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# FX interventions in Brazil: a synthetic control approach*

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**Abstract**

The taper tantrum of May 2013 generated sharp fall in risky assets prices, including the depreciation of several emerging market currencies. To fight excess volatility and exchange rate overshooting, the Central Bank of Brazil announced a major program of interventions in foreign exchange markets. We use a synthetic control approach to determine whether or not the intervention program was successful. Our results suggest that the first FX intervention program mitigated the depreciation of the real against the dollar. A second announcement made later in the year that the program was going to continue on a smaller basis had a smaller effect, which was not significant. This result is corroborated by a standard event study methodology. We also document that both program did not have an impact on the volatility of the exchange rate.

JEL classification codes: F31, G14.

Keywords: FX interventions; synthetic control; ArCo.

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# 1 Introduction

The taper tantrum of May 2013 caused major losses in risky assets, including many emerging markets' currencies. To fight excess volatility and overshooting of the Brazilian real, the Brazilian Central Bank (BCB) announced on August 22, 2013, a program of intervention in the foreign exchange market. Starting in early June, the BCB started intervening in FX markets in a ad hoc fashion, selling currency forwards that settle in domestic currency. Nevertheless, the exchange rate kept depreciating. On August 22, the BCB announced a program. The program consisted of daily sales of US$ 500 million worth of currency forwards, called US dollar swaps in the Brazilian markets, that provided investors insurance against a depreciation of the real. These swaps settle in domestic currency and provide investors the very same hedging they would obtain by buying spot dollars and holding them until the maturity of the swap.[1] The program also indicated that on Fridays, the central bank would offer offer US$1 billion on the spot market through repurchase agreements, i.e., the BCB would provide short term credit lines in USD. On December 19, 2013, the BCB announced that it would continue with the program until at least mid-2014, although the daily interventions were reduced to US$ 200 million.

Figure 1 shows the behavior of the exchange rate (depreciation of the BRL/USD occurs when the exchange rate increases) and the magnitude of these interventions up to May 2014. All in all, the announcement implied a cumulative intervention in excess of $90 billion over the horizon of the program, which amounts to about a quarter of total FX reserves.

There is a very large literature analyzing the effectiveness of central bank interventions. Sarno and Taylor (2001) survey the early literature, which typically focused on Advanced Economies and generally concluded that sterilized intervention was not very effective (with the possible exception of signaling future monetary policy). That is not surprising, since the amount of FX intervention pursued in advanced economies was a tiny fraction of the size of their bond markets. But in the case of Emerging Markets (EMEs), FX intervention has a non-trivial effect on the relative supply of local currency bonds. A number of more recent papers focusing on emerging markets tends to find more supportive evidence for an effect, but the evidence remains somewhat mixed. Menkhoff (2013) provides an excellent survey of that literature.

[1] Because they settle in real, they involve convertibility risk. For a detailed discussion of these contracts, please refer to Garcia and Volpon (2014).

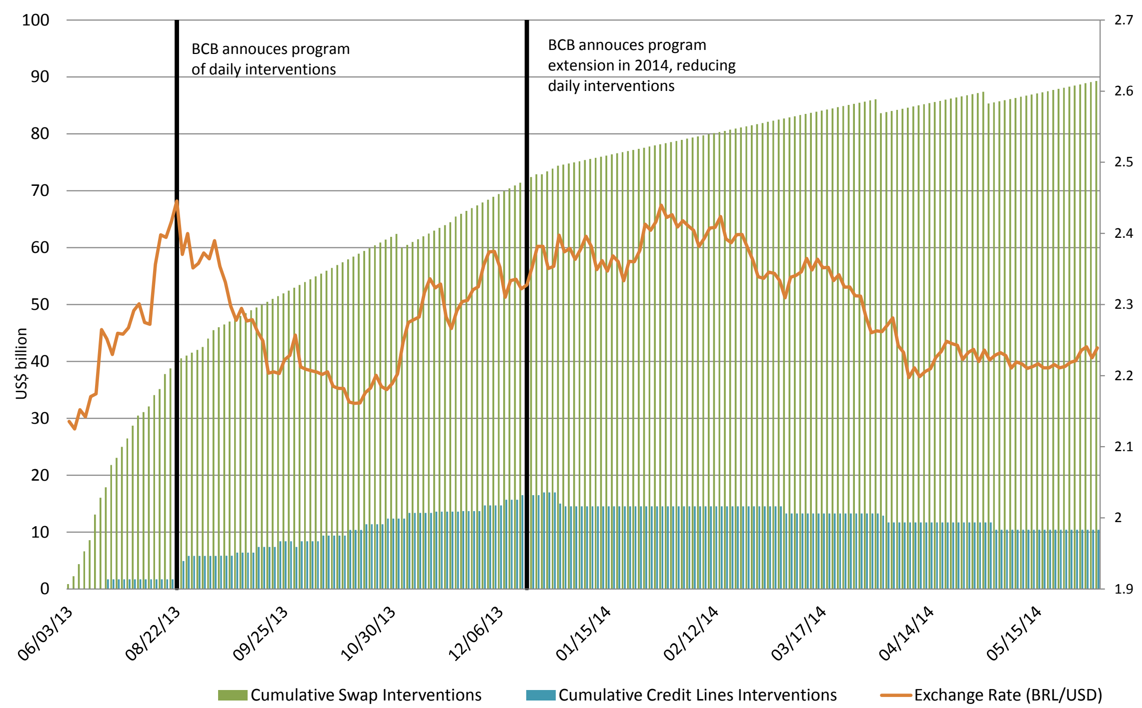


Figure 1: Cumulative Swap Interventions, Cumulative Credit Lines Interventions and Exchange Rate (BRL/USD). Source: BCB and AC Pastore.

In the Brazilian context, a number of papers have shown that FX intervention, including through swaps, can affect the exchange rate. For example, Andrade and Kohlscheen (2014) show that the Brazilian real moved about 0.33bps following the announcement of a currency swap auction. Barroso (2014) estimates that a purchase or sale of US$ 1 billion lead to a 0.51 percent depreciation or appreciation of the Brazilian real. Werther (2010) found that the effects of sterilized interventions are very small on its magnitude (between 0.10 and 1.14 percent for each US$ 1 billion) and of low duration. More generally, estimates for the effect of a US$1 billion dollar intervention on the exchange rate typically range from 0.10 to 0.50 percent.

Studies on FX intervention face a substantial, perhaps insurmountable, endogeneity problem, since a central bank tends to purchase FX when it wants to slow down an appreciation, and vice-versa. That can bias regression estimates (perhaps even to the point of flipping the sign of the effect). Different strategies have been used to address this problem, including VARs, IV strategies, and relying on high-frequency data. All of these strategies have some drawbacks, including the extent to which they truly tackle this endogeneity problem.

In this paper we use a synthetic control approach to estimate the effects of the Brazilian swap program. To our knowledge, we are the first paper to use this technique to study the effects of FX interventions.[2] This technique was introduced by Abadie et al. 2010, and in a nutshell, consists of constructing a synthetic control group that provides a counterfactual exchange rate against which we can compare the evolution of the Brazilian real after that announcement. This methodology is not appropriate for studying the effect of frequent interventions, but it is well suited for an event-study setting where a large change in intervention policy is announced, as in the case of Brazil. Our counterfactual uses data from other countries, with weights that are based on the pre-announcement co-movement with Brazil. As a result, whatever noise and error is involved in this type of analysis, it will be orthogonal to the endogeneity problem that plagues the literature on FX intervention. Our findings point to an appreciation of the BRL/USD in the first few weeks following the announcement of the program and placebo tests suggest the finding is robust. This is consistent with a surprise effect on the market, which by all accounts was not expecting the program.

We use another methodology proposed by Carvalho et al. (2015) which allows us to make inference of the results. That methodology points to a similar effect on the BRL/USD (if anything stronger) following the announcement of the FX swap program, and that effect is statistically significant relative to the evolution of the synthetic control group. Our quantitative estimates range from an appreciation of 7 to 19 percentage points on the exchange rate following that program. The evidence is much weaker for the December announcement (extending the program and reducing the daily interventions). That program had a smaller effect on the exchange rate (of about 5 percentage points), but its effect was not statistically significant. In addition, we use the approach proposed by Carvalho et al. (2015) to check if the FX swap program had an effect on the variance of the BRL/USD. Our findings suggest that both announcements did not affect the volatility of the exchange rate.

Finally, as a robustness check, we also perform a more standard event-study analysis, which confirms a large effect following the August announcement, but not for the second

[2] Jinjarak et al. (2013) use the synthetic control method to analyze the effects of the adoption and removal of capital controls in Brazil on capital flows and the exchange rate. Their results show that capital controls had no effect on capital flows and small effects on the the exchange rate.

program announcement.

The remainder of the paper is organized as follows. Section 2 outlines the methodologies used, section 3 presents data description and section 4 shows our results. Finally, Section 5 concludes.

# 2 Methodology

In this section, we present the synthetic control approach proposed by Abadie et al. (2010) and by Carvalho et al. (2015). Then, we use use these methodologies to evaluate the effects of the BCB intervention programs on the Brazilian exchange rate.

## 2.1 Abadie et al. (2010)

Let $Y_{it}^{I}$ denote the exchange rate in a country $i$ in period $t$ for a country that adopts a policy (e.g. an FX intervention program) at time $T_0$, and $Y_{it}^{N}$ denote non-observed exchange rate that would have occurred had the country not adopted the FX interventions program.

We assume that there is no effect of the intervention program in the period preceding the policy change ($t < T_0$), i.e., $Y_{it}^{N} = Y_{it}^{I}$. Hence, the effect of the intervention program is given by $\alpha_{it} = Y_{it}^{I} - Y_{it}^{N}$ from period $T_{0+1}$ to $T$. Without loss of generality, suppose the policy change occurred on country $i = 1$ (Brazil in our case). We assume that $Y_{it}^{N}$ follows a factor model given by:

$$Y_{it}^{N} = \delta_t + \theta_t Z_i + \lambda_t \mu_i + \varepsilon_{it} \tag{1}$$

where $\lambda_t$ is a constant unknown common factor between countries, $Z_i$ is a vector of observable variables, $\theta_t$ is a vector of parameters and $\mu_i$ is an unknown common factor that depends on time. At last, $\varepsilon_{it}$ is a mean zero iid shock.

In addition, consider $W = (\omega_2, ..., \omega_{j+1})'$ as a vector of weights such that $\omega_i \leq 0$ and $\sum_{i=2}^{j+1} \omega_i = 1$. Suppose that there is an optimal weight vector $\hat{W}$ that can accurately replicate pre-treatment observations in Brazil. Abadie et al. (2010) show that under regular conditions $Y_{it}^{N} = \sum_{i=2}^{j+1} \hat{\omega}_i Y_{it}$. Thus, we can calculate $\hat{\alpha_{1t}} = Y_{it} - \sum_{i=2}^{j+1} \hat{\omega}_i Y_{it}$ for $t \geq T_0$.

Define $X_1$ as a vector of pre-treatment characteristics of the Brazilian exchange rate that contains $Y$ and $Z$, and similarly $X_0$ for the control countries. Hence, the optimal weight vector $\hat{W}$ is chosen through the minimization of the following equation

$$\sqrt{(X_1 - X_0\hat{W})'V(X_1 - X_0\hat{W})} \tag{2}$$

where $V$ is a $k \times k$ symmetric and positive semi-definite matrix ($k$ is the number of explanatory variables). Also $V$ is chosen to minimize the mean square prediction error in the period prior to the policy change. We use the STATA *synth* routine to obtain $V$.

Finally, we use permutations tests to examine the significance of our results, due to the fact that the usual statistical inference is not available. For each control country in our sample, we assume that it implemented a FX intervention program in $T_0$. We then produce counterfactual synthetic control for each "placebo control" and calculate the effect $\alpha_{it}^P$ for $t \geq T_0$. Therefore, we can check if the effect found for Brazilian exchange rate is different from the effects on the control currencies.

## 2.2 Carvalho et al. (2015): ArCo

Consider $n$ countries for $T$ periods indexed by $i \in \{1, ..., n\}$. As in Abadie et al. (2010), assume that one country implemented a policy change in $T_0$. Furthermore, consider that we observe $q$ variables for each country $i$ and that they all follow jointly a covariance-stationary process. We can then stack all the $n$ countries in a vector $y_t = (y_{1t}, ..., y_{nt})'$ and use the Wold decomposition to write the following equation for $1 \leq t \leq T$

$$\mathbf{y_t} - \mu_\mathbf{t} = \sum_{j=0}^{\infty} \phi_{t-j}\varepsilon_{t-j} \tag{3}$$

where each $\phi_{t-j}$ is a $(nq \times nq)$ matrix and the constraint $\sum_{j=0}^{\infty} \phi_{t-j}^2 < \infty$ must be satisfied for $1 \leq t \leq T$. Also, $\varepsilon_t$ is a $nq$-dimensional serially uncorrelated white noise with covariance matrix $\Sigma_t$.

Moreover, consider that Brazil is indexed by 1 and define the direct effect in our variable of interest $y_{1t}$ as

$$\delta_\mathbf{1t} = \mathbf{y_{1t}} - \mathbf{y_{1t}^*} \tag{4}$$

where $\mathbf{y_{1t}^*}$ is our variable of interest without the FX intervention program. But, $\mathbf{y_{1t}^*}$ is not observed, therefore, we have to estimate $\mathbf{y_{1t}^*}$ before estimate $\delta_\mathbf{1t}$. For this reason, we consider the best linear predictor as $(\mathbb{E}(y^*_{1t}|1, y^*_{-1t}))$

$$\mathbf{y_{1t}} = \mathbf{y^*_{1t}} = \mathbf{w_0} + \mathbf{w_1}\mathbf{y_{-1t}} + \mathbf{v_{1t}}, 1 \leq t \leq T_0. \tag{5}$$

where $\mathbf{y_{-1t}}$ is a matrix with all $q$ variables for all $n-1$ countries (not including Brazil), $\mathbf{w_1}$ is a $(q \times (n-1)q)$ matrix and $\mathbf{w_0}$ is $(q \times 1)$ vector.

We estimate $w$ by OLS for all the $q$ equations.[3] Note that Abadie et al. (2010) approach consider that the weights should be non-negative and their sum should be equal to one. These restrictions provide a possible interpretation for the weights. However, Carvalho et al. (2015) argues that it is not clear the relevance of the interpretation when all that is needed is a strong correlation. For example, consider an extreme case where there is a perfectly negatively correlated country with Brazil. Under the restrictions adopted by Abadie et al. (2010), this peer would be disregarded despite the fact that using it would result in an almost perfect synthetic counterfactual. The opposite case is also troublesome, consider that all the peers are uncorrelated to Brazil. Due to the restriction to sum to one, the estimator automatically assign weights to countries that have no contribution in explaining the counterfactual trajectory.

Differently from Abadie et al. (2010), Carvalho et al. (2015) presents the statistical inference for the average direct effect between period $T_{0+1}$ and $T$. Hence, we can test if the effect of the intervention programs on the Brazilian exchange rate is statistically significant. In addition, another moments can be tested. In our case, we are also interested to analyze if the FX swap program had an effect on the variance of the exchange rate. We consider the same linear specification as in (5) and our dependent and independent variables becomes $\ddot{\mathbf{y}}_{\mathbf{1t}} = (\mathbf{y_{1t}} - \bar{\mathbf{y}}_{\mathbf{1t}})^2$ and $\ddot{\mathbf{y}}_{\mathbf{-1t}} = (\mathbf{y_{-1t}} - \bar{\mathbf{y}}_{\mathbf{-1t}})^2$, respectively. Therefore, the average effect is also estimated and all the hypothesis testing can be carried on (see Carvalho et al. (2015) for more details.).

# 3 Data

Besides the exchange rate, we use the flow of capital from the Emerging Portfolio Fund Research (EFPR) as one of the control variables. Due to the fact that we are interested in analyzing the short term behavior of the exchange rate, we use weekly data[4] from May

[3] As stressed by Carvalho et al. (2015), it is one of the possible ways to estimate equation (4).

[4] According to Jinjarak et al. (2013), EPFR weekly data have a higher correlation with Balance of Payments from the International Monetary Fund (IMF) than the monthly data.

29, 2013 to November 13, 2013 and from October 2, 2013 to March 19, 2014 to analyze the first and the second program, respectively. For each program, our sample consists of 25 weeks: 12 weeks prior the policy change, the week of the policy change, and 12 weeks after. As additional control variables, we use weekly data of the stock and bond markets in each country. For the implementation of both methodologies, the series used should be stationary. For this reason, our dependent variable is the log difference of the Brazilian exchange rate and the same transformation is used for the stock and bond markets. Capital flows to each country are scaled by the 2012 GDP in US dollars for each country.

# 4 Results

In this section, we use the approaches presented on the methodology section to analyze the FX intervention programs in Brazil. In addition, we present an event study to check the robustness of our results.

## 4.1 First intervention program: August 22, 2013

On August 22 2013, the BCB announced an FX swap program in order to mitigate the depreciation of the Brazilian exchange rate. Figure 2 presents our results for the change in the log of dollar-real bilateral exchange rate (BRL/USD) for the first intervention program using Abadie et al. (2010) approach. We consider a sample of 22 countries (in addition to Brazil). In the appendix, we present the estimated weights in Table A.1 and show the values of the controlled variables for the synthetic and the actual one in Table A.2. It is important to stress that the weights and countries used for the construction of the synthetic control group do not have an economic interpretation (see Abadie et al. (2010)). Having said that, the synthetic control group for the evolution of the Brazilian exchange rate draws on data from South Africa, India, Peru and Indonesia. There is a large difference in the actual log difference of the BRL/USD and the one in the synthetic control group during the first week, but the behavior of the two series is largely similar afterwards.

In order to illustrate the implied effect in the level of the exchange rate, Figure 3 accumulates the weekly log differences for the actual BRL/USD exchange rate, and for the synthetic exchange rate. For the latter we only reported from $T_0$ onwards, because we keep its values prior the intervention program as same as the actual, therefore the errors on the log differences before the announcement do not affect the period after August 22. There is a large effect on the level following the first week of the program, of almost 8 percentage points, consistent with the large difference for the first week in Figure 2. The gap between the two lines continues to widen in the second and third weeks, pointing to a cumulative gap of about 15 percentage points. This is largely consistent with the program having a one-off permanent effect on the level of the exchange rate, which is what one would expect since the exchange rate is a forward-looking asset price and presumably the expected effect of the program should be quickly priced in by the market.

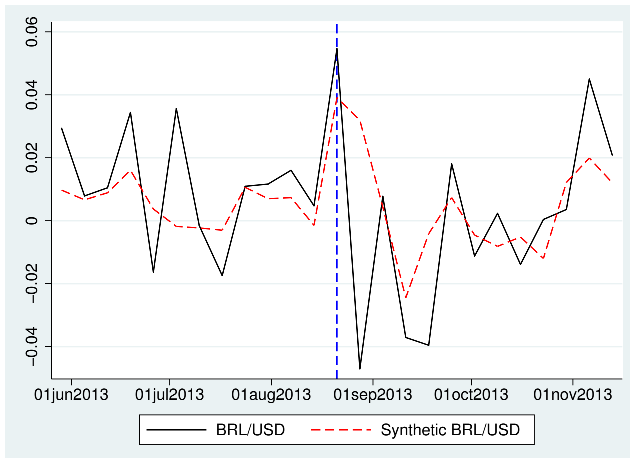


Figure 2: First Intervention Program: Log difference of BRL/USD and Synthetic BRL/USD, using Abadie et al. (2010).

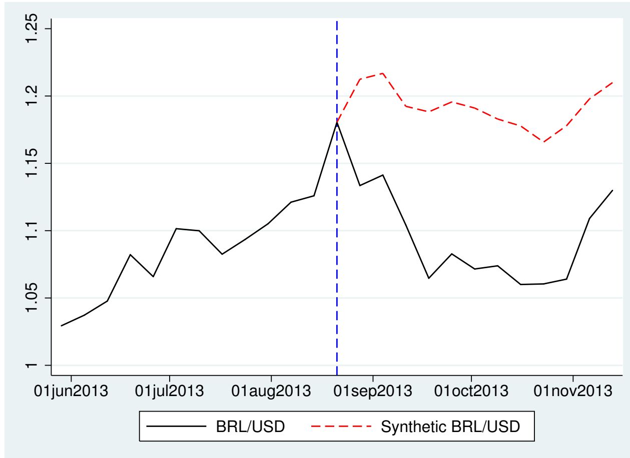


Figure 3: First Intervention Program: Log level of BRL/USD and Synthetic BRL/USD, using Abadie et al. (2010).

As proposed by Abadie et al. (2010), we implement a placebo test to check the significance of our results. Figure 4 presents this test for the log difference of the FX rate. This test confirms an unusually large appreciation in the week after the program, followed by a similar behavior to the other currencies in the weeks afterwards. This pattern is more clearly illustrated in Figure 5, which reports the placebo test in levels (cumulated changes).[5]

[5] When we consider only Inflation Targeting countries (which yields a more homogenous comparator group, where the exchange rate is allowed to float), the results persist.

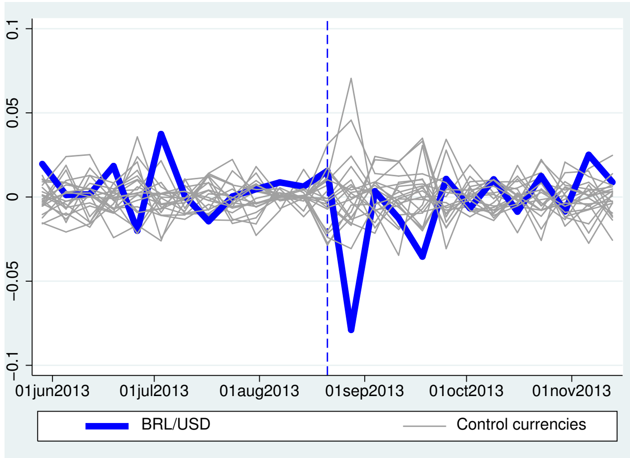


Figure 4: First Intervention Program - Placebo Test in log difference: Gap between actual and synthetic.

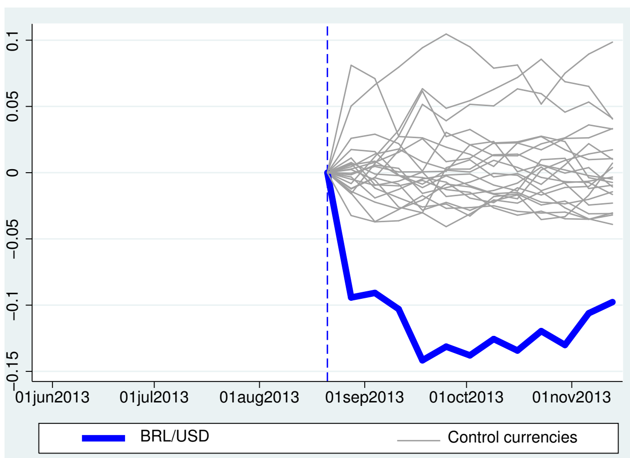


Figure 5: First Intervention Program - Placebo Test in log level: Gap between actual and synthetic.

The effect of this program is also estimated using the ArCo approach. Differently from Abadie et al. (2010), we can not consider all peers and all control variables, or else there would be more parameters being estimated than the data available. We choose 3 peers that explains a significant part of the Brazilian exchange rate: South Africa, Thailand and Peru.[6] The counterfactual is estimated through a regression of the BRL/USD on the others

[6]The $R^2$ of a regression of BRL/USD in these currencies is equal to 0.8.

peers' change in log of exchange rate and a constant.

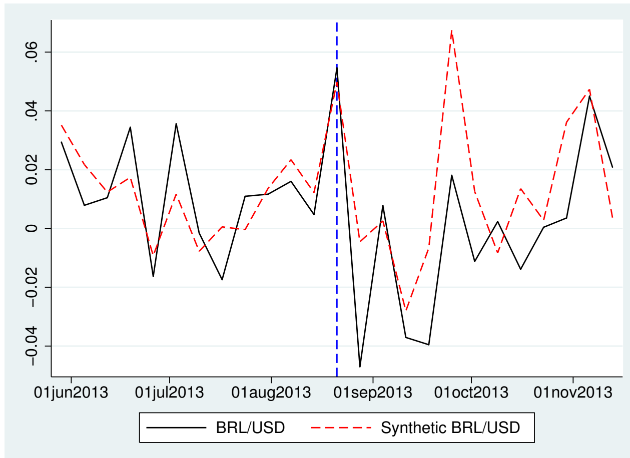


Figure 6: First Intervention Program: Log difference of BRL/USD and Synthetic BRL/USD, using ArCo.

Figure 6 shows this result for the log difference and the average effect found is an appreciation of 0.59 percentage point. The authors propose a statistical inference for the average effect and Table 1 shows that the average effect is statistical significant for various lags structures. When we consider the cumulative effect, we find an approximate 19 percentage points effect. This value is higher than the one we found using Abadie et al. (2010) approach. One possible explanation is the fact that we consider a constant when we estimate the counterfactual. When we consider a counterfactual without the constant, we find a cumulative effect of almost five percentage points.

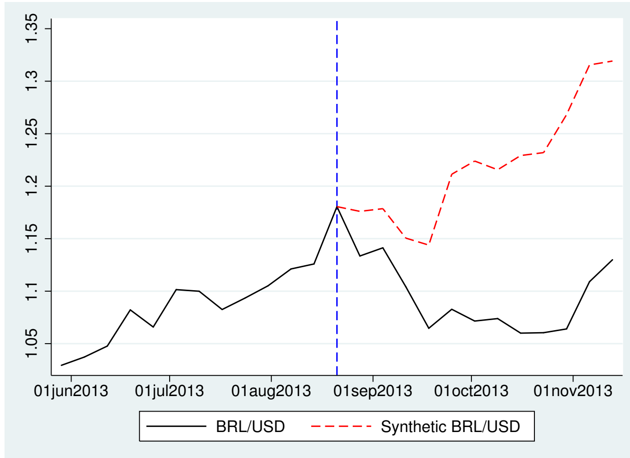


Figure 7: First Intervention Program: Log level of BRL/USD and Synthetic BRL/USD, using ArCo.

| **AVERAGE EFFECT: -0.0059** | | | | | |
|---|---|---|---|---|---|
| **LAGS** | **0** | **1** | **2** | **3** | **4** |
| **P-VALUE** | 0.0695 | 0.0549 | 0.0326 | 0.0224 | 0.0195 |

Table 1: First Intervention Program: Average effect and its P-values, according with lags in estimated the covariance matrix.

In addition, we analyze the effect of the FX swap program on the FX volatility. Using ArCo approach, we test if the Brazilian exchange rate variance was affected after the August 22 announcement.[7] We consider the same three peers (South Africa, Peru and Thailand) and the dependent and independent variables are the squared difference of the change in log and their means. We find that the average effect on the variance is close to zero and also this effect is not statistically significant.Table 2 shows that this result is robust to various lags structures. Also we find similar results for the option-implied exchange rate volatility, using both methodologies.[8]

[6]Note that these lags correspond to the covariance matrix estimated as shown in the methodology section.

[7]See methodology section for more details.

[8]Results are available upon request.

| AVERAGE EFFECT: 0.0000 | | | | | |
|---|---|---|---|---|---|
| **LAGS** | **0** | **1** | **2** | **3** | **4** |
| **P-VALUE** | 0.2533 | 0.2703 | 0.2670 | 0.2877 | 0.2334 |

Table 2: First Intervention Program - Variance: Average effect and its P-values, according with lags in estimated the covariance matrix.

All in all, our results suggest that the first intervention program mitigated the depreciation of the Brazilian exchange rate against the dollar. The quantitative size of the effect varies across methods, with estimates pointing to a cumulative effect in the range of 7 to 19 percentage points. We do not find much of an effect on the exchange rate volatility.

### 4.2 Second intervention program: December 19, 2013

On December 19, 2013, the intervention program was extended until mid-2014 and in addition, the daily interventions were reduced. Therefore, we analyze the effect of the extension of the FX swap program, which was accompanied by the reduction of daily interventions, on the Brazilian exchange rate. As for the first intervention program, we use the approaches from Abadie et al. (2010) and Carvalho et al. (2015).

Figure 8 presents our results for the log difference of BRL/USD using Abadie et al. (2010) methodology. In this case, the change in log of BRL/USD draws on the behavior for Chile, Turkey and Peru. There is a modest change in the behavior of the synthetic after the program announcement, but this trend is quickly reversed. Figure 9 shows that the synthetic BRL/USD is more depreciated than the real one and the cumulative effect is almost 7 percentage points after 12 weeks. This result is considering that the log differences before the announcement for the synthetic BRL/USD is the same as the actual.

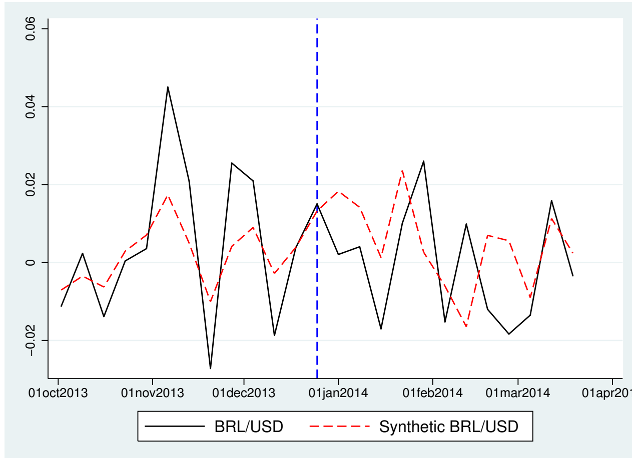


Figure 8: Second Intervention Program: Log difference of BRL/USD and Synthetic BRL/USD, using Abadie et al. (2010).

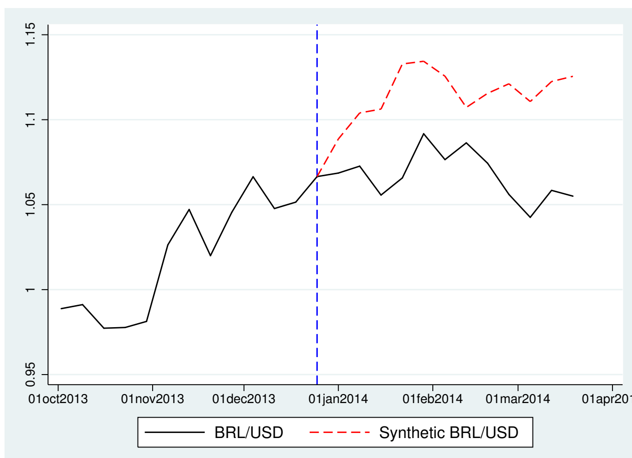


Figure 9: Secong Intervention Program: Log level of BRL/USD and Synthetic BRL/USD, using Abadie et al. (2010).

Figure 10 presents the placebo test. While the BRL/USD does tend to weaken relative to the other currencies in the first weeks after the announcement, the effect is much less pronounced than in the case of the first program. This is also confirmed in Figure 11 which shows the placebo test in levels.

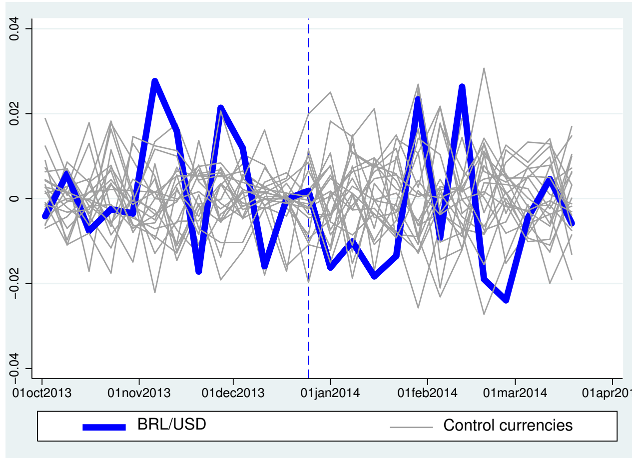


Figure 10: Second Intervention Program - Placebo Test in log difference: Gap between actual and synthetic.

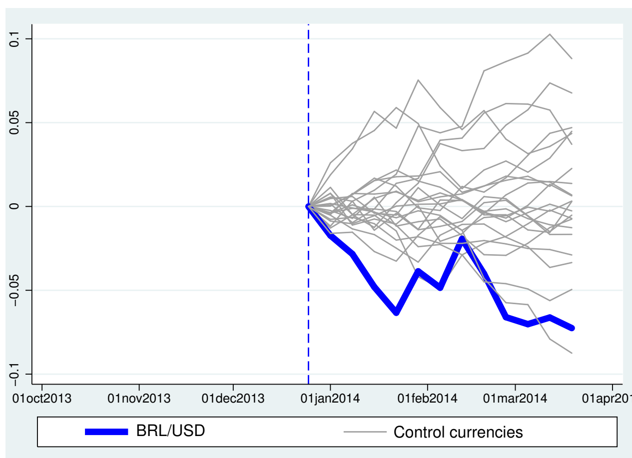


Figure 11: Second Intervention Program - Placebo Test in log level: Gap between actual and synthetic.

Figure 12 shows the results using the ArCo methodology. There is a difference in the changes relative to the synthetic BRL/USD at first, but afterwards the two series are very similar. Figure 13 reports the results in levels. The second intervention program mitigates the depreciation of the BRL/USD at first, but the cumulative effect is null. Moreover, as shown in Table 3, the average effect on the 12 weeks after the announcement is equal to -0.12 percentage points, but it is not statistically significant even when we consider different lag structures.

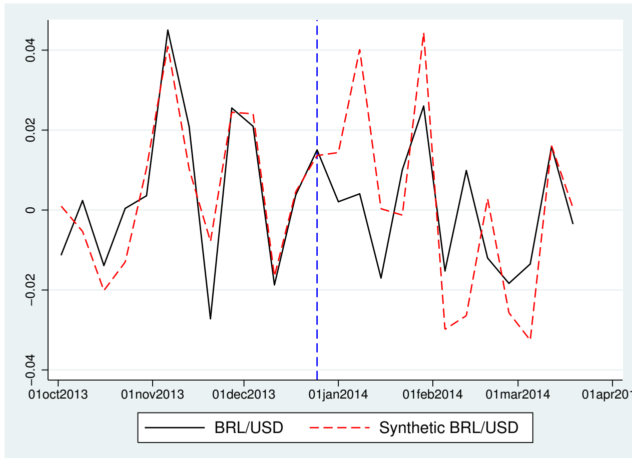


Figure 12: Second Intervention Program: Log difference of BRL/USD and Synthetic BRL/USD, using ArCo.

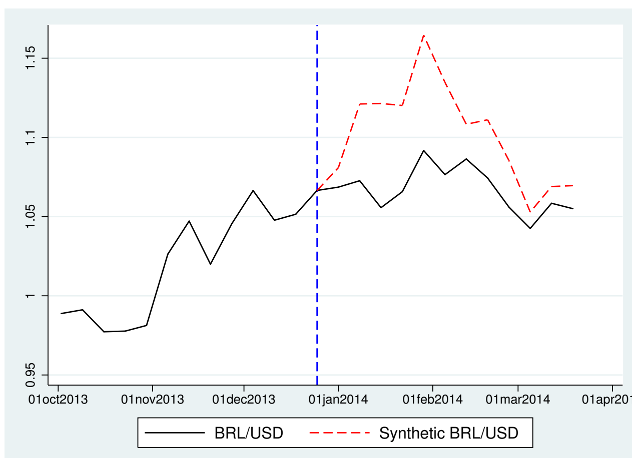


Figure 13: Second Intervention Program: Log level of BRL/USD and Synthetic BRL/USD, using ArCo.

| AVERAGE EFFECT: -0.0012 | | | | | |
|---|---|---|---|---|---|
| **LAGS** | **0** | **1** | **2** | **3** | **4** |
| **P-VALUE** | 0.8489 | 0.8489 | 0.8451 | 0.8451 | 0.8451 |

Table 3: Second Intervention Program: Average effect and its P-values, according with lags in estimated the covariance matrix.

Also we analyze if the FX swap program affect the FX volatility. Using ArCo approach, we test if the Brazilian exchange rate variance was affected after the December 19 announcement. We consider the same three peers (South Africa, Peru and Thailand). We find that the average effect on the variance was a reduction of -0.0004, but this effect is not statistically significant. As in the first intervention program, this finding persists when we consider the option-implied exchange rate volatility, using Abadie et al. (2010) and ArCo approaches. Table 4 shows that this result is robust to various lags structures.

| AVERAGE EFFECT: -0.0004 | | | | | |
|---|---|---|---|---|---|
| **LAGS** | **0** | **1** | **2** | **3** | **4** |
| **P-VALUE** | 0.1895 | 0.1704 | 0.1305 | 0.1487 | 0.1501 |

Table 4: Second Intervention Program - Variance: Average effect and its P-values, according with lags in estimated the covariance matrix.

In a nutshell, both methodologies point to a more modest, although not statistically significant, effect of the second FX swap program on the Brazilian exchange rate and continues to point to no effect on its volatility.

### 4.3 Event Study

As a robustness check, we complement our analysis with a standard event-study analysis around the announcement of the FX swap program.[9] Using daily data, we estimate:

$$\begin{aligned}\Delta log(e_t) = c + \gamma_1 \Delta(CDI_t - LIBOR_t) + \gamma_2 \Delta log(VIX_t) + \gamma_3 \Delta log(Commodities_t) \\ + \gamma_4 \Delta log(DollarIndex_t) + \gamma_5 \Delta(Dollar - AsiaIndex_t) + \gamma_6 FXInt_t + \varepsilon_t \end{aligned} \quad (6)$$

[9] Please refer to Campbell, Lo and MacKinlay (1996) for a description of the event study approach.

Where $e$ is the dollar-real bilateral exchange rate, and explanatory variables include the change in the spread between the one-month $CDI$ (Brazil's interbank rate) and the one-month $LIBOR$, the change in the log of the $VIX$, the change in the log of the $CRB$ commodity price index, the change in the log of an index constructed by the Federal Reserve for the value of the dollar relative to major currencies of advanced economies weighted by US trade shares, the change in the log of the Bloomberg JP Morgan Asia and Latin America currency indices (we recomputed the latter, based on published weights, to exclude the BRL/USD), and the Foreign Exchange Intervention by the central bank (based on announced swaps, netting out maturing ones).

We estimate this regression using data for January-May 2013. We then compute the change in the log of the exchange rate beyond what would have been implied by that fitted model (analogous to the Cumulative Abnormal Returns in a standard finance event study) and the corresponding error bands around that estimate.

We consider a $+/-$ 10 day window around the two August 22, and December 19 2013 announcements. The results point to a statistically significant cumulative appreciation of about 5 percent after 10 days of the August 22 announcement. The BRL/USD was already on an appreciation trend prior to the announcement (although the error bands include zero for most of that pre-announcement period). In contrast, there is virtually no response following the December 19 announcement.

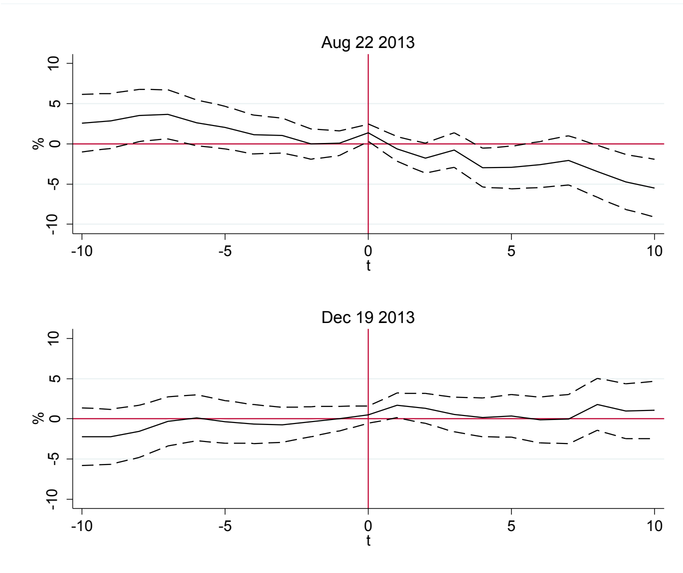


Figure 14: Cumulative changes in the exchange rate around FX program announcement. Notes: Dashed lines correspond to +/- 2 Standard Deviations. Cumulative changes start at 0 for both before and after period.

The results become stronger if we consider a longer estimation sample. For example, Figure 15 reports analogous plots based on an estimation sample starts in January 2013 and covers up to 20 days prior to the August 22 announcement. There is no significant cumulative movement in the BRL/USD in the 10 day window prior to that announcement, which is followed by a statistically significant cumulative depreciation of about 6.5 percent 10 days after that announcement. But the estimates continue to point to no response following the December 19 announcement.

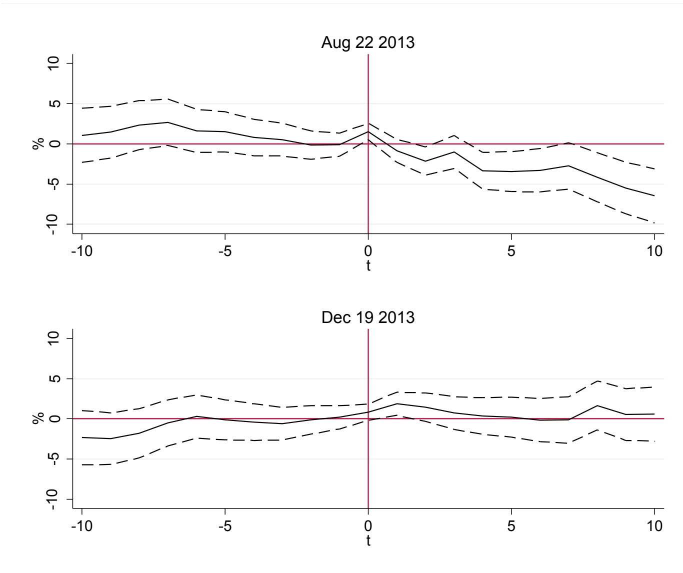


Figure 15: Cumulative changes in the exchange rate around FX program announcement. Notes: Dashed lines correspond to +/- 2 Standard Deviations. Cumulative changes start at 0 for both before and after period.

# 5 Conclusion

The gyrations in capital flows have brought renewed interest to interventions in FX markets: sterilized interventions, capital controls and other forms. In the wake of the taper tantrum of May 2013, which caused major upheaval among emerging market currencies, the Brazilian Central Bank conducted the world's largest sale of exchange rate hedge. The hedge has been provided via currency forwards that settle in domestic currency (Garcia and Volpon (2014)).

Immediately after the FX intervention program announcement, on August 22 2013, the Brazilian real, which was depreciating, reverted that trend, and stabilized at a more appreciated level. In this paper we used a synthetic control approach to confirm the success of that program in stabilizing the BRL/USD, which is, to our knowledge, the first application of that methodology to study FX interventions.

Our results indicate that the initial announcement of the program, on August 22 2013, was effective in changing the behavior of the exchange rate. The estimated cumulative effect of the FX intervention program on the BRL/USD exchange rate are in the range of 7 to 19 percentage points. However, the announcement of the program extension, albeit with a diminished size, on December 19 has not been shown to alter the Brazilian exchange rate significantly. Our estimates point to an effect of about 5 percentage points in the immediate aftermath, but it is relatively short-lived, and not significant, possibly because that extension was already being priced-in by the market. Robustness of the results are confirmed via an event-study methodology. We do not find evidence that either announcement had a significant impact on the volatility of the exchange rate.

Our results are consistent with the view that FX interventions can be effective in deterring exchange rate overshooting in times of market turmoil. The large size of the program, and the market surprise following its announcements facilitate the identification of an effect, which would be more challenging in the context of small and frequent interventions that have come to be expected by the market.

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# A Appendix

| Country | Weight | Country | Weight | Country | Weight | Country | Weight |
|---|---|---|---|---|---|---|---|
| Australia | 0.000 | Chile | 0.000 | Canada | 0.000 | Israel | 0.000 |
| Japan | 0.000 | Korea | 0.000 | Mexico | 0.000 | New Zealand | 0.000 |
| Phillippines | 0.000 | Poland | 0.000 | **South Africa** | **0.131** | Sweden | 0.000 |
| Turkey | 0.000 | UK | 0.000 | US | 0.000 | **India** | **0.253** |
| Russia | 0.000 | **Peru** | **0.146** | Colombia | 0.000 | **Indonesia** | **0.470** |
| Malaysia | 0.000 | Thailand | 0.000 | | | | |

Table A.1: Weights: First intervention program, using Abadie et al. (2010).

| Variables | Treated | Synthetic |
|---|---|---|
| Change in the log of BRL/USD on the week end at 08 - 14 -13 | 0.0047434 | -0.001454 |
| Change in the log of BRL/USD on the week end at 08 - 07 -13 | 0.0160345 | 0.0073479 |
| Change in the log of stock market index | -0.0086004 | -0.0085488 |
| Change in the log of stock market index on the week end at 08 - 14 - 13 | 0.0701756 | -0.0024488 |
| Change in the log of bond market index | -0.0114702 | -0.0083068 |
| Change in the log of bond market index on the week end at 08 - 14 - 13 | -0.0156849 | -0.0094137 |
| Ratio of cumulative flow over GDP | -0.000025 | -0.0000181 |
| RMSPE (Root Mean Squared Prediction Error) | 0.0154772 | |

Table A.2: Predictor Balance: First intervention program, using Abadie et al. (2010).

| Country | Weight | Country | Weight | Country | Weight | Country | Weight |
|---|---|---|---|---|---|---|---|
| Australia | 0.000 | **Chile** | **0.068** | Canada | 0.000 | Israel | 0.000 |
| Japan | 0.000 | Korea | 0.000 | Mexico | 0.000 | New Zealand | 0.000 |
| Phillippines | 0.000 | Poland | 0.000 | South Africa | 0.000 | Sweden | 0.000 |
| **Turkey** | **0.722** | UK | 0.000 | US | 0.000 | India | 0.000 |
| Russia | 0.000 | **Peru** | **0.210** | Colombia | 0.000 | Indonesia | 0.000 |
| Malaysia | 0.000 | Thailand | 0.000 | | | | |

Table A.3: Weights: Second intervention program, using Abadie et al. (2010).

| Variables | Treated | Synthetic |
|---|---|---|
| Change in the log of BRL/USD on the week end at 12 - 11 - 13 | 0.0037615 | 0.0038824 |
| Change in the log of BRL/USD on the week end at 12 - 04 - 13 | -0.0187096 | -0.0028032 |
| Change in the log of stock market index | -0.0058676 | -0.0054676 |
| Change in the log of stock market index on the week end at 12 - 11 - 13 | 0.0098467 | -0.0173936 |
| Change in the log of bond market index | -0.0026823 | -0.0007242 |
| Change in the log of bond market index on the week end at 12 - 11 -13 | -0.0089552 | -0.0039584 |
| Ratio of cumulative flow over GDP | -.00002 | -0.0000104 |
| RMSPE (Root Mean Squared Prediction Error) | 0.0138161 | |

Table A.4: Predictor Balance: Second intervention program, using Abadie et al. (2010).

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