billion, the model understands swap shocks as contributing to the depreciation of the Real. The main implication is that it

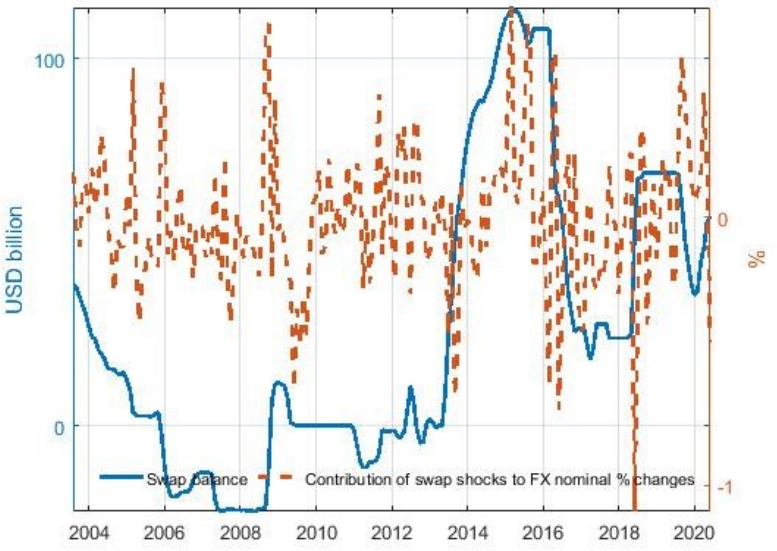


Figure 8. Contribution of swap shocks

is the change in the outstanding balance, not its level, that is relevant for FX dynamics.

Finally, Figure 9 depicts the evolution of the swap balance and the contribution of swap shocks to the evolution of the nominal exchange rate (same information as the previous figure), current account, risk premium and inflation. The most noticeable features are the negative contribution of swap shocks to the current account prior to the recession of 2014-2016 and the negative contribution of swap shocks to the risk premium in 2013–2014 and during the volatility stemming from Turkey and Argentina in 2018.

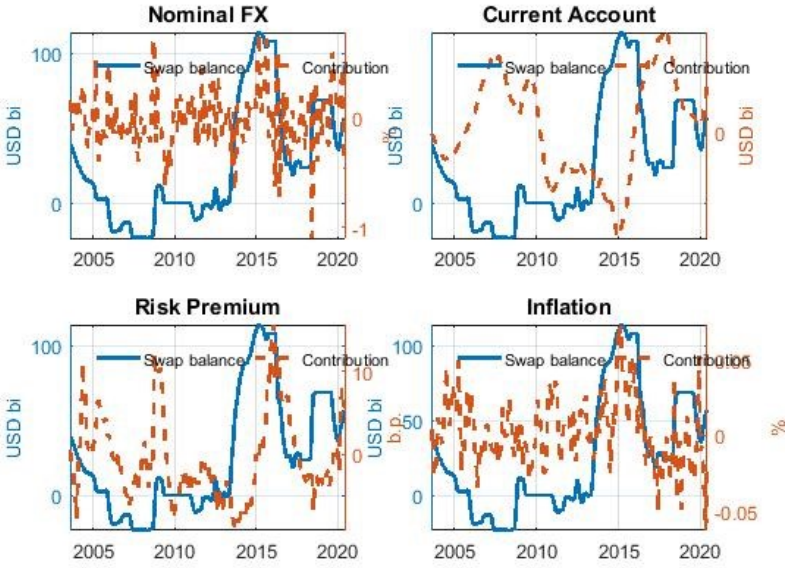


Figure 9. Contribution of swap shocks

6 A Synthetic Exchange Rate without Intervention

In order to assess the weight of swap shocks in the exchange rate, I back out the evolution of this variable disregarding the contribution of swap shocks in the model of subsection 4.3 and compare it to the actual evolution of the USDBRL exchange rate. The contributions of the other shocks are held fixed in this exercise.

Figure 10 shows the results. Without the contribution of swap shocks, the exchange rate would be sometimes almost 4% weaker than it actually

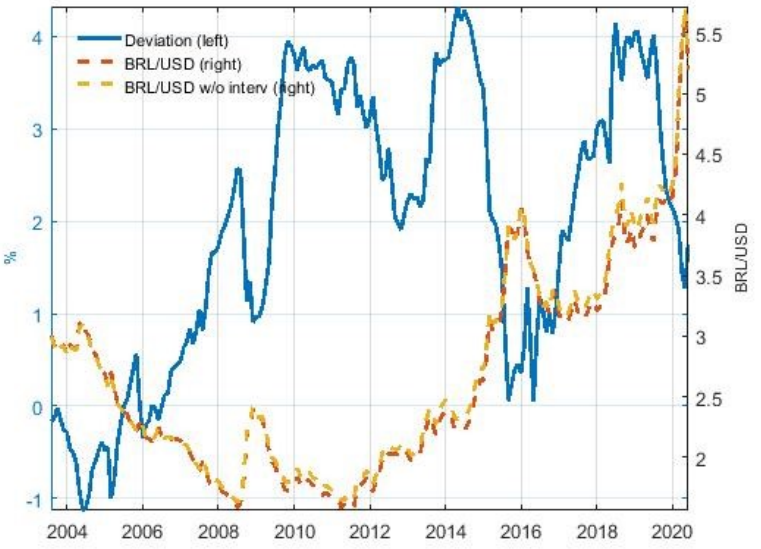


Figure 10. Exchange Rate without intervention

was. The main deviations happened in the aftermath of the build-up of swap balances following the Global Financial Crisis of 2008, after the swap program of 2013/2014 and following the build-up in 2018.

7 Conclusion

This paper took a macroeconomic perspective on FX swaps in Brazil. Since these instruments are often used by the Central Bank and have reached sizeable volumes relative to international reserves and GDP, the main question addressed was if they have macroeconomic implications.

The main conclusion is that, although there is evidence that swaps have high-frequency impacts on the exchange rate, these instruments seem to have low impact in lower frequencies. Estimation through local projections and a recursive VAR show that the nominal exchange rate barely moves after a swap shock at the monthly frequency. A model with sign restrictions, that impose the condition that the nominal exchange rate appreciates after a shock, shows that this condition is met only 44% of the times. All in all, FX interventions through swaps do not seem to be persistent.

Another result is that swaps ease financial conditions by lowering the risk premium, which benefits economic activity. This is consistent with the view

that the Central Bank usually expands the swap balance in times of crisis and volatility in financial markets, and also with the goal of provision of hedge to the private sector. The international evidence also shows that FX interventions are more likely in periods of turbulence (Fratzscher et al., 2019).[13]

Finally, swap shocks lower inflation, and this response is statistically significant across different models. The relationship between FX interventions and inflation in Brazil has been pointed out in other studies (Tobal & Yslas, 2018), and might deserve further investigation.

A counterfactual USDBRL exchange rate shows that, without the contribution of FX swaps, the Real would be more than 4% weaker in some periods. This deviation is quickly erased after periods of strong depreciation pressures on the Real.

From a policy perspective, the results of this paper suggest that an assessment of the nature of the shock—whether it is temporary or permanent—is required for the proper FX intervention. Permanent shocks are unlikely to be effectively addressed with FX interventions through swaps.

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[13] Fratzscher et al. (2019) document that in turbulence times central banks are active 22.5% of days.

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Appendix A

Table A1. Data

Series	Acronymn	Description	Source	Transformation
Swap Balance	swap_bal	FX intervention Variable of Interest	Nota à imprensa do mercado aberto, Table 12A	No
Current Account	cc	External Accounts	SGS database, code 22701	Accumulated in 12 months
Selic Rate	selic	Interest Rate	SGS database, code 4189	No
IBC-Br	ibc_br	Economic Activity	SGS database, code 24364	100 * log
Nominal FX	nominal_fx	FX	SGS database, code 3698	100 * log
Real FX	real_fx	FX	SGS database, code 11752	100 * log
IPCA	ipca	Inflation	SGS database, code 433	No
IC-Br	comm	Commodity Index	SGS database, code 27574	100 * log
EMBI	embi	Risk Premium	IPEADATA	Monthly average
DLSP	dlsp	Net Debt	SGS database, code 4513	No
DBGG	dbgg2	Gross Debt	SGS database, code 4537	No