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 from an ex-ante perspective, suggesting that FX intervention is used to stabilize the exchange rate against temporary excessive fluctuations relative to UIP conditions. Consistent with this interpretation, we document that the direction and size of FX intervention responds to UIP deviations. We also find that FX intervention responds more aggressively to UIP deviations when there is less uncertainty about the future level of the exchange rate and when the exchange rate is overvalued.

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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 adjustment forces. 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 has gained new prominence in recent years because of heightened trade tensions and growing complains about currency manipulation (Dominguez, 2020).

To shed light on the 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—defined as deviations from uncovered interest parity (UIP) conditions—the central bank should make a profit over time.

By going long in the domestic currency when the exchange rate is temporarily undervalued from a UIP standpoint, 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 UIP 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 temporarily disconnected from fundamentals. This is because financial frictions prevent financial intermediaries from seizing arbitrage opportunities, leading to UIP deviations. 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 at smoothing deviations from UIP.

Note that this argument does not require that FX intervention succeeds in affecting the exchange rate.[1] The claim that using FX intervention to lean against UIP deviations 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 does affect the exchange rate—for example by boosting its value when undervalued—this would reduce UIP deviations and thus the profitability of the intervention. It is also important to underscore that an FX intervention strategy that leans against UIP deviations is profitable irrespective of the factors that generate these deviations in the first place. Departures from UIP conditions may arise because of fluctuations in risk premia, financial frictions hampering market functioning, or intrinsic forms of mispricing. The analysis does not aim at disentangling these factors. It instead wants to understand whether FX intervention is used to lean against UIP deviations, irrespective of the underlying reasons.

We conduct the analysis based on the experience of Brazil between 2013 and 2022 because it offers several key advantages. First, during those years the Brazilian Central Bank (BCB) intervened in the exchange rate market using FX swaps rather than conventional spot transactions. Swaps are particularly suitable to analyze the profitability of FX intervention because they have an explicit maturity date. This makes it possible to transparently compute the profitability of each FX operation based on the evolution of interest rates and exchange rates between the auction and maturity date. Analyzing the profitability of traditional FX intervention in the spot market is much more challenging because when the central bank buys or sells FX reserves it is unclear how long it will keep the position for. Therefore, computing the profitability of a given spot-market operation requires making 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, Brazil offers an ideal case study because the central bank collects a rich survey dataset on exchange rate and interest rate forecasts by market participants. This makes it possible to examine the profitability of FX swaps from an ex-ante perspective, by considering the expected evolution of the exchange rate at the time of the intervention rather than its ex-post realized values. In principle, using expected or realized values should not alter the results of the analysis as long as expectations are rational and the sample is sufficiently long to ensure that realized values correspond on average to expected values. However, during 2013–2022 Brazil experienced multiple negative shocks that led to a stronger depreciation of the exchange rate than expected. Therefore, by focusing on the profitability of swaps from an ex-ante perspective, the analysis provides a more accurate test of whether the central bank intervened when the exchange rate was perceived to be out of equilibrium based on the expectations at the time of the intervention.[2]

Fourth, after accumulating a large stock of FX reserves between 2006 and 2012, the BCB kept reserves mostly stable during our period of analysis. Therefore, from 2013 onward FX intervention was no longer biased towards the accumulation of additional reserves but was focused on the management of the exchange rate. This offers an ideal testing ground for whether the central bank aimed at stabilizing the exchange rate or leaning against fundamental shocks.

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 an ex-ante 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 ex-ante profitable if the BRL is overvalued according to UIP conditions.

The analysis finds that FX intervention was considerably profitable from an ex-ante perspective, generating average annualized returns on FX swaps of up to 10 percent. FX swaps were profitable both when the BCB took short and long positions in the BRL. Furthermore, the direction and scale of FX intervention systematically responded to UIP deviations. More specifically, the BCB issued more swaps by going long in the *real* when the exchange rate was perceived to be more undervalued from a UIP standpoint and vice versa. These findings provide robust and consistent evidence that the BCB used FX intervention to smooth temporary excessive movements in the exchange rate.

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[1] The empirical literature reviewed later in the paper suggests that FX intervention, including via swaps, does affect the exchange rate in the short-term. There is instead no evidence that FX intervention changes the medium-term level of the exchange rate. A systematic FX intervention strategy by the central bank may also influence the frequency and size of UIP deviations. But this should not invalidate Friedman's argument that FX intervention should be profitable if it leans against UIP deviations.

[2] Ideally, the analysis would use the expectations held by the central bank rather than by market participants. However, the central bank does not publish this type of information.

We perform several robustness exercises. First, swaps remain profitable 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 an 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 et al., 2018).

We also document that FX intervention was more aggressive when there was less uncertainty about the future value of the BRL, captured by a lower dispersion in survey forecasts. Greater 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 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 may reflect the 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 can affect the exchange rate.[3] 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 (Adler et al., 2019; Dominguez et al., 2013; Fatum and Hutchison, 2003; Sarno and Taylor, 2001; Adler and Tovar Mora, 2011; Blanchard et al., 2015; Daude et al., 2016). Some papers also provide specific evidence about the effectiveness of FX intervention through swaps by the BCB (Kohlscheen and Andrade, 2014; Chamon et al., 2017; Nedeljkovic and Saborowski, 2019). Rather than considering the effectiveness of FX intervention, our work analyzes the profitability of FX intervention 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 a stream of the literature that analyzes the cost of holding FX reserves. This issue has acquired prominence with the large accumulation of reserves by emerging markets since 1990. Several studies find considerable costs from holding reserves (Hauner, 2006; Rodrik, 2006; Yeyati, 2008; Adler and Rui, 2021; Flood and Marion, 2001). 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 the financial returns associated with FX intervention.

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 average profitability of FX swaps. In Section 4, we look at the determinants of FX intervention to test more directly whether FX intervention responded to 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 Fig. 1. Until 2012, FX intervention was primarily conducted in the spot market and led to a large accumulation of FX reserves equal to about 18 percent of GDP.

From 2013 onward—the starting point of the analysis—FX intervention relied instead almost entirely on FX swaps. Because of past policy restrictions on FX spot transactions, Brazil developed a very active FX derivative market that settles in *reais* (Garcia and Volpon, 2014; Garcia et al., 2014). This market is much more liquid than the spot market and is therefore the target of intervention by the central bank. 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 at propping up the value of the *real*.[4]

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[3] 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, 2022; Fanelli and Straub, 2021, Chang (2019)Jeanne and Sandri (2020).

[4] Evidence about the impact of FX swaps on the exchange rate is provided in Kohlscheen and Andrade (2014), Chamon et al. (2017), and Nedeljkovic and Saborowski (2019).
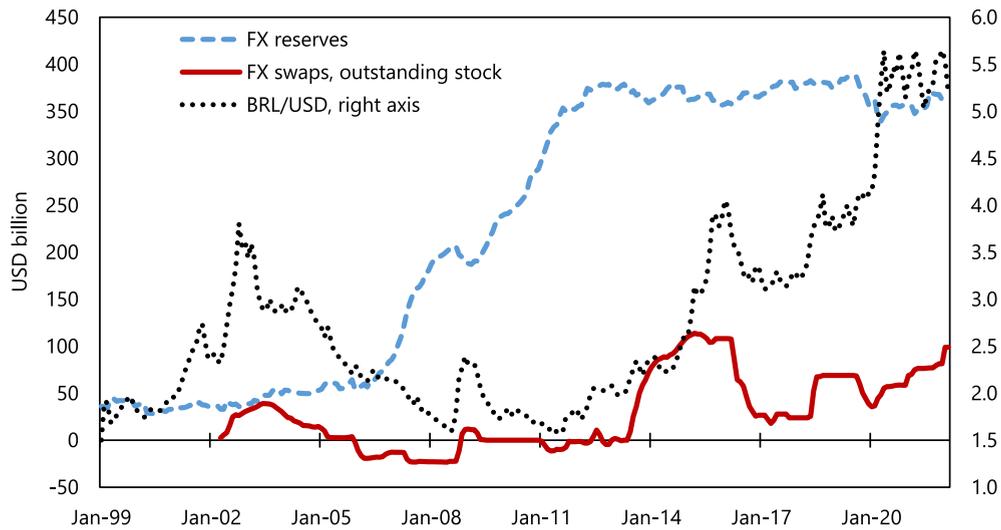
Fig. 1. FX reserves and swaps since 1999.

As illustrated in left chart of Fig. 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 and then declined 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 in emerging markets. The BCB reduced the stock of swaps in the second half of 2019 but this was matched with an equivalent reduction in FX reserves to shrink the central bank's FX balance sheets rather than to affect the exchange rate. The stock of swaps increased again during the COVID-19 pandemic when the *real* depreciated strongly.

FX swaps are sold in different amounts and with different maturities through auctions. The right chart of Fig. 2 illustrates the size and maturity of each auction between May 31st, 2013 and February 28th, 2022. The vertical axis shows that the maturity varies from a few days to a 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. In various instances, the BCB bought rather than sold swaps, as shown via negative sales of swaps. In this case, the BCB took short positions in the BRL, reducing the net 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. The swap price 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.[5] 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 ex-ante 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.

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[5] All swap transactions settle therefore in BRL, leaving unchanged the stock of FX reserves held by the central bank. In this respect, these instruments are more similar to non-deliverable futures than conventional currency swaps. The settlement currency does not affect the nature of our analysis.
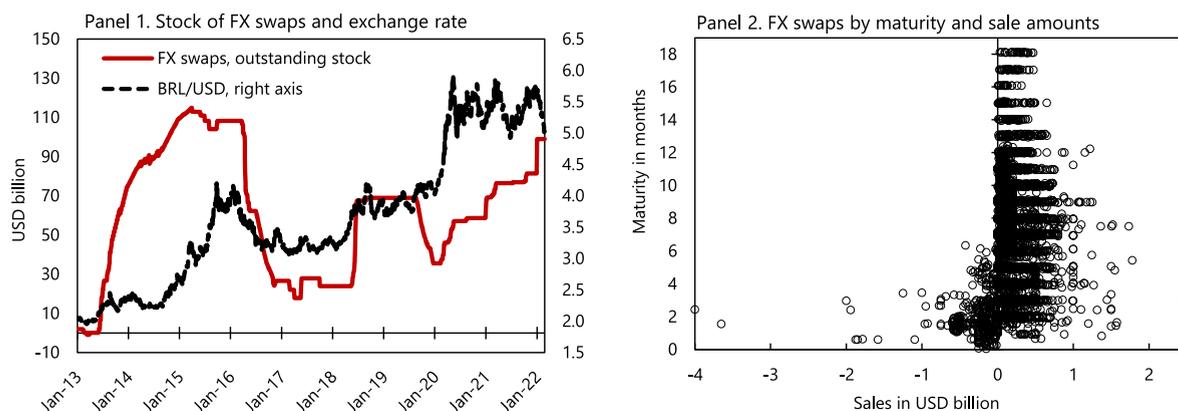
Fig. 2. FX swaps since 2013. Notes: Panel 2 reports the sale amounts and the maturity of the FX swaps for each auction held between May 2013 and February 2022.

3. The profitability of FX intervention

According to the BCB, swaps are used to "provide liquidity" and "ensure the smooth operation of the exchange market".[6] This suggests that intervention aims at leaning against temporary excessive movements of the exchange rate rather than at resisting fundamental adjustment forces. Following Friedman (1953), we test for this hypothesis by measuring the profitability of FX swaps. If swaps 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, at least from an ex-ante perspective. 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 2022. We use detailed information about each auction provided by the BCB, including the amount sold, the *bid cupom cambial*, and the day of the auction, settlement, and maturity.[7] We focus on the profitability of swaps from an ex-ante perspective, using expected values for the Selic and the exchange rate at the time of the swap auction. Expectations are collected by the BCB through a survey called the Market Expectations System. Survey respondents report their forecasts of the Selic at future meetings of the monetary policy committee and of the BRL/USD exchange rate at the end of each month.[8] Forecasts are reported for 18 months ahead and can be updated at any time. By linearly interpolating the available forecasts, we create daily projections of the Selic and the exchange rate over 18 months. To compute the ex-ante profits associated with each swap, we replace the exchange rate and Selic in Eq. (1) with their expected values taken on the day of each swap auction.[9]

Fig. 3 shows the ex-ante profits earned by the BCB on FX swaps as well as their annualized average rate of return during each quarter. In almost all quarters, FX intervention was ex-ante profitable, generating average ex-ante gains for the central bank of almost 1 billion USD per quarter.[10]

A notable exception to the systematic profitability of swaps is provided by the last two quarters of 2019 when FX swaps had sizeable ex-ante negative returns. As illustrated in Fig. 1, between August 2019 and December 2019, the BCB rapidly reduced the stock of outstanding FX swaps by 29.7 billion USD. However, those operations were not meant to affect the exchange rate. The reduction in FX swaps was matched with commensurate sales of FX reserves on the spot market by 29.6 billion USD. By doing so, the BCB reduced its gross FX balance sheets while leaving its net position unchanged to prevent effects on the exchange rate. Since swap operations between August and December 2019 were not intended to affect the exchange rate—neither for stabilization nor manipulation goals—these are excluded from the rest of the analysis, although they don't change the general result illustrated in Fig. 3 that FX swaps have been highly profitable on average.

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

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

[8] As described on the BCB's website, survey respondents include "banks, resource managers, nonfinancial companies, consultancies, class associations, academia, etc., which have specialized teams that project the main macroeconomic variables, to assist decision making, both by their professionals as well as by its clients."

[9] 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 forecast across 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.

[10] Ex-post returns were instead negative, equal to about 390 million USD per quarter. This is because Brazil experienced various adverse shocks during the period of analysis—in particular a severe recession in 2015 and the COVID-19 pandemic—that lead to a stronger than expected depreciation of the exchange rate.
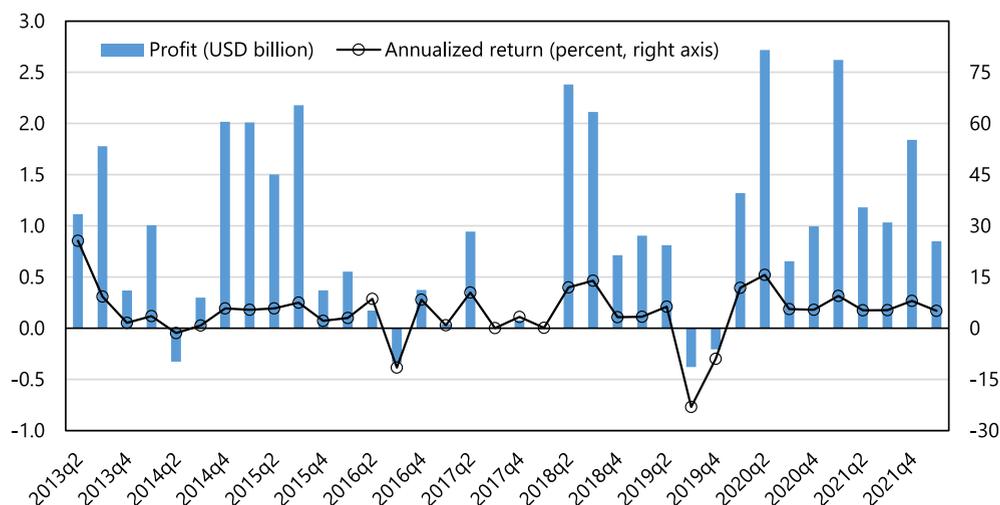
Fig. 3. Ex-ante profits and annualized returns on FX swaps for the central bank Notes: The blue bars report the total expected profits for the central bank from the sale or purchase of FX swaps during each quarter. The black circles show the average annualized return on the FX swaps sold or bought by the central bank in each quarter.

To examine the profitability of FX intervention in greater detail, 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 just to rollover maturing ones, keeping constant the outstanding stock of swaps as seen in the flat segments in the left chart of Fig. 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, 2022, the BCB held about 4,000 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 1000 swap auctions. Appendix A describes how we identify pre-announced and rollover swaps.

Table 1 confirms that swaps in the core sample are considerably more profitable. The average annualized rate of return is 6.2 percent for the full sample of swaps and increases to 10.0 percent for the core sample.[11] We also differentiate between positive sales and negative sales, referring to the latter as swap purchases. Swap sales and purchases were both profitable. Therefore, the BCB sold swaps when the exchange rate was undervalued from a UIP standpoint and purchased swaps when the exchange rate was overvalued. We test more formally for this mechanism in the next section using regression analysis. Across both swap sales and purchases, 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 recording of updated forecasts in the survey. Participants to the Market Expectations System can update their forecasts every day but they tend to do so only occasionally. In particular, to encourage survey participants to provide accurate forecasts, the BCB publishes rankings of the best forecasters. These rankings are constructed using the expectations recorded in specific days, called "reference dates".[12] Therefore, survey participants have no incentive to update their expectations away from these dates.

Delays in updating expectations could distort the measurement of the ex-ante 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 ex-ante profitability since we would use an outdated and overvalued exchange rate forecast.

Several considerations attenuate this concern. First, the example above applies symmetrically with opposite effects when the exchange rate appreciates. In this case, delays in recording an expected appreciation of the exchange rate would lead to a reduction, rather than an increase, in the ex-ante 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 expectations are likely to generate only a modest bias in favor of higher ex-ante profits on swap sales.

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[11] We calculate returns on a given swap by dividing the revenues computed with Eq. 1 by the face value of the swap equal to 50,000 USD. We annualize the returns to correct for differences in swap maturity. To compute 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 Eq. 1 are negative.

[12] Until December 2018, the reference dates were the last working day of the month and the 15th of the month (or the prior working day if the 15th occurred in a weekend or holiday). From January 2019 onward, the reference dates are the Friday prior to the Monetary Policy Committee meeting and the penultimate Friday of the month.

Table 1
Average ex-ante profitability of FX swaps (annualized, percent).

	(1) Full Sample All swaps	(2) Core sample All swaps	(3) Swap sales	(4) Swap purchases
Average ex-ante returns	6.2***	10.0***	10.2***	8.8***
	(0.2)	(0.4)	(0.4)	(1.7)
Number of auctions	3,988	1,008	918	90

Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Furthermore, we can check whether delays in updating exchange rate forecasts are driving the results via the following exercise. We re-compute the ex-ante profitability of swaps using survey data collected after the auction date which thus capture delayed forecast updates. Columns 1 and 2 in Table 2 show that the average expected returns remain positive and highly statistically significant even if we use expectations recorded one and two weeks after the auctions.

Finally, we can further dismiss concerns that the results might be driven by delays in the recording of updated expectations by considering two additional robustness results. First, as explained above, the BCB provides survey participants with incentives to update their expectations around reference dates. We thus re-compute the average profitability of swaps by considering only the auctions that occurred between one day prior to one day after these reference dates, when survey expectations are likely to be more up to date. Column (3) in Table 2 confirms that these swaps are highly profitable in expectation, with an average return equal to 7.2 percent.

Second, we re-compute the average swap profitability using only auctions around the end of the month, between the last two working days of each month and the first three working days of the subsequent month. This is because Andrade and Kohlscheen (2014) document that survey participants tend to update their expectations especially at the end of the month. The last column of Table 2 confirms that even these swaps are highly profitable in expectations.

We have established so far that FX intervention was profitable from an ex-ante perspective suggesting, in line with Friedman (1953), that the BCB used FX intervention to lean against temporary excessive movements of the exchange rate. However, there is a possible concern with this interpretation. During the period of analysis, the BCB held mostly a long position in the BRL via FX swaps. Since emerging markets' currencies tend to carry a positive risk premium (Gilmore and Hayashi, 2011; Chinn and Frankel, 2019), swaps may have been profitable merely because they involved long positions in the BRL, even if the central bank did not actively use FX intervention to stabilize 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 over the following j days is given by

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

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 6.3 and 5.6 percent at the 6 and 9 month horizon, thus confirming the presence of a significant premium.

Nonetheless, Table 1 shows that the ex-ante returns on swap sales, around 10.2 percent, considerably exceeded the average premium on BRL. Furthermore, the BCB also earned expected profits on swap purchases, when it took short positions in the BRL.

These observations imply that the ex-ante profitability of FX intervention does not derive merely from holding on average long positions in the BRL. It instead also reflects gains from using FX intervention to lean again UIP deviations, by issuing more swaps when the exchange rate became more undervalued relative UIP conditions 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 from an ex-ante perspective. Following Friedman (1953), this suggests that the BCB used FX intervention to offset temporary excessive fluctuations of the exchange rate, going long in the BRL when undervalued relative to UIP conditions and shortening it when overvalued. In this section, we provide more direct evidence of this mechanism by analyzing the determinants of FX intervention. More specifically, we test whether the size and type (sale vs purchase) of the swap auctions responded to the ex-ante 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 took long positions in the BRL when the exchange rate become undervalued from a UIP standpoint and vice versa.

Table 2
Average ex-ante profitability of FX swaps, robustness analysis (annualized, percent, core sample).

	(1) Using surveys delayed by one week	(2) two weeks	(3) Swaps around reference dates	(4) Swaps around the end of the month
Average ex-ante returns	5.3***	2.6***	7.2***	11.2***
	(0.4)	(0.3)	(0.7)	(1.1)
Number of auctions	849	849	244	165

Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.

In Table 3, we regress the amount of swaps sold in a given auction (with negative values reflecting swap purchases), expressed in million USD, over their ex-ante annualized return in percent. Column (1) considers the full sample of swaps and finds a positive and highly statistically significant relation between swap sales and their ex-ante profitability. The magnitude of the regression coefficient and the fit of the regression increase considerably in column (2) where we restrict the analysis to the core sample of swaps, thus excluding pre-announced and rollover swaps. The tight positive correlation between swap sales and ex-ante profitability confirms that the BCB tailored the sign and magnitude of FX intervention to lean against deviations from UIP equilibrium conditions.

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 among the regressors the BRL depreciation against the USD in the day before the auction as well as in the prior ten days. The regression does not detect any relation between between swap sales and recent movements in the exchange rate.[13]

We also include among the regressors the difference between the *cupom cambial*, i.e. the on-shore 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 and/or convertibility concerns associated with capital controls (Chamon and Garcia, 2016). Therefore, the central bank may want to respond to a relative decline in the *cupom cambial* by selling FX swaps and absorbing currency risk against a BRL depreciation. 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.[14]

Even after controlling for relative movements in the *cupom cambial*, FX intervention remains tightly connected with the ex-ante 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 but does not affect the statistical significance of the ex-ante swap profitability and movements in the *cupom cambial*. Yet it is important to recognize that the fit of the regression remains relatively modest, explaining about 40 percent of the variation in the size and direction of FX swaps. Therefore, other considerations may have also influenced the decision to intervene in the FX market beyond leaning against UIP and CIP deviations.

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 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 ex-ante profitability. The analysis neglects that in several days the BCB decided not to intervene, thus not issuing any swap. We now re-examine the results by analyzing the comovement between swap sales (including days when swap sales were zero) and the ex-ante excess return of the BRL over the USD. The latter can be computed even in days when no swaps were issued by using Eq. 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 2022. We start in column (1) and (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 intervening in the FX market, 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 500 days in which the BCB did not intervene with FX swaps, with and without controlling for movements in the the exchange rate and the *cupom cambial*. The results are broadly unchanged, confirming a strong positive correlation between swap sales and the ex-ante excess returns on the BRL.

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[13] We also don't find a relation between swap sales and the exchange rate depreciation over longer horizons, for example over the previous 30, 60, and 90 days. There is also no association of swap sales with movements of the nominal and real effective exchange rate over the previous year.

[14] Note that to the extent 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 without outliers				
	Full sample			without outliers				
Ex-ante return on swap	4.22***	12.73**	11.74***	8.30***	8.41***	7.59***	8.73***	8.38***
	(1.0)	(1.7)	(1.9)	(1.7)	(1.7)	(1.8)	(1.8)	(1.7)
BRL depreciation over prior day	-7.08	0.86	0.67	5.01	-1.18	2.48		
	(9.2)	(8.5)	(7.9)	(8.5)	(8.6)	(11.4)		
BRL depreciation over prior ten days			5.49	1.33	1.38	0.85	4.25	1.23
			(4.0)	(3.4)	(3.3)	(3.3)	(3.5)	(3.5)
Gap *cupom cambial* and USD rate			−114.4***	−89.27***	−88.56***	−62.99***	-52.66**	−89.01***
			(19.2)	(16.9)	(16.6)	(18.2)	(22.6)	(16.9)
Two-year soreign spread						37.27***		
						(8.7)		
Two-year CDS							-0.57	
							(0.4)	
Stock price increase over prior day								-2.28
								(7.6)
Constant	212.5***	170.3***	334.8***	215.3***	222.2***	178.2***	229.0***	214.5***
	(7.5)	(17.3)	(22.6)	(25.7)	(24.8)	(25.8)	(30.0)	(25.8)
Number of auctions	3,988	1,008	981	981	981	979	981	973
R-squared	0.02	0.13	0.16	0.38	0.39	0.39	0.38	0.38

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

Table 4
Swap sales and BRL excess return.

	(1)	(2)	(3)	(4)	(5)	(6)
	Only days with swap operations		Also days without swap operations			
Ex-ante BRL excess return, 6 month	17.35***		14.19***		12.23***	
	(2.4)		(2.1)		(2.1)	
Ex-ante BRL excess return, 9 month		28.10***		25.08***		25.75***
		(3.8)		(3.1)		(3.5)
BRL depreciation over prior day					31.00	30.75
					(31.0)	(30.9)
BRL depreciation over prior ten days					2.64	-6.74
					(4.9)	(4.9)
Gap *cupom cambial* and USD rate					-77.11***	-69.92***
					(25.2)	(24.7)
Constant	475.1***	422.3***	345.0***	294.0***	454.4***	381.1***
	(24.6)	(30.4)	(19.5)	(23.2)	(28.1)	(30.0)
Number of auctions	1,591	1,591	2,145	2,145	2,079	2,079
R-squared	0.04	0.06	0.03	0.05	0.04	0.06

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

The results reported in Table 3 and 4 provide compelling evidence that FX intervention responded to UIP deviations. We now consider whether FX intervention was also influenced by the uncertainty surrounding the future value of the exchange rate. This analysis is possible because the Market Expectations System provides information about the standard deviation of the exchange rate forecasts across survey participants which we normalize by the median forecast of the exchange rate to compute 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 different swaps, we need to correct for the maturity of the swap. We do so by first estimating predicted CV values at a given horizon.[15] 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.

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[15] We compute coefficients of variation at all forecast horizons reported in the Market Expectations System surveys between May 2013 and February 2022. 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) Swap sales Full	(2) Core	(3) Core, with swap lags	(4) Core, with swap lags	(5) Swap purchases Core
Ex-ante return on swap	6.4***	9.3***	8.4***	15.4***	33.2**
	(0.9)	(1.2)	(1.4)	(3.3)	(14.5)
Forecast uncertainty at maturity (s_μ)	−1.37	6.90	9.99		−76.53
	(4.7)	(10.8)	(17.5)		(56.6)
Ex-ante return on swap · s_μ	-2.4***	-3.2***	-3.3***		-8.6
	(0.4)	(0.6)	(0.7)		(8.2)
Forecast uncertainty 6-month ahead ($s_{6\,m}$)				−59.3***	
				(19.0)	
Ex-ante return on swap · $s_{6\,m}$				-1.8***	
				(0.6)	
BRL depreciation over prior day			−4.07	-6.00	
			(7.8)	(7.6)	
BRL depreciation over prior ten days			2.67	2.24	
			(3.5)	(3.0)	
Gap *cupom cambial* and USD rate			-24.85	55.94*	
			(28.2)	(29.0)	
Constant	244.2***	267.5***	211.0***	351.9***	-292.8***
	(5.0)	(9.8)	(40.6)	(54.7)	(91.4)
Number of auctions	3,680	903	876	891	85
R-squared	0.03	0.09	0.22	0.25	0.11

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

Columns (1) to (3) show that the interaction term between the ex-ante return on swaps and the uncertainty surrounding the exchange rate forecast is negative. This implies that the BCB sold more swaps in response to an undervaluation of the BRL when it faced less uncertainty about the exchange rate forecast. In other words, FX intervention was 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 the maturity of the swap, we simply consider the uncertainty surrounding the forecast of the exchange rate 6-month ahead. We find again that swap sales were more responsive to the swap profitability when there was less uncertainty about the future value of the exchange rate. Finally, in column (5) we consider the case of swap purchases, i.e. of negative swap sales. The regression coefficient on the interaction term between swap profitability and forecast uncertainty is negative but no longer statistically significant, possibly because the sample size is too small for proper identification.

The regression in column (5) also shows that swap purchases seem to respond more strongly to the ex-ante swap profitability than swap sales. This suggests that FX intervention may display asymmetries depending on whether the exchange rate is undervalued or overvalued from a UIP standpoint. To test more formally for this hypothesis, we create dummy variables depending on whether the ex-ante return of the swap is positive or negative. We then regress swaps sales on the interaction of these dummies with the ex-ante swap profitability. Columns (1), (2) and (3) of Table 6 show that swap sales tend to react more strongly when swap returns are negative, i.e. when the exchange rate is overvalued relative to UIP conditions.[16]

Columns (4) shows 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 Eq. 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. However, differences are no longer statistically significant if we include various additional as controls in column (5).

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 weaker response to an undervaluation of the exchange rate may reflect more caution in taking large long positions in the BRL via FX swaps, similarly to countries' reluctance to significantly reduce FX reserves. Note indeed that the outstanding stock of FX swaps rose in both 2015 and 2022 to fairly high levels, equal to about 30 percent of the stock of FX reserves.

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[16] Statistical tests confirm that the size of the regression coefficient on the interaction between the ex-ante return of the swap and the dummy for negative returns is larger than the coefficient on the interaction with the dummy for positive returns.

Table 6
Asymmetric responses in swap sales.

	(1) Full	(2) Core	(3) Core, with swap lags	(4) Core	(5) Core, with swap lags
Ex-ante return on swap · **1**(negative swap return)	30.57***	41.97***	27.26***		
	(5.2)	(6.4)	(6.1)		
Ex-ante return on swap · **1**(positive swap return)	0.52	7.45***	4.79***		
	(0.8)	(1.3)	(1.5)		
Ex-ante return on swap · **1**(decline in BRL excess return)				17.45***	7.90**
				(3.3)	(3.4)
Ex-ante return on swap · **1**(increase in BRL excess return)				11.59***	8.42***
				(1.7)	(1.8)
BRL depreciation over prior day			3.04		0.02
			(8.2)		(10.3)
BRL depreciation over prior ten days			4.03		1.45
			(3.2)		(3.6)
Gap *cupom cambial* and USD rate			-65.96***		−89.46***
			(15.7)		(16.8)
Constant	248.3***	234.4***	227.8***	166.8***	215.9***
	(6.2)	(13.5)	(25.4)	(17.6)	(25.6)
Number of auctions	3,988	1008	981	1008	981
R-squared	0.08	0.20	0.41	0.13	0.38

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

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 transitory excessive exchange rate fluctuations, intervention should be profitable, at least from an ex-ante perspective which takes into account the expected future value of the exchange rate at the time of the intervention.

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 maturity date which makes it possible to compute transparently the profitability of each FX operation. Furthermore, the central bank in Brazil collects detailed survey data on interest rate and exchange rate forecasts which allows to assess the profitability of FX swaps from an ex-ante perspective. 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 considerably profitable ex-ante. This was the case when the central bank took long as well as short positions in the BRL. The results are robust to controlling for possible delays in the update of exchange rate forecasts by survey participants. Furthermore, the ex-ante profitability of swap sales, taking a long position in the BRL, was higher than the average excess return of the BRL over the USD.

The fact that FX intervention was ex-ante profitable provides a first indication that the central bank aimed at leaning against temporary excessive movements of the exchange rate, by going long in the BRL when undervalued and vice versa. To further corroborate this conclusion, we used a regression analysis to examine whether FX intervention responded to UIP deviations. We found strong evidence that swap sales were tightly related to their ex-ante return. In other words, the central bank went long in the BRL (by selling more swaps) when the exchange rate was more undervalued from a UIP standpoint and shortened the BRL (by purchasing swaps) in case of overvaluation.

The tight connection between swap sales and their ex-ante returns is robust to the inclusion of various control variables. Notably, we find no 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 an asymmetry in the intervention strategy, with the central bank responding more strongly to an exchange rate overvaluation than to an undervaluation. This is possibly 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 ex-ante profitability of FX intervention can be computed in real time when survey fore-

casts are available, should the central bank explicitly monitor ex-ante 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?

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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 vaguer, 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.

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