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FX Intervention to Stabilize or Manipulate the Exchange Rate? Inference from Profitability

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Abstract

We analyze the profitability of FX swaps used by the central bank of Brazil to shed light on the rationale for FX intervention. We find that swaps are profitable in expectation, suggesting that FX intervention is used to stabilize the exchange rate in the face of temporary excessive movements rather than to manipulate it away from fundamental values. In line with this interpretation, we find that the scale of FX intervention responds to the degree of exchange rate misalignment relative to UIP conditions. We also document that intervention is more aggressive when there is less uncertainty about the medium-term level of the exchange rate and when the exchange rate is overvalued rather than undervalued.

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It would be little harm for a government agency to speculate in the exchange market provided it held the objective of smoothing out temporary fluctuations and not interfering with fundamental adjustments. And there should be a simple criterion of success – whether the agency makes or loses money. Friedman (1953)

1 Introduction

Many emerging markets make extensive use of foreign exchange (FX) intervention, as documented for example in Fratzscher et al. (2019). In most cases, central banks claim that they intervene to stabilize the exchange rate, by leaning against excessive temporary movements. However, some critics argue that central banks use FX intervention to manipulate the value of the exchange rate away from equilibrium conditions, by resisting fundamental shocks. For example, central banks may want to keep an undervalued exchange rate to improve export competitiveness or try to resist a fundamental-driven depreciation to shield domestic borrowers with FX debt. This debate is gaining new prominence because of heightened trade tensions and growing complains about currency manipulation (Dominguez, 2019). Furthermore, the ongoing Covid-19 pandemic is prompting central banks to intervene in the exchange rate market on a very large scale which will likely raise new questions on the underlying motives.

To shed light on the true intentions of central banks, we analyze the profitability of FX intervention in line with the argument put forward by Friedman (1953). If FX intervention is used to lean against temporary excessive fluctuations of the exchange rate—reflecting deviations from uncovered interest parity (UIP)—the central bank should make a profit in expectation. By going long in the domestic currency when the exchange rate is temporarily undervalued, the central bank makes money as the exchange rate recovers to its equilibrium level over time. Similarly, by shortening the local currency when it is temporarily overvalued, the central bank makes a profit as the currency depreciates over time. If instead the central bank tries to manipulate the exchange rate away from fundamental equilibrium conditions, for example by going long in the local currency when it is bound to depreciate, it would incur a loss.

Recent literature provides theoretical underpinnings for this argument. For example, Gabaix and Maggiori (2015) present a theory of exchange rate determination where the market can become disconnected from fundamentals. This is because financial frictions constrain the trading operations of financial intermediaries, generating deviations from UIP and excessive exchange rate volatility. Central banks can use FX intervention to stabilize markets by going long in the local currency when it is undervalued and shortening it when overvalued, earning profits in the process. Making money is thus a by-product of an FX intervention strategy which aims to smooth deviations from UIP.

Note that this argument does not require that FX intervention succeeds in affecting the exchange rate. The claim that FX intervention against temporary deviations from UIP is profitable hinges

merely on the notion that the exchange rate tends to revert to its fundamental value over time. In fact, if FX intervention is successful in affecting the exchange rate, for example by boosting its value when undervalued, it reduces UIP deviations and thus the profitability of the intervention.

We conduct the analysis based on the experience of Brazil between 2013 and 2019 because it offers several key advantages. First, during that period the Brazilian Central Bank (BCB) intervened using FX swaps. These instruments are particularly suitable for an analysis of profitability since they have an explicit maturity date, making it possible to transparently compute their financial returns. Analyzing the profitability of traditional FX intervention in the spot market is much more challenging since when the central bank buys or sells FX reserves it is unclear how long it will keep the position for. Therefore, the profitability of spot-market intervention depends on arbitrary assumptions on when the central bank intends to reverse the position. Second, the BCB provides detailed information on each individual FX swap transaction which is crucial to calculate the associated returns. For example, the BCB discloses the issuance size, the sale price, and the dates of auction, settlement, and maturity.

Third, the BCB conducts a survey to collect exchange rate and interest rate forecasts by market participants at daily frequency. This allows us to analyze the profitability of swaps from an ex-ante perspective, going beyond realized returns which are affected by random shocks. By focusing on the expected profitability of swaps, the analysis provides a more accurate test of whether the central bank intervened when the exchange rate was perceived to be out of equilibrium. Fourth, after accumulating a large stock of FX reserves between 2006 and 2012, the BCB kept reserves stable at around 370 billion USD during our period of analysis. This level was considered appropriate by the Brazilian authorities and international institutions. Therefore, FX intervention was not biased towards the accumulation of additional reserves.

Regarding the design of FX swaps, by issuing these instruments the BCB takes a long position in the Brazilian *real*, BRL, while shortening the US dollar, USD. The swap is profitable if the BRL depreciates during the life of the swap by less than the interest rate differential earned on the BRL relative to the USD. In other words, the swap generates a profit if the BRL is undervalued from a UIP standpoint. In some instances, the BCB also issued negative swaps, thus shortening the BRL. In this case, the swap is profitable if the BRL is overvalued according to UIP conditions.

The analysis shows that FX intervention was profitable in expectation. This is despite the fact that FX swaps incurred realized losses because the exchange rate depreciated more than expected during the period of analysis. FX intervention was profitable in expectation both when the BCB went long in the BRL as well as when it took a short position. Furthermore, we show that the direction and scale of intervention was tightly correlated with the expected profitability of swaps, i.e. with UIP deviations. For example, the BCB issued more swaps by going long in the *real* when swaps were expected to be more profitable, i.e. when the exchange rate was perceived to be more undervalued from a UIP standpoint. These findings provide robust and consistent evidence that the

BCB used FX intervention to smooth temporary excessive movements in the exchange rate rather than lean against fundamental adjustment forces.

We perform several robustness exercises. First, swaps remain profitable in expectation even if we use exchange rate projections from surveys collected several weeks after each swap auction. This shows that the results are not driven by delays in the updating of exchange rate forecasts. Second, the results are robust to controlling for other possible determinants of FX intervention. We don't find a robust association between FX intervention and past movements in the exchange rate, confirming that the BCB did not try to resist all exchange rate movements, but only those that appeared excessive relative to UIP conditions. Swap operations were instead correlated with deviations from covered interest parity that reflect the inability of financial intermediaries to exploit arbitrage opportunities because of binding financial constraints (Du, Tepper and Verdelhan, 2018).

We also document that FX intervention was more aggressive when there was greater clarity about the future value of the BRL, captured by a lower dispersion in survey forecasts. Great clarify about the future exchange rate allows to pin down more reliably the current equilibrium level based on UIP considerations. This likely prompted the central bank to intervene more strongly when UIP deviations emerged. Finally, we show that FX intervention displayed an asymmetric response to the expected profitability of swaps, i.e. to deviations from UIP. The BCB responded more strongly to an overvaluation of the BRL by reducing the stock of outstanding swaps than to an undervaluation. This may seem surprising since a currency undervaluation is often perceived to be more worrisome due to possible effects on financial stability, in line with the proverbial fear of floating (Calvo and Reinhart, 2002). However, the asymmetric nature of the intervention likely reflects a perceived equivalence between the issuance of swaps and a reduction in FX reserves, since they both shorten the position of the central bank in USD. As such, the BCB appeared more hesitant to increase swaps than to reduce them.

The paper is related to a growing literature on FX intervention. An important stream of the literature tackles the question of whether FX intervention is able to affect the exchange rate.[1] Using daily intervention data from 33 countries between 1995 and 2011, Fratzscher et al. (2019) document that FX intervention is generally successful in affecting the exchange rate. Their analysis corroborates the findings in earlier studies about the effectiveness of FX intervention that were based on fewer countries and less detailed data (Sarno and Taylor, 2001; Fatum and M. Hutchison, 2003; Adler and Tovar Mora, 2011; Dominguez, R. and P., 2013; Blanchard, Adler and de Carvalho, 2015; Adler, Lisack and Mano, 2015; Daude, Yeyati and Nagengast, 2016). Some papers provide also specific evidence about the effectiveness of FX intervention through swaps by the BCB (Kohlscheen and Andrade, 2014; Chamon, Garcia and Souza, 2017; Nedeljkovic and Saborowski, 2019). Rather than considering the effectiveness of FX intervention, our work analyzes the profitability of FX in-

[1]There is a also a theoretical literature that analyzes the channels through which FX intervention may affect the exchange rate, including Dominguez and Frankel (1993), Gabaix and Maggiori (2015), Cavallino and Sandri (2018), Fanelli and Straub (2018), Chang (2018), and Jeanne and Sandri (2018).

tervention to understand whether central banks act to smooth temporary excessive fluctuations of the exchange rate or lean against fundamental movements.

The profitability of FX intervention has already been studied in an older literature spurred by the comments in Friedman (1953) and surveyed in Sweeney (1997). Taylor (1982) provided an early analysis of FX intervention by the US during the 1970s, finding considerable losses. Subsequent papers challenged the results arguing that intervention was in fact profitable (Jacobson, 1983; Sweeney, 1997; Neely, 1998). This early literature suffers from significant data challenges since FX intervention was often conducted in secrecy. Furthermore, it computes profitability by focusing on exchange rate movements, often failing to account for interest rate differentials. Finally, it considers only ex-post realized profits given the lack of information about expected interest rates and exchange rates.

The paper is also related to another stream of the literature that analyzes the cost of holding FX reserves. This issue has acquired prominence with the large increase in reserve holdings by emerging markets since 1990. Several studies find considerable costs from holding reserves (Rodrik, 2006; Flood and Marion, 2001; Hauner, 2006; Yeyati, 2008; Adler and Mano, 2019). This is generally the mirror image of the excess return that emerging market currencies tend to pay over the US dollar, reflecting UIP deviations documented for example in Gilmore and Hayashi (2011). Rather than considering the cost of holding reserves, we analyze whether trading operations associated with FX intervention are profitable or not.

The paper is structured as follows. We start in section 2 by discussing the extent and modalities of FX intervention by the BCB. We then analyze in section 3 the profitability of FX swaps, distinguishing between ex-ante and ex-post returns and between positive and negative swap sales. In section 4, we look at the determinants of FX intervention to test more directly whether the BCB changed the extent of intervention based on UIP deviations. Section 5 concludes by summarizing the key insights of the analysis and discussing questions for future research.

2 FX Intervention in Brazil

In 1999, Brazil adopted an inflation targeting regime with a flexible exchange rate. Since then, the Brazilian Central Bank (BCB) has intervened frequently in the FX market as illustrated in Figure 1. Between 2006 and 2012, the BCB tried to stem appreciation pressures on the *real* and strong capital inflows by accumulating FX reserves of almost 400 USD billion. This is a large level of reserves, equal to about 18 percent of GDP, that the BCB has kept stable throughout the period of the analysis.

FX intervention from 2013 onward has been conducted primarily in the derivative market. Because of past policy restrictions on FX spot transactions, Brazil has developed a very active FX derivative market that settles in reais (Garcia and Volpon, 2014; Garcia, Medeiros and Santos,

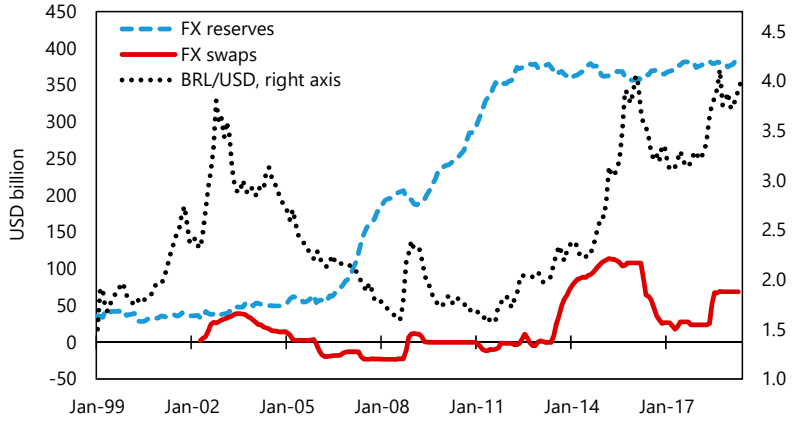

Figure 1: FX intervention since 1999

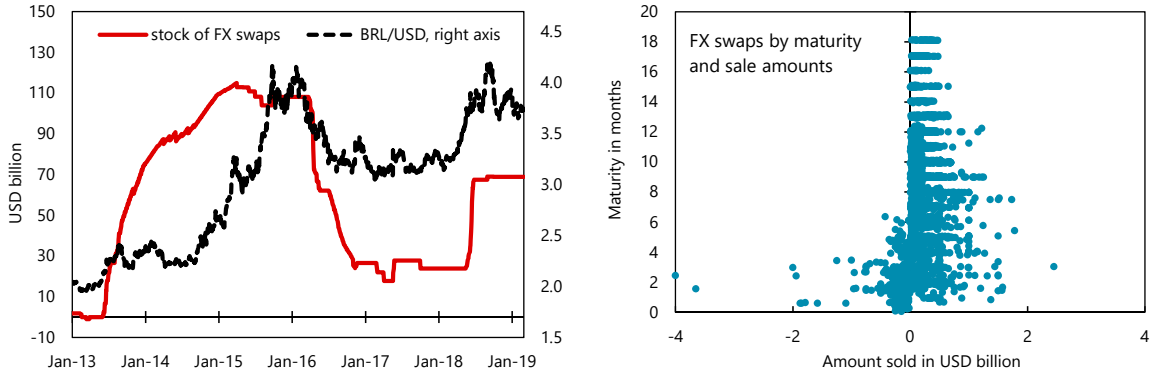

Figure 2: Intervention through FX swaps since 2013

2014). This market is now much more liquid that the spot market and is therefore the target of the central bank intervention. The BCB intervenes in the derivative market by offering FX swaps through which the central bank takes a long position in the BRL against the USD, thus aiming to prop up the value of the *real*.[2]

As illustrated in left chart of Figure 2, the stock of FX swaps started to increase sharply in 2013, as the BRL came under pressure in conjunction with the tapering announcement by the US Federal Reserve. Swaps increased to almost 120 billion USD in 2015, to then decline rapidly in 2016 as the *real* regained strength. The BCB issued again large amounts of FX swaps in May 2018 when monetary tightening in the US stirred turbulence for emerging markets.

FX swaps are sold through auctions which vary both in the amount of swaps and in their maturity. The right chart of Figure 2 shows the size and maturity of each auction between May 31st, 2013 and February 28th, 2019. The vertical axis shows that the maturity varies from a few days to a

[2]Evidence about the impact of FX swaps on the exchange rate is provided in Kohlscheen and Andrade (2014), Chamon, Garcia and Souza (2017), and Nedeljkovic and Saborowski (2019).

year and a half, with an average of 7 months. The average value of FX swaps sold in a given auction is 200 million USD, but in some instances the auction size reached a few billion USD. The auction size can be negative in which case the BCB reduces the outstanding stock of swaps.

By selling an FX swap, the BCB pledges the repayment of 50,000 USD at a future maturity date T converted in BRL at the spot exchange rate of the previous day. Through an auction process, market participants bid for the swaps by offering a discounted value relative to the 50,000 USD face value which is paid to the BCB in BRL at the exchange rate of the day before settlement, i.e. when the swap contract enters into effect.[3] The discount rate is called the *bid cupom cambial*. Furthermore, swap buyers pay the BCB the domestic policy rate, called the Selic rate, accumulated between settlement and maturity.

Therefore, on a given swap the BCB earns net revenues expressed in USD equal to

$$50,000 \left[\frac{e_{S-1}}{e_{T-1}} * \frac{\prod_{t=S}^{T-1} (1+i_t)}{1+c_A} - 1 \right] \tag{1}$$

where e_t is the exchange rate expressed in BRL per USD, the subscripts A, S and T denote the day of the swap auction, settlement and maturity, the product operator compounds the daily Selic rate i_t over the working days between settlement and maturity, and c_A is the *bid cupom cambial* that buyers offer at the time of the auction. Through an arbitrage mechanism, the *bid cupom cambial* closely tracks the on-shore USD rate, called *cupom cambial*. This is the rate that investors earn by investing in the BRL and converting the proceeds in USD using forward exchange rate contracts.

When the BCB issues a swap and goes long in the BRL, the operation is profitable if the BRL depreciates against the USD by less than the interest rate differential between the Selic rate and the on-shore USD rate. In other words, the swap is profitable if the BRL is undervalued from a UIP standpoint. Similarly, the BCB makes a profit by issuing a negative amount of swaps if the BRL depreciates by more than the interest rate differential, i.e. if the BRL is overvalued from a UIP perspective.

3 The profitability of FX intervention

According to the BCB, swaps are used to "provide liquidity to the market" and "ensure the smooth operation of the exchange market".[4] This suggests that intervention aims to avoid temporary excessive movements of the exchange rate rather than resisting fundamental adjustment forces. Following Friedman (1953), we test for this hypothesis by analyzing the profitability of FX swaps. If swaps

[3] All swap transactions settle therefore in BRL, leaving unchanged the stock of FX reserves held by the central bank. The settlement currency does not affect the nature of our analysis.

[4] See press releases on August 22, 2013 and August 30, 2018 when the BCB announced significant increases in FX swaps.

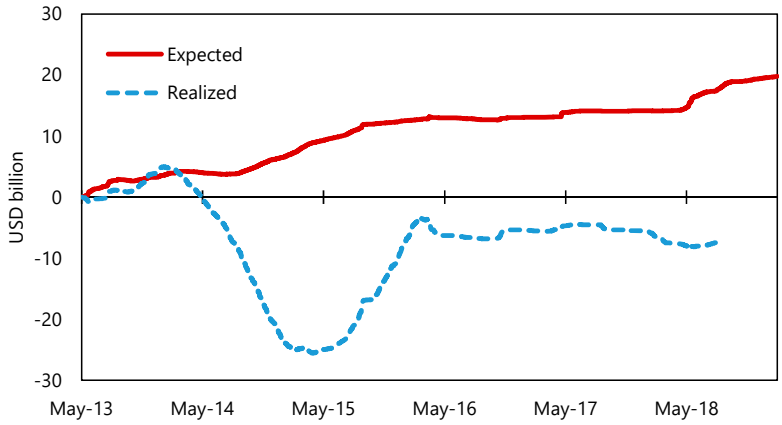

Figure 3: Cumulative profits on FX swaps for the central bank

are used to lean against excessive exchange rate movements—by going long in the BRL when undervalued from a UIP perspective and shortening the BRL when overvalued—they should generate profits for the central bank. On the contrary, if the BCB intervenes to prevent or slow down the exchange rate from adjusting to a new equilibrium level—for example by going long in the BRL when a depreciation is bound to occur—swaps should incur losses.

We analyze the profitability of swaps issued between May 31st 2013 and February 28th 2019, the latest available data at the time of the analysis. We use detailed information about each auction provided by the BCB, including the amount sold, the *bid cupom cambial*, and day of auction, settlement, and maturity.[5] We compute the profitability of swaps both from an ex-post and ex-ante perspective, using respectively realized and expected values for the Selic and the exchange rate. Expectations are collected by the BCB through a survey called the Market Expectations System. Survey respondents report their end-of-the-month forecasts for the Selic and BRL/USD exchange rate over the 18 months ahead and can update their forecasts every day. By linearly interpolating monthly forecasts, we create daily projections over 18 months. To compute expected net revenues, we replace the exchange rate and Selic in equation 1 with their expected values taken on the day of each swap auction.[6]

From an ex-post perspective, Figure 3 shows that the BCB incurred significant losses on FX

[5]Data on FX swaps are available at https://www.bcb.gov.br/estabilidadefinanceira/selicleilaoresultado .

[6]Data from the Market Expectations System are available at https://www3.bcb.gov.br/expectativas/publico/en/serieestatisticas . Following the BCB practice, we measure expectations using the median of survey responses. For some swaps, the settlement day occurs before the first forecast reported in the Market Expectations System. In this case, to measure the expected exchange rate at the time of the swap settlement, we use a linear interpolation between the spot exchange rate at the time of the auction and the expected exchange rate at the end of the month of settlement. We follow the same procedure to construct the expected Selic. For the few swaps whose maturity exceeds the 18-month forecast horizon reported in the Market Expectations System, we assume that expectations are constant beyond the forecast horizon. We subtract 10 basis points from the Selic forecast to obtain the so-called market Selic which is the rate contractually paid on the swaps.

swaps. Between May 2013 and September 2018 FX swaps generated cumulative losses of about 7.3 billion USD, after peaking to 25.6 billion USD in April 2015.[7] Therefore, based on realized losses, it appears that the BCB did not react to excessive temporary exchange rate fluctuations, but tried to lean against fundamental exchange rate movements.

However, realized returns are affected by shocks to the Selic and the exchange rate that were not foreseen at the time of intervention. These shocks may thus generate arbitrary losses or gains on FX swaps which do not reflect the intentions of the BCB at the time of intervention. If the sample is long enough, these shocks should offset each other over time, bringing realized returns in line with expected returns. However, the analysis is based on a relatively short period during which the BRL depreciated against the USD well beyond market expectations as we will discuss shortly.

Therefore, to provide a more accurate test of whether the BCB intervened when the exchange rate was perceived to be out of equilibrium, we focus the analysis on the profitability of FX swaps from an ex-ante perspective. Using the expectations on the auction dates for the Selic and exchange rate, Figure 3 shows that FX swaps have been profitable in expectation. Cumulative expected profits reached 19.8 billion USD at the end of February 2019, suggesting that the BCB intervened against deviations of the exchange rate from UIP equilibrium conditions.

Regarding the reasons for the difference between ex-ante and ex-post profits, two factors can account for it: unexpected movements in the Selic or in the exchange rate. To identify the key factor, we compute an hybrid version of the cumulative profits using realized exchange rates together with market expectations for the Selic. This leads to losses of about 8.4 billion, very close to the calculations based entirely on realized data. This implies that differences between Selic expectations and realized values have a minimal impact on the profit calculations. The difference between realized and expected profits is thus explained by the BRL depreciating more than expected during the period of analysis.

In analyzing the profitability of FX intervention, it is helpful to distinguish between different types of swap auctions. In several instances, the BCB pre-announced a schedule of future auctions. Being decided in advance, these swaps were not issued based on the market conditions prevailing on the day of the auction. Therefore, we expect these pre-announced auctions to be less profitable in expectation. Furthermore, the BCB often issued swaps to simply rollover maturing ones, keeping constant the outstanding stock of swaps as seen in the flat segments in the left chart of Figure 2. We also expect these swaps to be less profitable since they were not issued with the intent to lean against specific daily shocks.

Between May 31st, 2013 and February 28th, 2019, the BCB held about 2,900 swap auctions that we refer to as the "full sample" of analysis. By removing pre-announced and rollover swaps, we are left with a "core sample" of about 800 swap auctions. Appendix A describes how we identify pre-

[7] We stop the calculations of realized losses in September 2018. We cannot compute realized returns for subsequent swaps because they mature in the future relative to the time of this writing.

Table 1: Average expected profitability of FX swaps (annualized, percent)

	all swaps	swap sales	swap purchases
Full sample	5.6	6.1	0.8
Core sample	9.8	10.0	8.8

announced and rollover swaps. Core swap actions account for about 36 percent of the total notional value of swaps issued and purchased during the period of analysis. This proportion is relatively stable across of years.

Table 1 confirms that swaps in the core sample are considerably more profitable in expectation. The average annualized rate of return is 5.6 percent for the full sample of swaps and increases to 9.8 percent for the core sample.[8] We also differentiate between positive sales and negative sales, referring to the latter as swap purchases. Swaps sales and purchases were both profitable in expectation. Therefore the BCB sold swaps, going long in the BRL, when the exchange rate was undervalued and purchase them when the exchange rate was overvalued. We test more formally for this mechanism in the next section. Even when distinguishing between swap sales and purchases, we find that swap profitability is considerably higher for the core sample.

A possible concern with the analysis is that the results could be affected by delays in the update of exchange rate forecasts. In principle, survey participants to the Market Expectations System can update their forecasts every day, but they tend to do so only occasionally. This could distort the measurement of the expected profitability of swaps. For example, assume that a depreciation of the exchange rate in the spot market leads to a downward revision of the exchange rate forecast. If this is not timely recorded in the survey and the central bank issues a swap, we would overestimate its expected profitability since we would use an outdated and overvalued future expected exchange rate.

Several considerations attenuate this concern. First, the example above applies symmetrically with opposite effects to swap sales when the exchange rate appreciates. In this case, delays in recording an appreciation of the expected future exchange rate would lead to a reduction, rather than increase, in the expected profitability of the swap. During the period of analysis, swap sales were only slightly more frequent in days when the exchange rate depreciated, accounting for 55 percent of the full sample. Therefore, delays in updating survey projections are likely to generate only a modest bias in favor of higher expected profits on swap sales.

Second, delays in updating forecasts have opposite effects on the profitability of swap purchases,

[8] We calculate returns on a given swap by dividing the revenues computed with equation 1 by the face value of the swap equal to 50,000 USD. We annualize the returns to correct for differences in swap maturity. In computing average returns, we weigh each swap auction by the absolute quantity of swaps sold or purchased. When computing the returns on swap purchases, we invert the sign since the central bank makes money on swap purchases when revenues computed with equation 1 are negative.

Table 2: Average expected profitability of FX swaps using later surveys (annualized, percent)

	Using surveys collected after auction by:			
	one week	two weeks	three weeks	four weeks
Full sample	3.3	2.0	1.7	1.1
Core sample	4.5	1.9	1.1	-0.1

with delays reducing the profitability of swap purchases that occur in days when the exchange rate depreciates. Since swap purchases were also moderately more frequent in days when the exchange rate depreciated, accounting for 52 percent of the full sample, this should generate a negative bias against their profitability. Despite this, also swap purchases were profitable in expectation.

Third, we can check whether delays in the update of exchange rate forecasts are driving the results through this simple exercise. We re-compute the expected profitability of swaps using surveys collected several weeks after the auction date which thus capture delayed revisions to forecasts. Table 2 shows that the average expected returns using the forecasts recorded one week after the auction are about 3.3-4.5 percent. This is less than the returns of 5.6-9.8 percent reported in Table 1 using the forecasts on the day of the auction, possibly reflecting delays in the recording of new forecasts (or the occurrence of new shocks biasing down the results). Nonetheless, even using surveys up to four weeks after the auction dates, swaps remain profitable, thus dispelling concerns that the results could be driven by delays in the recording of revised forecasts.

We have established that FX intervention by the BCB was profitable in expectation and argued, in line with Friedman (1953), that this implies that the BCB leaned against temporary excessive movements of the exchange rate. A possible concern with this interpretation is that the profitability of swap sales could merely reflect a positive risk premium on the BRL, as common to other emerging markets (Gilmore and Hayashi, 2011; Chinn and Frankel, 2019), rather than FX intervention against abnormal movements of the exchange rate.

To analyze this issue, we compare the profitability of swap sales with the expected excess return of the BRL over the USD. On a given day t, the expected excess return of the BRL during the following j days is

$$\frac{e_t}{E_t\left[e_{t+j}\right]} * \frac{1+i_{t,j}}{1+c_{t,j}} - 1 \tag{2}$$

where $E_t\left[e_{t+j}\right]$ is the expected exchange rate from the Market Expectations System, $i_{t,j}$ is the domestic inter-bank rate, and $c_{t,j}$ is the*cupom cambial* which is traded in Brazil at 6 and 9 month maturities. As explained above, the*cupom cambial* is the on-shore USD rate that investors earn by investing in the BRL and converting the proceeds at the forward exchange rate. We find that on average the BRL delivered an excess return over the USD equal to 4.7 and 4.2 percent at the 6 and

9 month horizon, thus confirming the presence of a significant premium.

Nonetheless, Table 1 shows that the expected returns on swap sales, between 6 and 10 percent, is considerably higher than the average premium on BRL. Thus, the profitability of swap sales reflects also trading gains that the BCB seized by intervening against abnormal movements in the exchange rate. Furthermore, the BCB earned expected profits also on swap purchases, taking a short position in the BRL and thus facing a negative average premium on the USD. These observations imply that the expected profitability of FX intervention derives from a trading strategy that leaned against deviations from UIP conditions, issuing swaps when the exchange rate was undervalued relative to medium-term expectations and vice versa. We analyze this aspect more formally in the next session using a regression analysis.

4 The determinants of FX intervention

We have showed so far that FX intervention by the BCB was on average profitable in expectation. Following Friedman (1953), this suggests that the BCB intervened in the exchange rate market to offset temporary excessive fluctuations, going long in the BRL when undervalued and shortening it when overvalued. In this section, we provide more direct evidence by analyzing the determinants of FX intervention. More specifically, we test whether the size and type (sale vs purchase) of each swap action was a function of the expected profitability of the swap. Since the profitability of swap sales reflects the degree of undervaluation of the BRL from a UIP standpoint, a positive correlation between swap sales and profitability would confirm that the BCB intervened more strongly to prop up the BRL when the exchange rate was more undervalued and vice versa.

In Table 3, we regress the amount of swaps sold in a given auction (with negative values capturing swap purchases), expressed in million USD, over their expected return in annualized percent. Column (1) considers the full sample of swaps and finds a positive and highly statistically significant correlation between swap sales and profitability. The size of the regression coefficient and the fit of the regression increase considerably in column (2) where we restrict the analysis to our core sample of swaps, thus excluding pre-announced and rollover swaps that not meant to react to daily market conditions. The tight positive correlation between swap sales and expected profitability confirms that the BCB tailored the extent of FX intervention based on the perceived deviation of the BRL from UIP equilibrium conditions rather than leaning against fundamental shocks.

A possible concern with simple bi-variate regressions is that they may suffer from omitted variable bias. For example, FX intervention may have been driven by short-term movements in the exchange rate rather than by considerations regarding UIP conditions. To control for this, in column (3) we include as regressors the BRL depreciation against the USD in the day before the auction and in the prior ten days. The regression detects a positive correlation between swap sales and the 10-day depreciation but this does not remove significance from the expected returns on swaps.

We also include among the regressors the difference between the *cupom cambial*, i.e. the onshore USD rate, and the US treasury yield. We consider the difference at the 6-month horizon, close to the average maturity of FX swap. Differences between the *cupom cambial* and USD rates capture deviations from covered interest parity (CIP). More specifically, a decline in the *cupom cambial* relative to USD rates reflects a depreciation of the forward BRL rate, possibly because of strains in the ability of financial intermediaries in Brazil to bear currency risk. Therefore, the central bank may want to respond to a relative decline in the *cupom cambial* by absorbing itself currency risk against a BRL depreciation through the sale of FX swaps. Column (3) shows that this is indeed the case since swap sales are negatively correlated with the gap between the *cupom cambial* and USD rates.[9]

Even after controlling for relative movements in the *cupom cambial*, FX intervention remains tightly connected with the expected returns on swaps. This result is robust to the inclusion of several other controls. In column (4) we control for serial correlation in swap auctions by adding as regressors the swaps sales during the prior ten working days. The coefficients (not reported for space considerations) tend to be positive, reflecting auto-correlation in the scale of intervention. The inclusion of lags leads to a considerable increase in the R-squared and weakens the statistical significance of short-term movements in the exchange rate. However, swap profitability and movements in the *cupom cambial* remain highly significant. Regarding the quantitative impact, swap profitability played a preponderant role in driving FX intervention. One-standard-deviation shocks to the swap expected return, to the exchange rate depreciation during the previous ten days, and to the *cupom cambial* affected swap issuance by 135, 21 and 51 million USD, respectively.

Column (5) shows that the results are robust to excluding outliers by winsorizing 1 percent of the data with respect to the auction size and swap returns. In columns (6), (7), and (8), we add other financial variables among the regressors. Swap sales are positively correlated with sovereign spreads, while there is no association with CDS on sovereign bonds and the performance of the domestic stock market. The inclusion of these financial variables tends to further weaken the influence of recent exchange rate movements on the scale of intervention.

The regression results in Table 3 show that, conditional on holding swap auctions, the BCB chose the amount of swap sales or purchases depending on their expected profitability. The analysis neglects that in several days the BCB decided not to intervene, thus not issuing swaps. We now re-examine the results by analyzing the comovement between swap sales (including days when swap sales were zero) and the expected excess return of the BRL over the USD. The latter can be computed even in days when no swaps were issued by using equation 2.

In Table 4, we regress total daily swap sales in USD million over the expected BRL excess return at 6 and 9 month horizons between May 2013 and February 2019. We start in column (1) and

[9]Note that to the extend that swap sales are successful in supporting the *cupom cambial* as discussed in Garcia and Volpon (2014), this should weaken the negative correlation between FX swap sales and the *cupom cambial*.

Table 3: Determinants of swap sales

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Core sample						
				controlling for swap sales over prior ten days				
	Full sample				without outliers			
Expected return on swap	4.821***	17.25***	16.27***	12.18***	12.44***	11.36***	12.21***	12.45***
	(1.2)	(2.1)	(2.4)	(2.2)	(2.2)	(2.2)	(2.2)	(2.2)
BRL depreciation over prior day			-12.82	-5.74	-5.56	-1.217	-6.038	0.0438
			(10.1)	(9.4)	(8.6)	(9.3)	(9.5)	(13.2)
BRL depreciation over prior ten days			11.83***	6.278*	6.25*	2.424	6.786*	6.164
			(4.5)	(3.7)	(3.6)	(3.5)	(4.0)	(3.8)
Gap *cupom cambial* and USD rate			-90.20***	-88.45***	-87.98***	-81.06***	-82.08***	-88.60***
			(19.5)	(17.6)	(17.4)	(17.8)	(28.5)	(17.8)
Two-year soreign spread						52.21***		
						(15.2)		
Two-year CDS							-0.0889	
							(0.4)	
Stock price increase over prior day								-7.974
								(9.1)
Constant	176.3***	133.4***	274.9***	198.8***	204.57***	199.5***	199.8***	197.7***
	(8.4)	(18.6)	(25.6)	(26.3)	(25.5)	(25.9)	(28.7)	(26.6)
Number of auctions	2,898	795	773	773	773	773	773	767
R-squared	0.02	0.18	0.20	0.43	0.45	0.44	0.43	0.43

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

(2) by considering only those days in which swaps were issued, in line with the analysis presented in Table 3. We confirm that, conditional on intervention, swap sales were tightly and positively correlated with the expected excess return on the BRL, both at 6 and 9 month horizons. In columns (3) to (6) we add to the sample about 300 days in which the BCB did not intervene with FX swaps, also controlling for movements in the the exchange rate and the *cupom cambial*. The results are broadly unchanged, still showing a strong positive correlation between swap sales and the expected excess returns on the BRL.

The results reported in Table 3 and 4 provide compelling evidence that FX intervention responded to first-moment shocks to the UIP condition. We now consider whether FX intervention was also influenced by second-moment shocks about the uncertainty regarding the future value of the exchange rate. This analysis is possible because the Market Expectations System provides information about the dispersion of the exchange rate forecasts across survey participants, measured with a coefficient of variation (CV).

In the data, the CV for the exchange rate forecast tends to increase with the forecast horizon. Therefore, to compare the forecast uncertainty across various swaps, we need to correct for the maturity of the swap. We do so by first estimating predicted CV values at any given horizon.[10]

[10] We collect all coefficients of variation at all forecast horizons reported in the surveys between May 2013 and February

Table 4: Swap sales and BRL excess return

	(1)	(2)	(3)	(4)	(5)	(6)
	Only days with swap operations		Also days without swap operations			
Expected BRL excess return, 6 month	19.99***		20.48***		17.01***	
	(3.6)		(3.2)		(3.5)	
Expected BRL excess return, 9 month		34.75***		35.84***		35.14***
		(5.8)		(4.9)		(5.8)
BRL depreciation over prior day					41.37	44.09
					(47.2)	(48.1)
BRL depreciation over prior ten days					8.431	-1.641
					(7.4)	(7.7)
Gap *cupom cambial* and USD rate					-67.93**	-85.36***
					(29.0)	(29.8)
Constant	430.9***	373.1***	315.2***	259.2***	425.6***	385.7***
	(30.8)	(37.9)	(24.3)	(28.7)	(34.2)	(35.0)
Number of auctions	1,072	1,055	1,388	1,375	1,344	1,331
R-squared	0.04	0.06	0.04	0.07	0.05	0.07

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

We then compute the gap between the CV of the exchange rate forecast for a given swap with its predicted value based on the swap maturity. This gap captures the uncertainty in the exchange rate forecast for a given swap relative to the average uncertainty at the same forecast horizon.

In Table 5 we test for the correlation between FX intervention and forecast uncertainty by splitting the sample between swap sales and swap purchases. This is because uncertainty may have a non-monotonic impact across swap sales and purchases. For example, an increase in uncertainty may deter (or prompt) the central bank from both selling and buying swaps. Columns (1) to (3) show that swaps sales are negatively correlated with forecast uncertainty, across both the full and core samples and with the inclusion of additional controls. More notably, the interaction term between the forecast uncertainty and the expected profitability of swaps is negative and highly significant. This implies that the BCB sold more swaps in response to an undervaluation of the BRL if it faced less uncertainty about the exchange rate forecast. In other words, FX intervention were more decisive when the BCB could assess more confidently if the BRL was undervalued from a UIP standpoint.

Column (4) shows that the results are similar if we consider an alternative measure of uncertainty. Instead of using the uncertainty about the exchange rate at maturity corrected by the forecast horizon, we simply consider the uncertainty regarding the exchange rate at the 6-month horizon for all swaps. We find again that swap sales were more responsive to the swap profitability, i.e. to UIP deviations, when there was less uncertainty about the exchange rate forecast. Finally, in column (5)

2019 by the Market Expectations System. To generate predicted values of uncertainty at a given horizon, we regress the CVs over the number of days of the forecast horizon and their squared values, including fixed-effects for each survey.

Table 5: Swap sales and exchange rate uncertainty

	(1)	(2)	(3)	(4)	(5)
	Swap sales				Swap purchases
	Full	Core	Core, with swap lags	Core, with swap lags	Core
Expected return on swap	7.664***	11.58***	10.86***	28.23***	33.06**
	(1.1)	(1.5)	(1.7)	(6.0)	(14.8)
Forecast uncertainty at maturity (σ_{μ})	-11.31**	-7.527	-43.01*		-78.66
	(5.7)	(10.4)	(22.5)		(58.4)
Expected return on swap • σ_{μ}	-2.994***	-3.617*	-5.914***		-8.539
	(0.7)	(1.9)	(1.5)		(8.4)
Forecast uncertainty 6-month ahead (σ_{6m})				-88.19***	
				(22.1)	
Expected return on swap • σ_{6m}				-4.720***	
				(1.3)	
BRL depreciation over prior day			-16.40*	-15.02*	
			(9.3)	(8.5)	
BRL depreciation over prior ten days			7.883**	8.605***	
			(4.0)	(3.2)	
Gap *cupom cambial* and USD rate			51.78	110.2***	
			(37.2)	(33.6)	
Constant	217.7***	249.0***	82.57*	367.6***	-292.2***
	(5.3)	(10.7)	(48.3)	(62.2)	(91.8)
Number of auctions	2,590	690	668	683	85
R-squared	0.05	0.13	0.31	0.35	0.105

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

we consider the case of swap purchases, i.e. of negative swap sales. The regression coefficients on the forecast uncertainty are no longer statistically significant, possibly because the sample size is too small for proper identification.

The regression in column (5) also reveals that swap purchases respond to the expected swap profitability considerably more than swap sales reported in column (4). This suggests that FX intervention may display important asymmetries depending on whether the exchange rate is perceived to be undervalued or overvalued. To test more formally for this hypothesis, we create dummy variables depending on whether the expected swap return is positive or negative. We then regress swaps sales on the interaction of these dummies with the expected swap profitability. Columns (1), (2) and (3) of Table 6 show that swap sales tend to react considerably more when swap returns are negative, i.e. when the exchange rate is overvalued.

The fact that the BCB responded more strongly to a temporary overvaluation of the BRL than to an undervaluation may appear surprising since the latter may raise financial stability concerns. However, Brazil does not face major financial vulnerabilities to exchange rate fluctuations since public debt is denominated in local currency and FX debt by private companies is relatively low and mostly hedged. The stronger response to an overvaluation of the currency can be understood by considering that sales of FX swaps are similar to sales of FX reserves since they both shorten

Table 6: Asymmetric responses in swap sales

	(1)	(2)	(3)	(4)	(5)
	Full	Core	Core, with swap lags	Core	Core, with swap lags
Expected return on swap • **1**(negative swap return)	28.59***	40.12***	26.32***		
	(5.1)	(6.4)	(6.3)		
Expected return on swap • **1**(positive swap return)	0.604	11.42***	8.461***		
	(1.0)	(1.7)	(1.9)		
Expected return on swap • **1**(decline in BRL excess return)				24.75***	14.23***
				(3.7)	(4.0)
Expected return on swap • **1**(increase in BRL excess return)				15.81***	11.70***
				(2.2)	(2.3)
BRL depreciation over prior day			-2.53		-2.96
			(9.1)		(11.1)
BRL depreciation over prior ten days			8.111**		5.91
			(3.6)		(3.9)
Gap *cupom cambial* and USD rate			-68.69***		-88.13***
			(16.7)		(17.4)
Constant	215.2***	193.9***	208.6***	129.6***	197.2***
	(7.3)	(15.5)	(25.8)	(18.7)	(26.2)
Number of auctions	2,898	795	773	795	773
R-squared	0.08	0.23	0.45	0.19	0.43

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

the position of the central bank in USD. Therefore, in line with central banks' reluctance to sell reserves, it appears that the BCB was less eager to sell swaps when the BRL became undervalued than to repurchase swaps in case of overvaluation.

Columns (4) and (5) show that similar results are obtained if we allow for asymmetric responses to daily changes in the excess return of the BRL over the USD, rather than on whether the swap return was positive or negative. To explore this issue, we create dummies depending on whether the 6-month BRL excess return, computed according to equation 2, increased or declined relative to the day prior to each swap auction. We then interact these dummies with the expected swap returns and find that the BCB responded more aggressively to a decline in the BRL excess return, i.e. to an appreciation of the BRL.

5 Conclusion

In this paper, we asked whether FX intervention is used to stabilize the exchange rate—leaning against temporary UIP deviations—or to manipulate the exchange rate away from equilibrium conditions. In the spirit of Friedman (1953), we tackled this question by examining the profitability of FX intervention. If central banks lean against excessive exchange rate fluctuations, intervention should be profitable, at least in expectation.

We considered the case of Brazil where FX intervention takes place in the derivative markets using swaps. This is a key advantage for the analysis since these instruments have an explicit ma-

turity date which makes it possible to compute transparently the profitability of each FX operation. Furthermore, the central bank in Brazil collects a daily survey of interest rate and exchange rate forecasts which allowed us to assess the expected profitability of swaps on the day of issuance. This provides a more accurate perspective on the goals of FX intervention based on the understanding of market conditions that prevailed at the time of intervention.

We found that FX intervention was profitable in expectation during the period of analysis. This was the case both when the central bank went long in the BRL and when it took a short position. The results are robust to controlling for possible delays in the update of exchange rate forecasts by survey participants. Furthermore the expected profitability of swap sales, taking a long position in the BRL, was higher that the average excess return of the BRL over the USD.

The fact that FX intervention was profitable in expectation provides a first indication that the central bank aimed to lean against temporary excessive movements of the exchange rate, by going long in the BRL when undervalued and vice versa. To further validate this conclusion, we performed a regression analysis to test whether the central bank tailored the extent of intervention based on the degree of undervaluation of the BRL from a UIP standpoint. We found strong evidence that swap sales were tightly related to their expected return. In other words, the central bank went long in the BRL (by selling more swaps) when the exchange rate was more undervalued and shortened the BRL (by purchasing swaps) in case of overvaluation.

The tight connection between swap sales and swap expected profitability is robust to the inclusion of various control variables. Notably, there is no robust evidence that FX intervention responded to past movements in the exchange rate. This supports the notion that the central bank was not trying to prevent all exchange rate movements, but it intervened selectively when the exchange rate moved beyond UIP equilibrium conditions. FX intervention responded also to deviations in covered interest parity.

Furthermore, the analysis found that the central bank intervened more aggressively against UIP deviations when there was less uncertainty about the exchange rate forecast. This is possibly because when there is more clarity about the future value of the exchange rate, the central bank can assess more confidently the current equilibrium value of the exchange rate based on UIP considerations. We also detected a substantial asymmetry in the intervention strategy, with the central bank responding more strongly to an exchange rate overvaluation than to an undervaluation. This is likely because the central bank was more hesitant to shorten the USD by selling swaps in line with other central banks' reluctance to sell FX reserves in the spot market.

Overall, the analysis provides robust and consistent evidence that FX intervention in Brazil was used to lean against excessive movements of the exchange rate based on UIP equilibrium conditions. The paper raises interesting questions for future research. First, since the expected profitability of FX intervention can be computed in real time when survey forecasts are available, should the central bank explicitly explicitly monitor expected profitability and UIP deviations to guide FX

intervention? Could this provide investors with greater clarity about the FX intervention strategy and possibly contribute to stabilize market conditions? Second, since the central bank uses FX swaps to take a long position in the domestic currency when there are depreciation pressures, these operations may appear prone to losses. Therefore, there is often a perception among policymakers that FX swaps are sustainable only if the central bank has large holdings of FX reserves that generate offsetting valuation gains when the currency depreciates. Could this concern be overstated since FX swaps tend to be profitable if used to smooth excessive exchange rate movements? Thus, can intervention based on FX swaps be a viable option even for countries that do not have large reserves?

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Appendix

A Pre-announced and rollover swaps

The core sample of analysis excludes pre-announced and rollover swaps. We identify pre-announced swaps based on the BCB press releases in 2013 and 2014. Table 7 reports the date of the press release, an extract of the statement, and the number of auctions that we identify as pre-announced. The BCB provided some indications regarding future swap sales also in 2018, but the statements were more vague, making it hard to identify specific auctions as pre-announced. We experimented with removing some of those auctions from our core sample and the results of the analysis were broadly unchanged.

Table 7: Identifying pre-announced swap auctions

Date	Press release description	Number of pre-announced auctions
August 22, 2013	Swap auctions of $500 million will take place every Monday, Tuesday, Wednesday and Thursday, from August 23 to at least December 31.	97
December 18, 2013	Swap auctions of $200 million per day will take place from Monday to Friday, starting from January 2 to at least June 30, 2014.	183
June 14, 2014	Swap auctions of $200 million per day will take place from Monday to Friday, starting from July 1 to at least December 31, 2014.	227
December 30, 2014	Swap auctions of $100 million per day will take place from Monday to Friday, starting from July 1 to at least March 31, 2015.	113

To identify rollover swaps, we compute the total amount of swaps that settle and that mature in a given day. If the difference between the two is less than 0.5 billion USD, we code the swaps that settle that day as rollover swaps and exclude them from the core sample of analysis. For example, during the month of October 2018 the BCB held 46 swap sales with settlement date on November 1st, 2018 for a total of 8,026.5 million USD. Since on November 1st 2018 a similar amount of swaps came to maturity for 8,026.7 USD million, we consider the swaps sold in October 2018 as rollover ones.