

FX Interventions, Signalling and Intermediary Constraints

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Abstract

We study the impact of unanticipated foreign exchange (FX) intervention in the Brazilian market. Our identification exploits over 20 years of announcements of Brazilian Central Bank (BCB) at an intra-day (tick-level) frequency since 2000. We combine our auction data with intra-day spot and futures prices. We find that surprise sales of USD reserves by the BCB results in an appreciation of the Brazilian Real (BRL) and an increase in domestic short-term interest rates, supporting the signalling channel of FX interventions. We then test efficiency in the FX market by measuring the impact on covered interest rate parity (CIP). Surprise sales of USD reserves reduces the magnitude of CIP violations. Our results are consistent with dollar liquidity provision by the central bank reducing the relative cost of borrowing dollars via FX forward and swap markets, improving efficiency.

Keywords: Exchange Rate; Central Bank; Interventions; Yield Curve; Asset pricing

JEL Classifications: E44; E58; F31; G14

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1 Introduction and Motivation

There is a large empirical literature studying the effects of FX interventions ([Sarno and Taylor 2001](#)). While the literature focuses principally on the dynamics of the spot exchange rate, a less studied question is documenting the effect of interventions on interest rate markets and in alleviating intermediary constraints in the supply of USD liquidity. In this paper we test two channels of FX interventions. The first channel is whether FX interventions signal the stance of monetary policy to economic agents, which is known as the *signaling* channel. The second channel relates to portfolio balance effects in the intermediation of dollars, which we label the *dollar intermediation* channel. We can study the interaction between FX and interest rate markets through the covered interest rate parity (CIP) condition, which is the most important no-arbitrage condition in international finance. Deviations from the no-arbitrage benchmark can indicate a relative scarcity of dollar liquidity in cross-border financial markets. FX interventions can play an important role in alleviating dollar scarcity and reduce frictions in intermediating dollars in FX markets.

In this paper, we use Brazil as a case study to test these hypotheses. We find evidence for both the signaling and dollar intermediation channels. In particular, unanticipated sales of USD reserves by the BCB lead to a systematic appreciation of the BRL, an increase in the domestic interest rate, and a narrowing of the CIP deviation, consistent with FX interventions being a useful policy tool in improving efficiency in the FX forward market.

To motivate our empirical framework, we model the impact of foreign exchange (FX) interventions on dollar intermediation following [Gabaix and Maggiori \(2015\)](#). The analysis involves two countries, the US (home) and Brazil (foreign), across two periods. House-

holds in each country make consumption decisions subject to intertemporal budget constraints. The foreign exchange market involves financiers who fund in dollars and lend to Brazilian firms, aiming to maximize the value of their investments. The study introduces a model of FX intervention by the BCB, which sells USD reserves in the initial period. The intervention affects the spot exchange rate and dollar intermediation by financiers. First, an FX intervention of selling USD and buying BRL leads to the appreciation of BRL through portfolio balance effects: financiers require the relative price of USD to fall to absorb the excess supply of dollars by the central bank. The effectiveness of the intervention on the spot rate is shown to increase with the magnitude of intermediation constraints. Second, the FX intervention reduces the size of dollar intermediation by financiers. Tighter intermediary constraints lead to a larger decline in net dollar intermediation, and in turn a larger decline in the relative costs of intermediating dollars in financial markets.

To test model predictions, we study the high frequency effects of FX interventions by the Brazilian Central Bank (BCB). We exploit a large historical database on Brazil Central Bank interventions. The database includes a high frequency timestamp of the transaction, the type of intervention (spot, swap), the sign (buy or sell of USD) and amount of the auctions. We can also classify interventions either as anticipated or unanticipated depending on whether the announcement of the intervention occurs on the same day as the auction. We combine our database on interventions with tick level data on spot and futures prices at the 5 minute level from Thomson Reuters Tick history. Using this data, we measure the effects of using the local projections method in [Jordà \(2005\)](#). We estimate the effects of FX buy and sell interventions on prices, interest rates and CIP deviations using the method of local projections, a procedure that controls for feedback

effects in prices and the intervention amount.

First, we test for the impact of unexpected buy and sell interventions. The level of the spot rate appreciates by approximately 1.5 percentage points per USD Billion for a sell intervention. In contrast, we observe smaller transitory effects (10 basis points) on the spot exchange rate from FX swap interventions. We do not find exchange rate effects for buy interventions, suggesting the dollar intermediation channel is important in explaining the asymmetric effect between USD buy and sell interventions. Second, we test for spillover effects on interest rate markets through our measure of the forward premium. Under a no-arbitrage benchmark, the forward premium measures the interest rate differential between the Brazil and US. Our results suggest the Brazil interest rates increase relative to the US interest rate. Our evidence is consistent with a signaling channel of FX sell interventions. A reduction in central bank reserves can signal to economic agents a signal of the future stance of monetary policy. For example, the sale of U.S. dollars by an emerging market central bank leads to a local currency appreciation, not because the intervention changes the fundamental supply and demand conditions in the market, but because it signals a contractionary monetary policy (i.e., higher interest rates) in the future if downward exchange rate pressures persist.

Third, we test for effects on cross-border funding through measuring the difference in borrowing costs in USD and BRL. In practice, it is more costly to borrow dollars synthetically by converting BRL to dollars in the forward market. This inefficiency is measured by the CIP deviation, which records the difference in USD and BRL interest rates after hedging exchange rate risk with a forward contract. CIP deviations reflect a combination of factors. One is the scarcity of dollar liquidity, as dollars are the reserve currency and there are constraints in the global supply of dollars. We test whether FX

interventions impact CIP deviations. This connects to an emerging literature on whether FX interventions can be used as a policy tool to target inefficiency in cross-border dollar funding markets. Our findings suggest unanticipated sell interventions lead to a decline in the magnitude of CIP deviations. This improves efficiency of cross-border markets as it reduces the relative cost of borrowing USD using forward markets.

Our results are broadly consistent with a theory of FX interventions providing dollar liquidity and alleviating the constraints on global financial intermediaries (Gabaix and Maggiori 2015). These models imply intermediary constraints in the supply of dollar liquidity. All else equal, the central bank intervention reduces the size of the dollar portfolio intermediated by the global financial intermediary.¹ Given limits to inter-mediating the supply of dollars, this reduces the cost of obtaining dollars in FX markets.

The remainder of the paper is structured as follows. Section 2 reviews the related literature. Section 3 introduces a model framework with testable predictions on the effects of FX interventions on spot rates and CIP violations. In section 4 we introduce the institutional setting of FX interventions conducted by the BCB. In section 5 we present our findings of FX intervention effects on the exchange rate, interest rates and the CIP violation. Section 6 concludes.

2 Related Literature

Sarno and Taylor (2001) survey theoretical and empirical literature on central bank interventions in foreign exchange markets up to the turn of the century.² They discuss

¹As in the model framework, the central bank will conduct an operation to sell USD reserves and buy domestic bonds from the intermediary. The intermediary now has a larger share of dollar assets, and this makes it easier to intermediate dollar funding to domestic firms.

²There are a number of additional surveys, see (Neely 2005; Vitale 2006; Menkhoff 2010). Neely:2005ud discusses the limitations of several event study methodologies that authors in this lit-

primarily two channels through which sterilized foreign exchange intervention may operate: a portfolio balance channel [Mussa \(1981\)](#) and a signalling channel ([Mussa 1981](#)), and identify more support in the empirical literature for the signalling channel than for the portfolio balance channel. In a standard sterilized intervention, the Central Bank engages in selling foreign currency while simultaneously purchasing domestic bonds. This action results in a change in the composition of the Central Bank’s balance sheet, characterized by a decrease in foreign reserves followed by a rise in the stock of domestic bonds. Conversely, the private sector’s balance sheet undergoes an opposite shift as the proportion of foreign currency holdings increases, while the percentage of domestic bonds decreases. If holding foreign currency is perceived as riskier than holding domestic bonds, private agents will be willing to absorb a higher share of foreign currency in their portfolio if they expect a higher return. Consequently, the portfolio balance channel necessitates a corresponding decrease in the relative price of foreign currency, all other factors remaining constant (*ceteris paribus*). Alternatively, in the signaling channel, the act of selling dollar reserves by the Central Bank signals an anticipated increase in domestic interest rates, which, in turn, triggers a decrease in the spot rate.

We contribute to an empirical literature studying the exchange rate effects and spillovers to other financial markets ([Menkhoff, Rieth, and Stöhr 2021](#); [Payne and Vitale 2003](#); [Dominguez 2003](#); [Fratzscher et al. 2019](#); [Fratzscher et al. 2020](#); [Fratzscher et al. 2022](#); [Kearns and Rigobon 2005](#)). [Menkhoff and Taylor \(2007\)](#) conducted a study on the effects of foreign exchange interventions using a new proxy-SVAR methodology and daily data

erature have used, including the use of high-frequency data, and emphasizes problems of identification and simultaneity bias that can arise in event studies in the specific context of foreign exchange intervention. [Menkhoff \(2010\)](#) surveys empirical studies of foreign exchange intervention that use high-frequency data, and groups the studies according to high-frequency data quality: quoted prices by dealing banks and news reports of interventions; precise transaction data with price, volume, and time; order flow data. [Menkhoff \(2013\)](#) surveys empirical studies of foreign exchange intervention in emerging markets.

for currency pairs from developed economies. They found that interventions permanently raise stock prices of large firms and temporarily lower stock prices of small firms. Additionally, their research revealed that interventions temporarily lower longer-term (2-yr and 10-yr) interest rates. In a study by [Payne and Vitale \(2003\)](#), high-frequency tick-by-tick data from 1986 to 1995 was used to analyze the effects of sterilized intervention operations by the Swiss National Bank (SNB) on the USD/CHF spot market. Using an event study approach, they find interventions had a persistent effect on exchange rates. They also observed that coordinated and with-the-trend interventions had a more significant impact on exchange rates. Notably, the exchange rates showed a “anticipation effect,” moving in the same direction 15 minutes before SNB interventions. The impact of these interventions was immediate and persistent, with the cumulative effect remaining significant even after a few hours. [Dominguez \(2003\)](#) analyzed the effects of interventions by the USA, Japan, and Germany Central (G3) Banks in the USD-DEM and USD-JPY markets between 1987 and 1995. Empirical evidence indicated that Fed intervention operations significantly influenced both USD-DEM and USD-JPY intra-day returns and volatility.

Turning to emerging markets, a number of studies have focused on interventions by the central bank of Brazil ([Nakashima 2012](#); [Kohlscheen and Andrade 2013](#); [Janot and Macedo 2016](#); [Santos 2021](#)). In the study by [Nakashima \(2012\)](#), the authors analyzed BRL/USD futures contracts returns in relation to CBB FX intervention auctions. They found statistically positive abnormal returns shortly after the auction opening and negative returns after the auction closing. They also noted that the timing of the auction had only a minor effect on the returns. [Kohlscheen and Andrade \(2013\)](#) conducted a study using high-frequency data and an event study approach to examine the effects of FX swap

auctions on exchange rates. They found that the most significant impact on exchange rates occurred 60 to 70 minutes after the CBB announcement, which was attributed to the release of auction results. In the research by [Janot and Macedo \(2016\)](#), the authors analyzed CBB interventions' effects on intraday returns and volatility between October 2011 and March 2015. They discovered that non-programmed interventions had a more substantial and persistent impact on the foreign exchange market than programmed ones. In the study by [Santos \(2021\)](#), the impact of pre-announced and unexpected CBB FX interventions on the exchange rate was investigated. The findings indicated that unexpected interventions were more effective than pre-announced ones, with their effects persisting on the intervention day and the following day.

As well as studying effects on the spot market, we contribute to a literature on emerging market CIP deviations ([Du and Schreger 2016](#); [Cerutti, Cerutti, and Zhou 2023](#); [Hartley 2020](#)). One key determinant of CIP deviations is sovereign risk. This can be due to higher default rates and the lower credit worthiness of emerging markets, and explain why covered interest rate parity violations exist. A less studied role is the impact of policies such as FX interventions or central bank swap lines. There is some evidence that China's central bank swap lines can be used to internationalize the Renminbi, however it aims to facilitate export credit and increase the share of invoicing trade in Renminbi. The dollar intermediation channel proposed in [Gabaix and Maggiori \(2015\)](#) suggests that FX interventions can impact emerging markets through alleviating the demand for dollar liquidity. In our paper, we study the extent to which these policies through using CIP deviations as a proxy for dollar scarcity in cross-border funding markets.

3 Model

To motivate the effects of FX interventions on dollar intermediation, we follow [Gabaix and Maggiori \(2015\)](#). There are two countries, which are the US (home) and Brazil (foreign), and two periods ($t = 0, 1$). There is a unit measure of households in each country. There are four goods: a non-tradable (NT) and 1 tradable good in each country. For simplicity, NT are endowments, and tradables are produced with inelastically supplied labor. Each country can either borrow or lend in a risk-free bond that is priced in units of the domestic numéraire (the NT good) for each economy.

3.1 Households

$$\max_c \mathbb{E} [\theta_0 \ln C_0 + \beta \theta_1 \ln C_1] \quad (1)$$

Subject to the intertemporal budget constraint,

$$\sum_{t=0}^1 \frac{C_{NT,t} + p_{H,t} C_{H,t} + p_{F,t} C_{F,t}}{R^t} \leq \sum_{t=0}^1 \frac{Y_{NT,t} + p_{H,t} Y_{H,t}}{R^t} \quad (2)$$

where $C_t \equiv [(C_{NT,t})^{\chi_t} (C_{H,t})^{a_t} (C_{F,t})^{\iota_t}]^{\frac{1}{\theta_t}}$, and $\theta_t = \chi_t + a_t + \iota_t$

The problem for the foreign country is analogously given. Solving first order conditions for the household problem in each time period $t = 0, 1$, we can show that the import and export share of goods in the home country is given by:

$$p_{F,t}C_{F,t} = \iota_t \quad (3)$$

$$p_{H,t}^*C_{H,t} = \xi_t \quad (4)$$

The risk-free rates in each country are priced by their respective Euler equations:

$$1 = \mathbb{E} \left[\beta R \frac{\chi_1/C_{NT,1}}{\chi_0/C_{NT,0}} \right], \quad (5)$$

$$1 = \mathbb{E} \left[\beta R^* \frac{\chi_1^*/C_{NT,1}^*}{\chi_0^*/C_{NT,0}^*} \right], \quad (6)$$

Under the assumption that the non-tradeables are equal to a constant endowment in each period, the risk-free rates are $R = R^* = \frac{1}{\beta}$.

3.2 Financiers

Households borrow and lend in domestic “risk-free” bonds with the financiers. Financiers absorb resulting imbalances in global capital flows, and are assumed to fund in dollars and lend these dollars to Brazilian firms. The financiers maximize the value of the firm, where Q_t is the value of bonds invested in the foreign country, and e is the nominal exchange rate expressed as the domestic currency price of a unit of foreign currency.

$$V = E \left[\Lambda \left(\frac{R^*}{R} \frac{e_1}{e_0} - 1 \right) \right] Q_0 \quad (7)$$

Subject to the constraint,

$$\frac{V}{e_0} \geq \underbrace{\frac{Q_0}{e_0}}_{\text{claims to creditors}} \times \underbrace{\Gamma \frac{Q_0}{e_0}}_{\text{fraction of divertible funds}} \quad (8)$$

The collateral constraint is given as the fraction of the amount of divertible funds, multiplied by the total claims to creditors. The underlying assumption of the constraint is that creditors correctly anticipate the incentives to divert funds. Γ measures the risk bearing capacity of financiers, and in the limit as $\Gamma = 0$ means there is maximum risk bearing capacity and it approaches an economy in which interest rate parity holds. If Γ approaches infinity it suggests infinite risk aversion and we approach financial autarky.

The net demand for foreign (BRL) bonds, and corresponding supply of dollars, is given as follows:

$$Q_0 = \frac{1}{\Gamma} \mathbb{E} \left[\frac{R^*}{R} e_1 - e_0 \right] \quad (9)$$

3.3 FX intervention

We write the balance of payments constraint in each period, which show the net demand for dollars in each period. The net exports of the home country must net out

the capital account, which is the amount of lending done by the home country. We follow [Gabaix and Maggiori \(2015\)](#) and model an intervention by the central bank of Brazil to sell USD at $t = 0$ and buy the BRL back at $t = 1$.

$$e_0 \xi_0 - \iota_0 - q^* - Q_0 = 0 \quad (10)$$

$$e_1 \xi_1 - \iota_1 + q^* + Q_0 = 0 \quad (11)$$

Substituting equation (9) for the financier supply of dollars in period $t = 0$ and corresponding demand for dollars in period $t = 1$, and making the following simplifying assumptions on interest rates, imports and exports ($R = R^* = \iota = \xi = 1$), we can derive the equilibrium spot exchange rate in period 0, and the expected spot rate in period 1.

$$e_0 = 1 + q^* \frac{\Gamma}{\Gamma + 2} \quad (12)$$

$$\mathbb{E}[e_1] = 1 - q^* \frac{\Gamma}{\Gamma + 2} \quad (13)$$

This framework yields the following testable implications on the effects of FX interventions on the spot exchange rate and the intermediation of dollars.

Prediction 1: An FX intervention of selling USD reserves and buying BRL leads to an appreciation (depreciation) of the BRL (USD) at $t = 0$. The effectiveness of the intervention on the spot rate at $t = 0$ is increasing in the magnitude of intermediation constraints.

$$\frac{\partial e_0}{\partial q^*} = \frac{\Gamma}{\Gamma + 2} > 0 \quad (14)$$

This supports the portfolio balance channel of exchange rates as discussed in [Sarno and Taylor \(2001\)](#). Selling USD reserves requires the relative price of USD to fall in order to induce the financiers to absorb the excess supply of dollars in the balance of payments constraint in equation (12).

Turning to the role of intermediation constraints, we can show that the sensitivity of the spot rate to FX interventions is increasing in Γ . An increase in Γ is associated with a decline in risk bearing capacity of the financiers, and their supply of dollars is more inelastic. Therefore a FX intervention elicits a larger price change in the spot rate.

$$\frac{\partial e_0}{\partial q^* \partial \Gamma} = \frac{2}{(\Gamma + 2)^2} > 0 \quad (15)$$

Prediction 2: An FX intervention of selling USD reserves and buying BRL reduces the size of the dollar intermediation by financiers.

The equilibrium level of dollar intermediation Q_0 is given by equation (16). Note that in this simplifying setup, the FX intervention requires financiers to absorb the excess supply of dollars by the central bank. Therefore their net dollar intermediation is negative.

In particular, financiers have to absorb a larger supply of dollars if they face tighter intermediary constraints ($\Gamma \uparrow$).

$$Q_0 = -2q^* \frac{\Gamma}{\Gamma + 2} \quad (16)$$

While the amount of dollar intermediation by financiers is not directly observable in the data, we can test this indirectly through measuring covered interest rate parity deviations in the BRL/USD pair. In the model framework, the CIP violation can be written as the difference between interest rates on foreign and domestic currencies after hedging exchange rate risk with a forward contract. If forward markets are efficient, and the forward rate is an unbiased predictor of the future spot rate, $f = \mathbb{E}[e_1]$, the dollar intermediation by financiers is proportional to the CIP violation. Therefore we can test whether FX interventions affect the net intermediation of dollars through measuring the CIP violation.

4 Definitions and Data

4.1 Mechanics of sterilized intervention

Central banks may seek to manage exchange rates without altering the money supply through sterilized intervention. Consider spot purchase intervention as an example. In a non-sterilized intervention, the central bank purchases foreign currency with domestic currency, leading to an increase in the domestic money supply. To "sterilize" the impact on the money supply, the central bank sells domestic-currency bonds to absorb the excess domestic currency in the money market. If the sterilization is perfect, the money supply

would remain constant, while the relative ratio of domestic currency and foreign currency bonds held by the public(and the central bank) would change.

A sterilized intervention therefore can be viewed as a combination of two transactions. First, in the FX market, the central bank a non-sterilized intervention by purchasing foreign currency with domestic currency that it issues

Central Bank Balance Sheet	
Assets	Liabilities
Assets in Foreign Currency(+1)	Currency in Circulation(+1)

Second, in the money market, the central bank "sterilize" the effect on money supply by selling the same amount of domestic bonds to absorb the initial increase in money supply.

Central Bank Balance Sheet	
Assets	Liabilities
Assets in Domestic Currency(-1)	Currency in Circulation(-1)

The net effect of a sterilized spot purchase is the change in the relative ratio of domestic currency assets and foreign currency assets held by the central bank(and the public).

Central Bank Balance Sheet	
Assets	Liabilities
Assets in Foreign Currency(+1)	Currency in Circulation(-)
Assets in Domestic Currency(-1)	

4.2 BCB FX Interventions

In this section we introduce the BCB intervention database and interventions we study in the paper.

Spot Purchase and Spot Sales: Operations in which the BCB buys or sells US dollars in the interbank foreign exchange market for immediate delivery, settling within two business days, with the corresponding counterpart in Brazilian Reais.

Traditional Swap: Auctions when the BCB assumes a buying position in the Swap contracts. The central bank exchanges USD for BRL at the spot leg. Interest repayments on the swap are exchanged at regular intervals until maturity, with the central bank paying USD Libor to the dealer, and the dealer paying the Selic interest rate in BRL. At maturity of the swap, the central bank and dealer re-exchange BRL for USD.

Reverse Swap: Auctions when the BCB assumes a selling position in the Swap contracts. The central bank exchanges BRL for USD at the spot leg. Interest repayments on the swap are exchanged at regular intervals until maturity, with the central bank paying the Selic interest rate in BRL to the dealer, and the dealer paying the USD Libor rate. At maturity of the swap, the central bank and dealer re-exchange USD for BRL. Figure 1 shows the spot, interest rate and maturity legs of a traditional and reverse swap contract.

We define *unexpected interventions*: as those where the operational date is on the same day as the date of announcement, while *expected interventions* are those for which the operational date is later than the date of announcement.

Date and Time of Announcement: The date and time at which the BCB informed the public that there would be, at a future time or date, an intervention in the foreign exchange market, or, in the case of auctions in the interbank spot or forward markets, that an intervention had begun.³

Operational Date: The date on which the intervention occurred. BCB only pub-

³With the exception of direct operations in the spot market between July 1999 and February 2003 when the corresponding Announcements were disclosed at the end of the day, making public that the BCB had intervened in the exchange on that day.

lishes the date but not the exact time of the operations.

Table 1 provides summary statistics on the Brazilian Central Bank’s (BCB) foreign exchange (FX) interventions, categorized into the different types. Examining unexpected interventions, spot sales, the mean unexpected intervention amount is 0.17 billion USD, with a standard deviation (S.D) of 0.22 billion USD. For traditional (reverse) swaps, the mean unexpected intervention amount is 0.43(0.35) billion USD, with an S.D of 0.41 (0.45) billion USD. Turning to expected interventions, the amounts are generally smaller for each category, however there is big difference in the number of interventions. For spot sales, most are conducted intra-day with the date of announcement and operation being the same, with 385 unexpected and 87 expected announcements. All spot purchases are unexpected. In contrast, for swap transactions, there are more expected announcements, for example over 5000 expected announcements for the traditional swap, in contrast to 345 unexpected.

Figures 2 and 3 plot the time series of FX interventions and the distribution of expected and unexpected distribution in amounts offered. Figure 4 shows the cumulative interventions of each category over time. There has been a general move by the BCB to traditional swaps over time as the principal policy instrument, and reduced reliance of using USD. The motivations for switching toward derivative contracts is that they are balance sheet neutral for the central bank. A traditional FX swap is essentially a USD loan collateralized by BRL, and the central bank maintains their USD reserves after maturity of the FX swap. In contrast, selling USD spot results in a permanent reduction in the central bank reserves, which can be costly due to the need for reserves as a level of precautionary savings or as insurance against periods of tight intermediary constraints (Cheng 2015; Jeanne and Sandri 2020). For example, spot sales of USD reserves, after

being used very little in 2010-2019, were reintroduced in 2020 during the pandemic in response to dollar scarcity in cross-border markets and an increase in dollar funding costs as measured by CIP deviations.

Finally, Figure 5 plots the maturity of traditional and reverse currency swaps for both expected and unexpected announcements. Unexpected swaps are typically of short maturities (less than 2 days), whereas expected swaps have a wide distribution of maturities that range from overnight to 3 months. The motivation for expected and unexpected currency swaps may differ: unexpected swaps may be typically used for short-term liquidity provision to specific dealers to address roll-over risk and ensure the functioning of interbank money markets. In contrast, long-term liquidity provision may be to address the maturity and currency mismatch of bank balance sheets.

4.3 Additional Data

4.3.1 Spot and forward prices

We obtain tick-by-tick high-frequency data for spot and forward indicative quotes from Thomson Reuters Tick History and interdealer trades from the Thomson Reuters D3 platform. These quotes are given at 5 minute intervals and include bid and ask prices. We use the mid-quote of the spot and forward price for our analysis in Section 5.

4.3.2 Interest rates

We obtain daily interest rates from the IPEA Brazil Government dataset. For a given maturity (eg. 1 month) it is constructed using the rates of return for different maturity dates of a given security. For the 1 month maturity, it uses the yield curve of the National Treasury Bill (LTN) with a term of 21 business days.

4.3.3 Intermediary constraints

We use balance sheet constraints of financial intermediaries (He, Kelly, and Manela 2017). Specifically, we use the *intermediary capital risk factor*⁴. The intuition is that a negative shock to the intermediary's capital ratio tightens primary dealers borrowing constraints and thus reduces their demand for risky assets in the presence of capital requirements such as the Tier 1 capital ratio.

4.3.4 Credit risk

One issue with measuring CIP deviations for emerging markets is accounting for differences in credit risk across currencies (Du and Schreger 2016). To control for credit risk, we use EMBI+ (Emerging Markets Bond Index Plus), which estimates the daily performance of emerging countries' debt securities in relation to United States Treasury bonds, obtained from the IPEA Brazilian government dataset. The index is based on the bonds (debt securities) issued by this group of countries and shows the financial returns obtained each day by a selected portfolio of securities.

4.4 CIP deviation

CIP states that the interest rate differential between two currencies should be equal to the differential between the forward and spot exchange rates. The idea behind Covered Interest Rate Parity is simple. An investor with one US dollar in hand at time t can either: a) Invest in US and earn a risk free interest rate. Or b) Exchange her dollar for at spot market for foreign currency and earn a risk free interest rate in foreign currency.

⁴The data is obtained from the website of Zhiguo He: <https://voices.uchicago.edu/zhiguohe/data-and-empirical-patterns/intermediary-capital-ratio-and-risk-factor/>.

She can sign currency forward contract at time t to convert the foreign currency earned back to US dollar at time $t + n$.

The CIP violation states that two strategies should give investor same return, i.e.,

$$(1 + r_{t,t+n})^n = (1 + r_{t,t+n}^*)^n \frac{S_t}{F_{t,t+n}} \quad (17)$$

where $r_{t,t+n}$ is the risk-free interest rates between t and $t + n$ in US dollar, and $r_{t,t+n}^*$ is the corresponding risk-free interest rate in foreign currency. S_t is the spot rate in units of US dollar per foreign currency, and $F_{t,t+n}$ is the corresponding forward rate.

Violations of CIP can be quantified by the cross currency basis $x_{t,t+n}$. Follow [Du, Tepper, and Verdelhan \(2018\)](#), the Cross-Currency Basis is defined as the difference between the direct U.S. dollar interest rate and the synthetic dollar interest rate:

$$(1 + r_{t,t+n})^n = (1 + r_{t,t+n}^* + x_{t,t+n})^n \frac{S_t}{F_{t,t+n}} \quad (18)$$

In log terms, the cross currency basis is equal to:

$$x_{t,t+n} = (r_{t,t+n} - r_{t,t+n}^*) + \rho_{t,t+n} \quad (19)$$

where $\rho_{t,t+n}$ denotes the forward premium:

$$\rho_{t,t+n} \equiv \frac{1}{n} (f_{t,t+n}^{bid} - s_t^{ask}) \quad (20)$$

Figure 6 plots the CIP deviations for BRL/USD at maturities of 1,3,6 months and 1 year. These deviations are using high frequency spot and forward rates and daily measures of BRL and US Libor interest rates, and therefore reflect variation in the futures premia.

The direction of the CIP deviation is systematically negative, indicating a premium to swap BRL for USD in FX forward and swap markets.

5 Empirical Evidence

We use the following specification to test the effects of FX interventions on the outcome variable y_t , which includes BRL/USD spot prices, forward premia and CIP deviations.

$$y_{t+h} - y_{t-1} = \beta_h^z INT_t^z \times SAD_{t+h} + \gamma_h^z INT_t^z \times (1 - SAD_{t+h}) + SAD_{t+h} + HKM_t + \text{Daily frequency controls}_t + \text{High frequency controls}_t + u_{t+h} \quad (21)$$

Where HKM_t is the HKM Intermediary Capital Risk Factor, and INT_t^z represents the amount of BCB's intervention at time t in US dollar, $z \in \{Spot\ sale, Spot\ Purchase, Traditional\ Swap, Reverse\ Swap\}$. SAD_{t+h} indicates whether y_{t+h} is on the same day as y_t , when the announcement of intervention occurred.

$$INT_t^z = \begin{cases} \text{Amount in USD} & \text{if intervention of type } z \text{ was announced at } t \\ 0 & \text{otherwise} \end{cases}$$

$$SAD_{t+h} = \begin{cases} 1 & \text{if } t+h \text{ is on the same } \mathbf{day} \text{ as } t \\ 0 & \text{otherwise} \end{cases}$$

Daily frequency controls includes lagged value up to 10 days for interest rates, the term interest rate spread, spot market volatility, the total amount of interventions in USD

(of all instruments) at date t , Brazilian Emerging Markets Bond Index Plus (EMBI+), which measures the sovereign risk of Brazil. High frequency controls includes lags of the outcome variable, and lagged spot rate bid-ask spreads up to 10 lags.

5.1 Spot prices

The results of our local projections method are shown in Figure 7. Our results disaggregate interventions into spots and swaps and further classifying whether they are buy or sell. Spot sale interventions have the largest effect on spot prices—reaching a 1.5 percentage point appreciation intra-day over a 7 hour window. In contrast, buy interventions have no effect. Turning to FX swaps, we find weak transitory effects of unexpected traditional FX swap interventions, with a 10 basis point appreciation within 1 hour of the shock. Similarly, we observe a short-term transitory depreciation of the BRL for an unexpected reverse swap of approximately 15 basis points over a 1 hour horizon. For both a traditional and reverse swap, the effects are transitory and insignificant over a longer horizon.

A number of studies have quantitative results regarding the effect of a FX intervention on the spot rate (Kearns and Rigobon 2005; Santos 2021; Dominguez, Fatum, and Vacek 2013; Naef and Weber 2023; Arango-Lozano et al. 2020). In the Brazil case, Santos (2021) estimated that for each USD 1 billion discretionary intervention, the BRL appreciated by 29.4 basis points (bps) in the futures market. These results are quantitatively smaller than the effects of the unexpected spot sales, however are larger than the effects we find for traditional and reverse swap auctions. To reconcile our findings, we note that the disaggregation of interventions shows clear heterogeneity in the effects. In particular, any permanent effects on the spot rate are derived from spot sale interventions, whereas swap

interventions are transitory. Another interesting result is that spot purchase interventions are less effective. One potential reason for the asymmetry is that USD buy interventions are typically conducted during periods of relaxed intermediary constraints. During these periods, we expect weaker effects on spot exchange rates as intermediaries can absorb the excess supply of BRL on their balance sheet. We test the asymmetry of interventions more concretely when we proxy for intermediary constraints in section 5.2.

5.1.1 Interest rates and forward premia

We do not observe interest rates at a high frequency. However, we can construct a proxy for the interest rate differential using the forward premia, which is the (log) difference in the spot and forward rates. Taking first differences in the equation for the cross-currency basis in equation (19), we can show that changes in the interest rate difference on BRL and USD is a function of the change in the forward premium and the change in the cross-currency basis. Under the assumption that the cross-currency basis is constant, the change in the forward premium tells us about the high frequency stance of BRL interest rates relative to the US.

$$\Delta(r_{t,t+n}^* - r_{t,t+n}) = \Delta\rho_{t,t+n} - \Delta x_{t,t+n} \quad (22)$$

The results are shown in Figure 8. As before, our results dis-aggregate interventions into spots and swaps and further classifying whether they are buy or sell. Spot sales interventions lead to a systematic increase in the forward premium: therefore these interventions signal an increase in BRL interest rates relative to the US. Spot sale interventions have the largest effect on the forward premium—reaching a 30 basis point increase over a 7 hour window. Spot purchase interventions reduce forward premia by approximately 15

basis points over 2 hours, however the effects are transitory. Turning to FX swaps, we find weak transitory effects of unexpected traditional FX swap interventions, with a 2 basis point increase in the forward premium within an hour of the shock. We find a steady decline in the futures premium for unexpected reverse swap, however it is not significant at the 5% level. For both a traditional and reverse swap, the effects are transitory and insignificant over a longer horizon.

One concern with our results is that we are assuming the forward premium is a proxy for the interest rate differential. This is incorrect if CIP deviations are responding to the FX intervention, which we test in subsection 5.1.2. Another concern is if our results are driven by US monetary policy. For example, if USD sell interventions are typically conducted during periods of tight intermediary constraints or in a recession, we expect US monetary policy to be expansionary. Therefore, we control for US interest rate policy by constructing a synthetic Brazil interest rate.

The Synthetic Brazilian 1 month interest rate is recovered from the forward premium and the USD interest rate (under the simplifying assumption that the cross-currency basis $x_{t,t+n} = 0$). We recover the high frequency Brazilian 1 month interest rate from high frequency US interest rate and high frequency USD/BRL spot and forward rate data.

$$r_{t,t+n}^{\text{Synthetic BZ}} = r_{t,t+n}^{\text{ask}} + \rho_{t,t+n} \quad (23)$$

where $\rho_{t,t+n}$ denotes the forward premium:

$$\rho_{t,t+n} \equiv \frac{1}{n}(f_{t,t+n}^{\text{bid}} - s_t^{\text{ask}}) \quad (24)$$

The results are shown in Figure 9. Our results are robust to controlling for US interest

rates. Spot sales interventions lead to an increase in the synthetic BRL rate of 50-75 basis points over a period of 7 hours. Spot purchase interventions reduce the BRL synthetic rate by 50 basis points over 2 hours, however the effects are transitory. Turning to FX swaps, we find weak transitory effects of unexpected traditional FX swap interventions, with a 2 basis point increase in the forward premium within an hour of the shock. For a traditional (reverse) swap, there is a weak (insignificant) 10 basis point increase (decrease) in the synthetic interest rate. The results are suggestive that investors assume unexpected spot interventions signal a permanent stance of monetary policy tightening by the BCB.

5.1.2 CIP deviations

The CIP deviation measures the difference between the synthetic and direct dollar interest rate. Based on the model framework, we hypothesize that a FX intervention to sell USD and buy BRL will reduce the amount of USD that is absorbed by global financiers. All else equal, this will reduce the risk premium associated with providing USD in FX forward and swap markets, narrowing the CIP deviation. The local projections method estimates the intra-day effects of FX interventions on the CIP deviation. The results in Figure 10 suggest that of the different policy instruments, spot sales have the most persistent effects on the CIP deviation. The positive coefficients report an attenuation of the CIP deviation, which reduces the relative cost of swapping BRL into USD using forward and swap contracts. This makes it easier to obtain dollar liquidity in FX markets, and is consistent with our model framework.

5.2 Intermediary constraints and FX Interventions

The model framework suggests that the effects of FX interventions are stronger during periods of intermediary constraints. The price effects of the FX intervention are dependent on the relative elasticity of supply of dollars by the global bank. When global banks are constrained, there is a limited supply of dollar liquidity to Brazilian firms, and the supply of dollars is relatively inelastic. The central bank therefore conducts operations to supply dollars (in either spot or forward/swap markets) to alleviate the demand for dollar liquidity. When the supply of dollars are more inelastic, we expect stronger price effects of FX interventions.

To proxy for intermediary constraints, we use the measure of dealer capital ratio in [He, Kelly, and Manela \(2017\)](#). This measures shocks to the daily growth in dealer capital. The specification we run is shown in equation (25).

$$\begin{aligned}
 y_{t+h} - y_{t-1} = & \beta_h^z INT_t^z \times SAD_t \times D_{HKM,t} + \gamma_h^z INT_t^z \times (1 - SAD_{t+h}) \times D_{HKM,t} + SAD_{t+h} + D_{HKM,t} \\
 & + \text{Daily frequency controls}_t + \text{High frequency controls}_t + u_{t+h}
 \end{aligned}
 \tag{25}$$

A dummy variable $D_{HKM,t}$ takes a value of 1 for periods in which the HKM is in the 75th and 25th percentile and is interacted with the size of the FX intervention INT for spot and swap transactions. We present our results for the effects on the spot rate, forward premia and CIP deviation in Figures 11, 12 and 13.

Three observations emerge from our analysis. First, the results for the effects of spot sales are evident only for interventions during the upper quartile of the HKM measure. This corresponds to periods of tighter intermediary constraints. In contrast, we find no ef-

fects of interventions conducted during periods of slack constraints (lower quartile of HKM measure). Weaker effects are observed for traditional and reverse swaps. Second, when intermediary constraints are tight, we find a stronger signalling channel: forward premia estimates suggest markets anticipate Brazil policies to tighten interest rates relative to the US. Third, as dollar intermediation is scarce, FX interventions relax intermediation constraints and reduce the inefficiency in pricing of FX swaps, with a narrowing of CIP deviations.

6 Conclusion

The empirical literature on foreign exchange (FX) interventions has focused on the dynamics of the spot exchange rate, but a less explored area is understanding the spillover effects of these interventions on interest rate markets. This study aims to investigate this relationship, particularly concerning the signaling channel and the covered interest rate parity (CIP) condition, which is a critical no-arbitrage benchmark in international finance. To address these questions, we analyze high-frequency FX interventions conducted by the Brazilian Central Bank (BCB). We have access to a comprehensive historical database of these interventions, including their type, volume, and timing. Combining this intervention data with tick-level information on spot and futures prices, we employ the local projections method to measure the effects of FX interventions.

Our findings reveal several key insights. First, we observe that unexpected sell interventions lead to an appreciation of the spot exchange rate, while buy interventions do not have a significant impact, consistent with previous literature. Second, our study shows that these interventions spill over into interest rate markets. Brazil's interest rates increase relative to the U.S.. This aligns with the signaling channel, where the reduction

in central bank reserves signals a contractionary monetary policy, potentially leading to a permanent increase in future interest rates. Third, we investigate cross-border funding by examining the CIP deviation, which measures the relative cost of borrowing dollars synthetically. Our results indicate that unanticipated sell interventions reduce the magnitude of CIP deviations, enhancing the efficiency of cross-border markets and lowering the relative cost of borrowing USD through forward markets.

Taken together, our findings align with the theory that FX interventions provide dollar liquidity, alleviate constraints on global financial intermediaries, and reduce the cost of obtaining dollars in FX markets. This has implications for understanding the impact of FX interventions on both exchange rates and interest rate markets.

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Figures

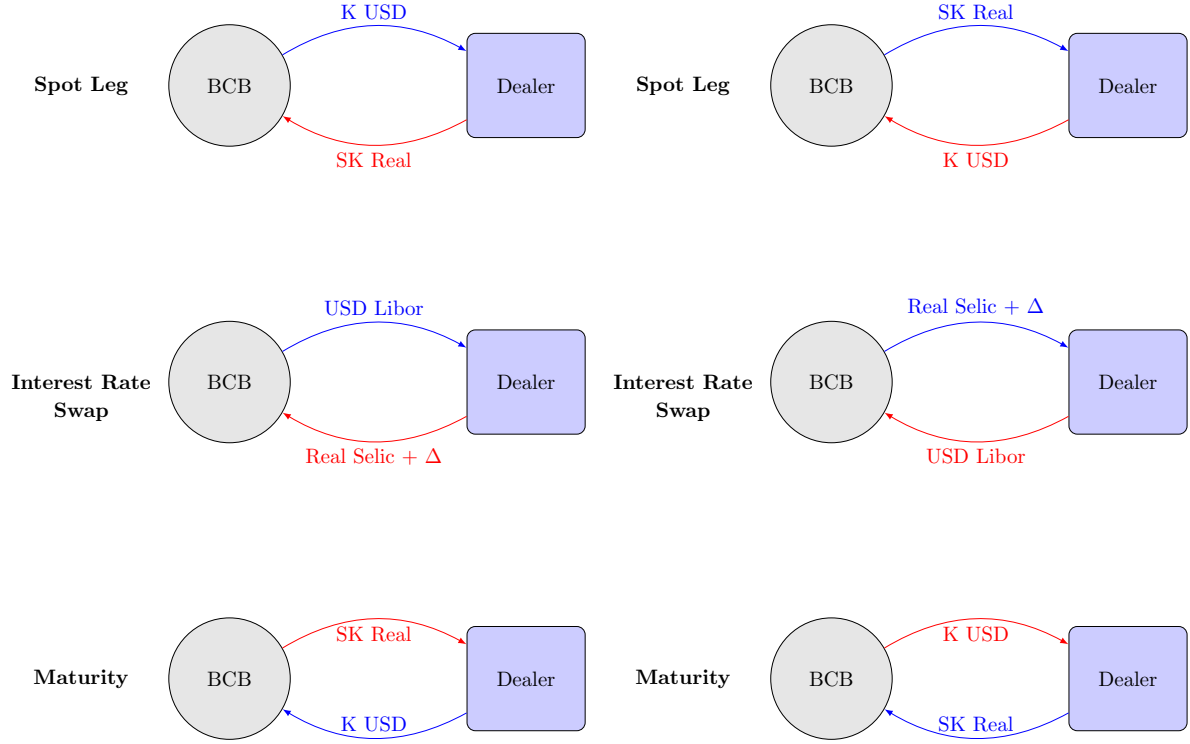


Figure 1: **Traditional and Reverse Cross-Currency Swap.** In the traditional swap (left panel), the central bank exchanges USD for BRL at the spot leg. Interest repayments on the swap are exchanged at regular intervals until maturity, with the central bank paying USD Libor to the dealer, and the dealer paying the Selic interest rate in BRL plus the addition of the cross-currency basis Δ . At maturity of the swap, the central bank and dealer re-exchange BRL for USD. In the reverse swap (right panel), the central bank exchanges BRL for USD at the spot leg. Interest repayments on the swap are exchanged at regular intervals until maturity, with the central bank paying the Selic interest rate in BRL to the dealer plus the addition of the cross-currency basis Δ , and the dealer paying the USD Libor rate. At maturity of the swap, the central bank and dealer re-exchange USD for BRL.

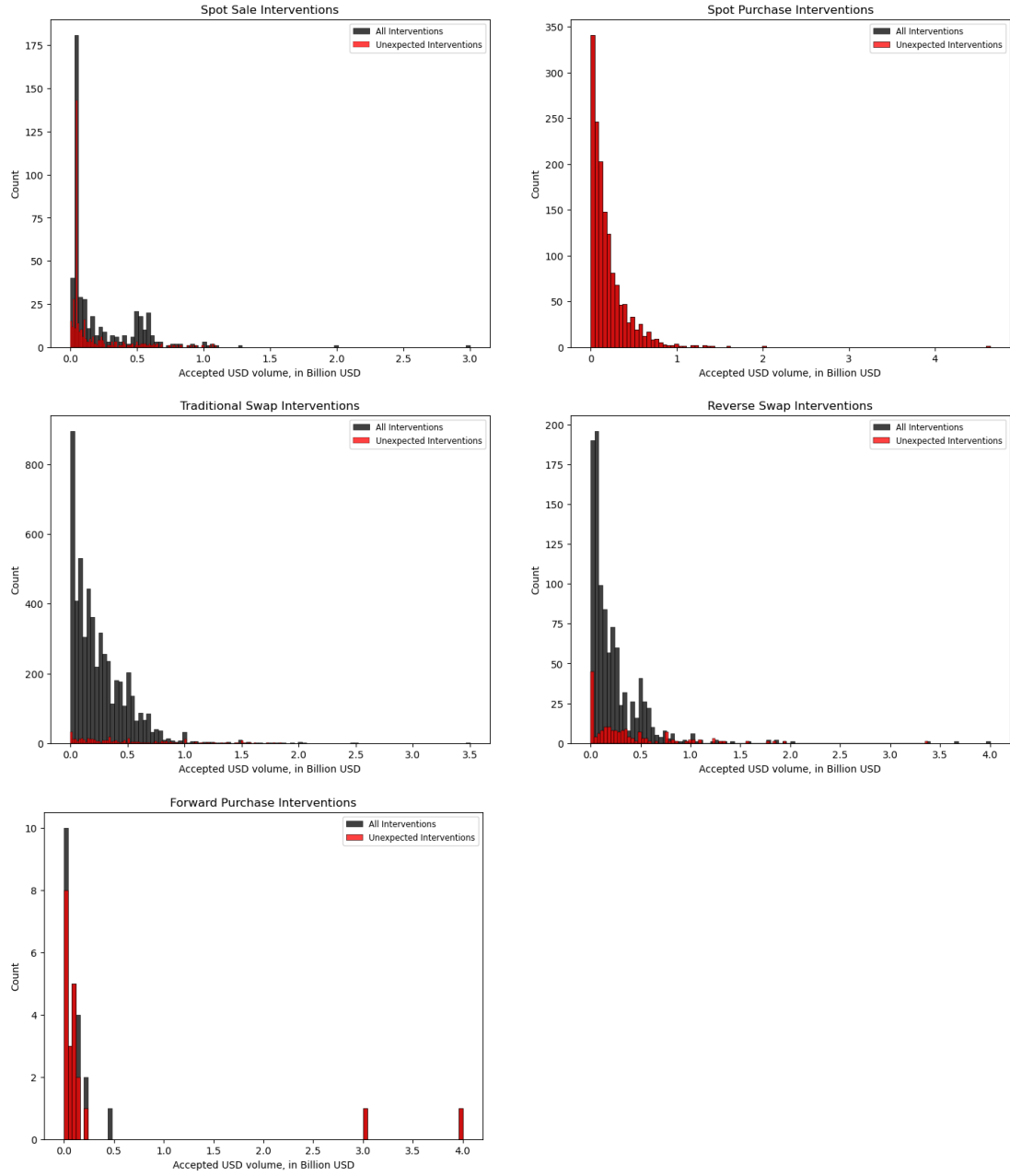


Figure 2: **Distribution of The BCB's Interventions in FX market.** These figures show the distribution of BCB's interventions in the FX markets. The amount of intervention is in billion USD, and is aggregated at daily level. Sample period is from 1999-01-22 to 2023-04-27.

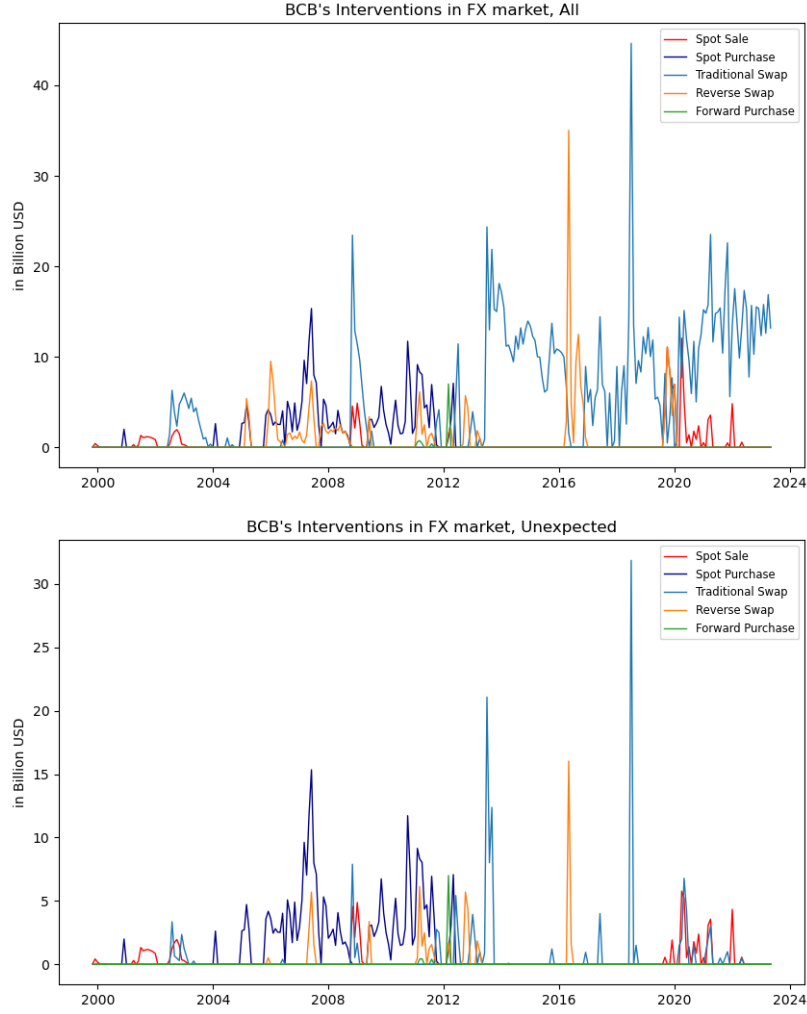


Figure 3: **The BCB's Intervention in FX markets since 2000.** These figures show the monthly USD amount of BCB's interventions in the FX markets. The figure at the top shows all interventions, while the figure at the bottom shows the unexpected interventions. Sample period is from 1999-01-22 to 2023-04-27.

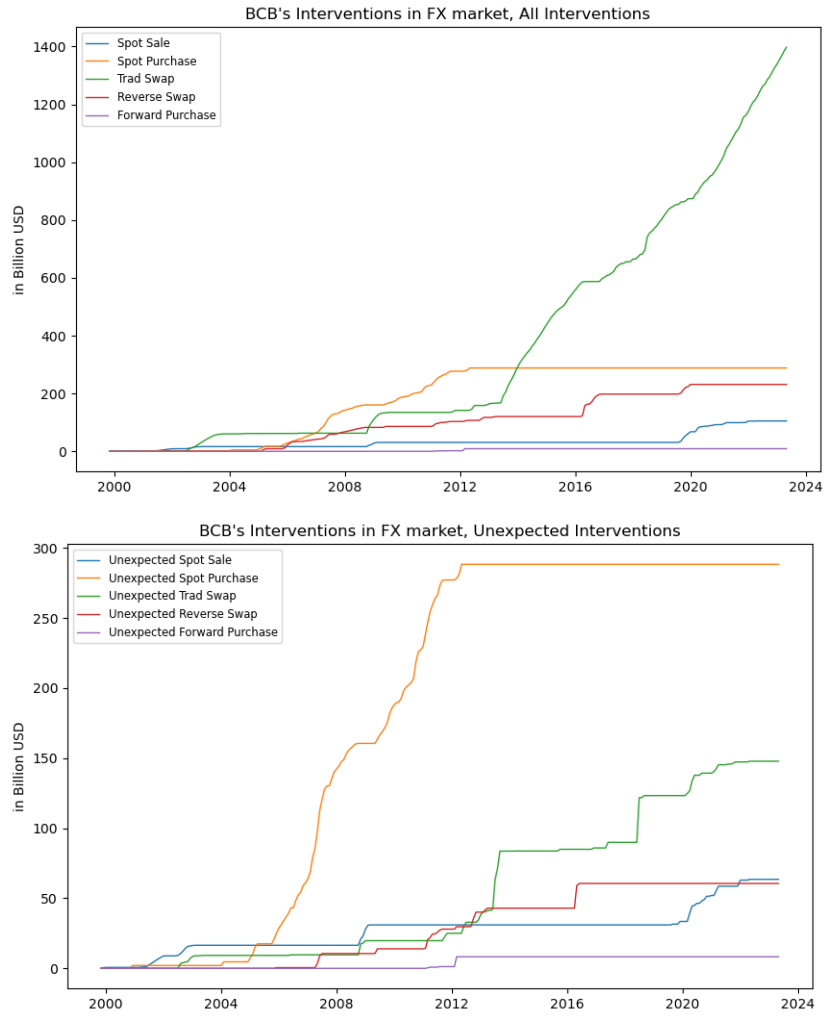


Figure 4: **The Cumulative BCB's Intervention in FX markets since 2000.** These figures show the cumulative USD amount of BCB's interventions in the FX markets. The figure at the top shows all interventions, while the figure at the bottom shows the unexpected interventions. Sample period is from 1999-01-22 to 2023-04-27.

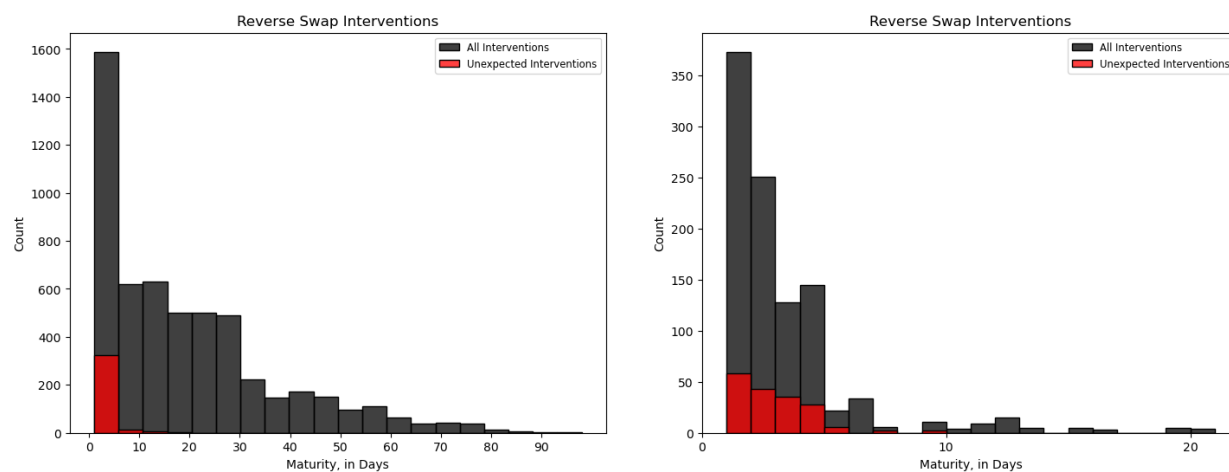


Figure 5: Maturity breakdown of BCB's Swap Line Interventions.

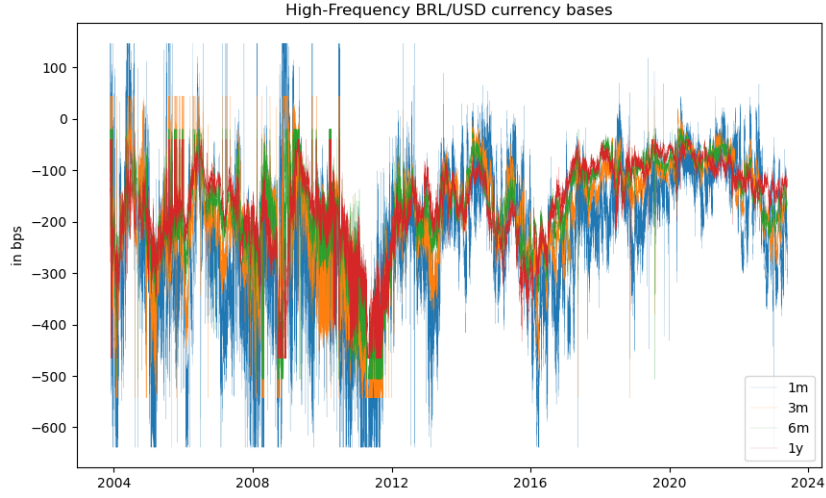


Figure 6: **The BRL/USD currency Bases.** This figure plot the BRL/USD currency bases for 1 month, 3 month, 6 month, and 1 year maturity. We Construct the currency bases using high frequency forward points, high frequency spot rate data, daily US Libor rate, and daily Brazilian inter-bank rate data. Currency bases are Winsorized at 1 % and 99 %. Sample period is from 2003-11-24 to 2023-04-27.

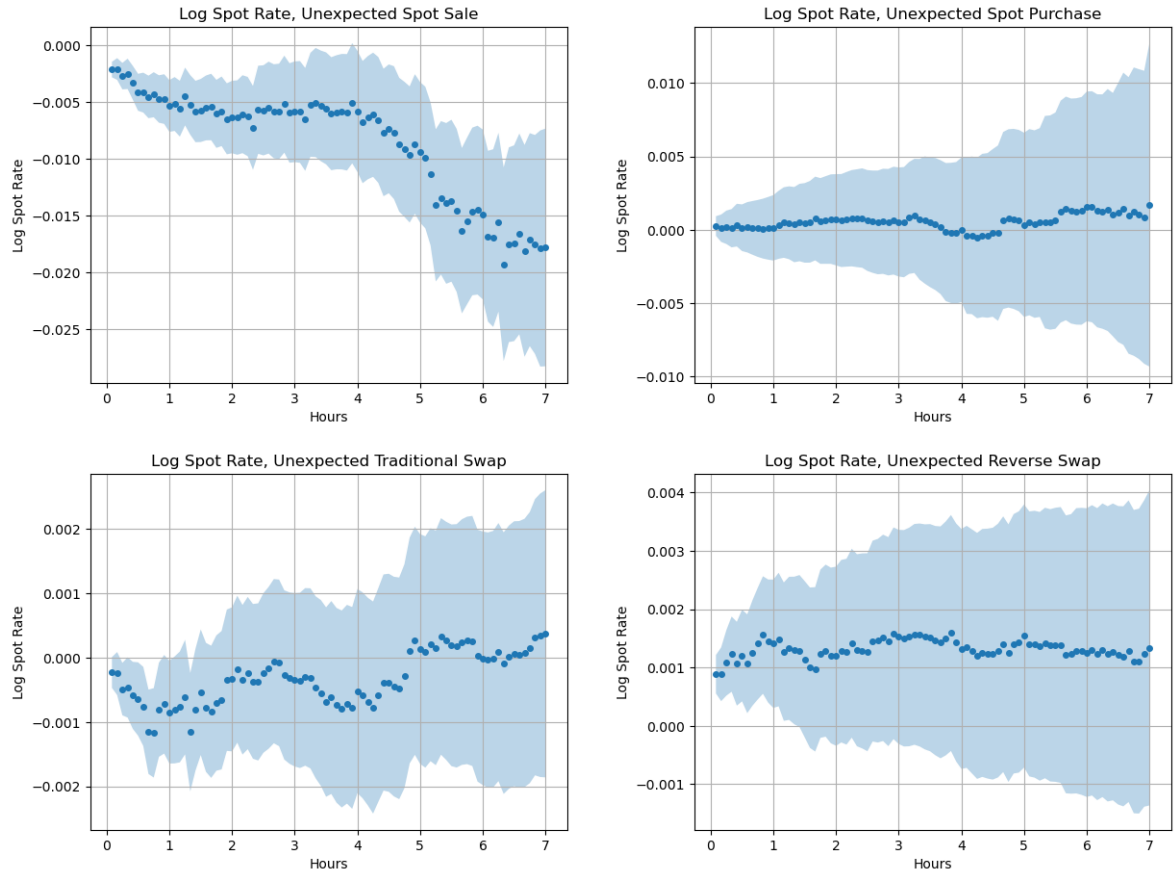


Figure 7: **Dynamic Response of Log Spot Rate to BCB's Unexpected Interventions.** Spot sales(top left), spot purchase(top right), traditional Swap(bottom left), and reverse Swap(bottom Right)

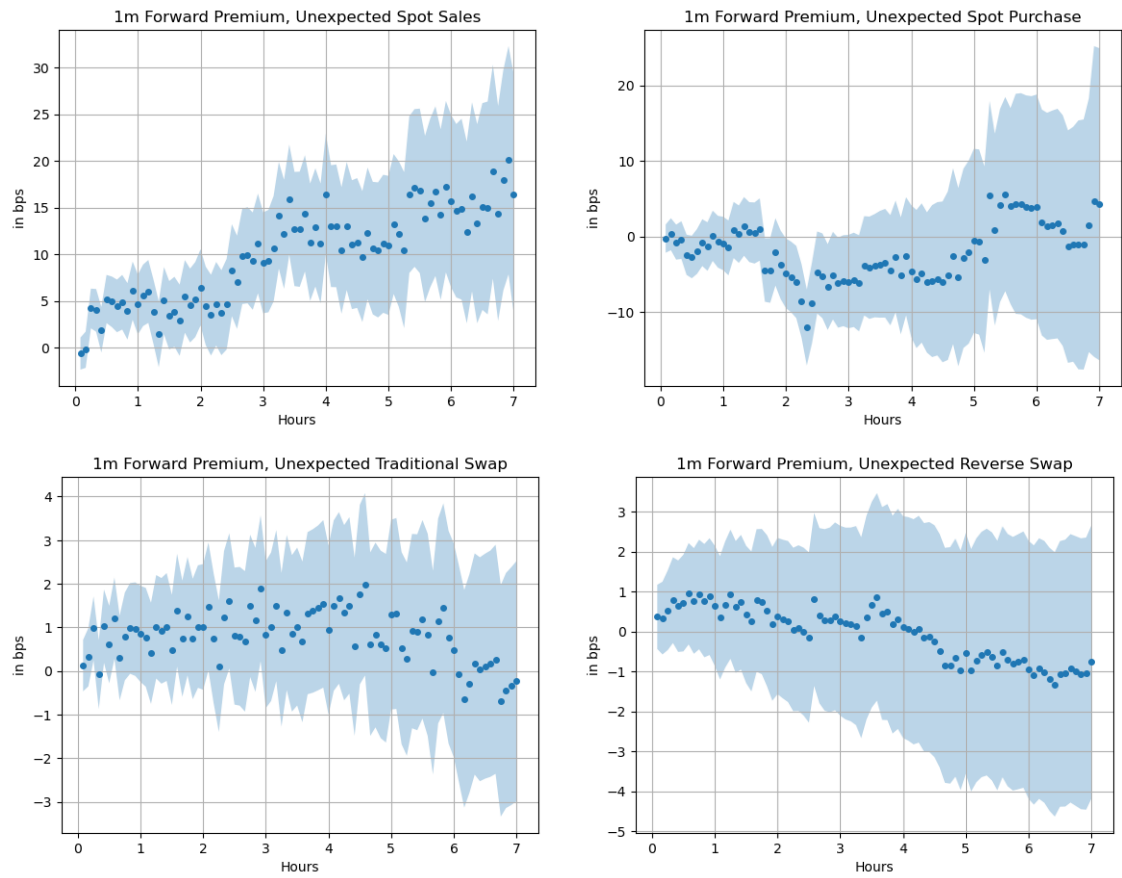


Figure 8: **Dynamic Response of 1m Forward Premium to BCB's Unexpected Interventions.** Spot sales(top left), spot purchase(top right), Traditional Swap(bottom left), and Reverse Swap(bottom Right)

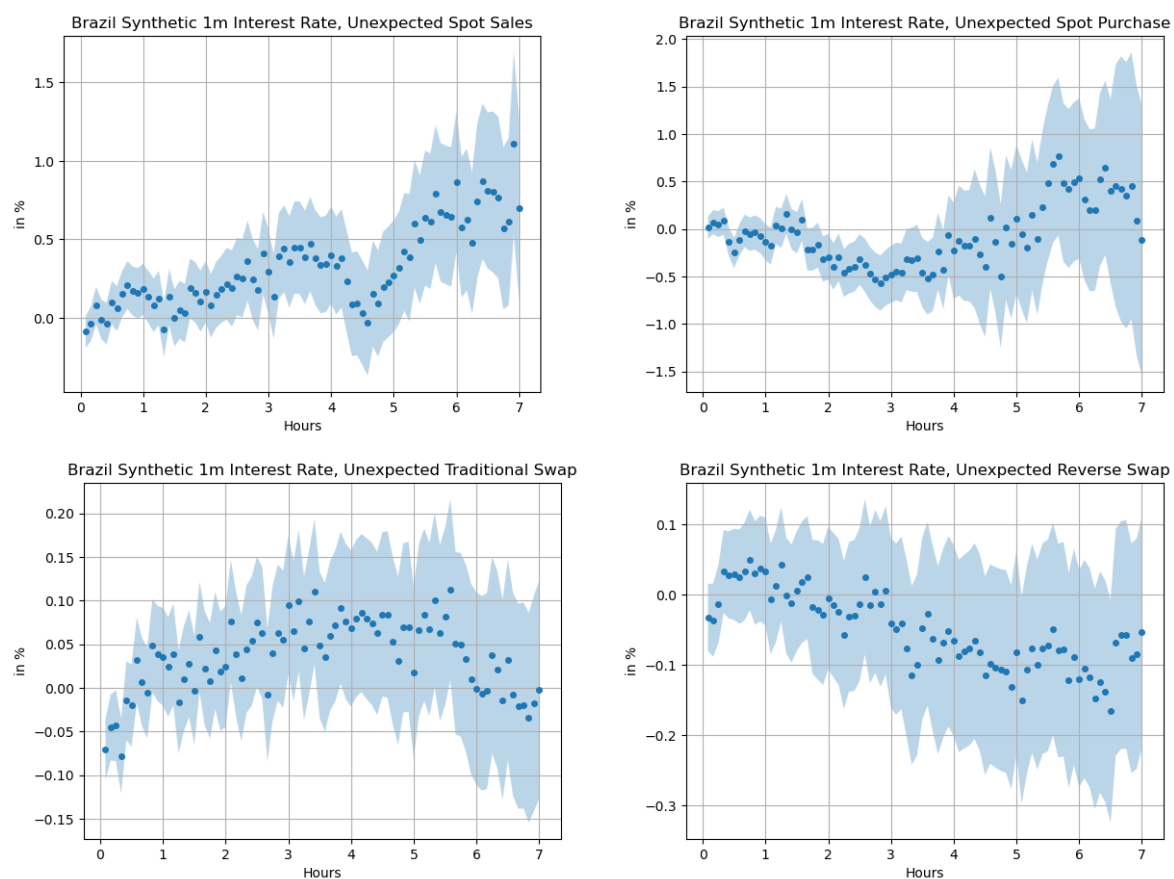


Figure 9: **Dynamic Response of 1m Synthetic Brazil Interest Rate to BCB's Unexpected Interventions.** Spot sales(top left), spot purchase(top right), Traditional Swap(bottom left), and Reverse Swap(bottom Right)

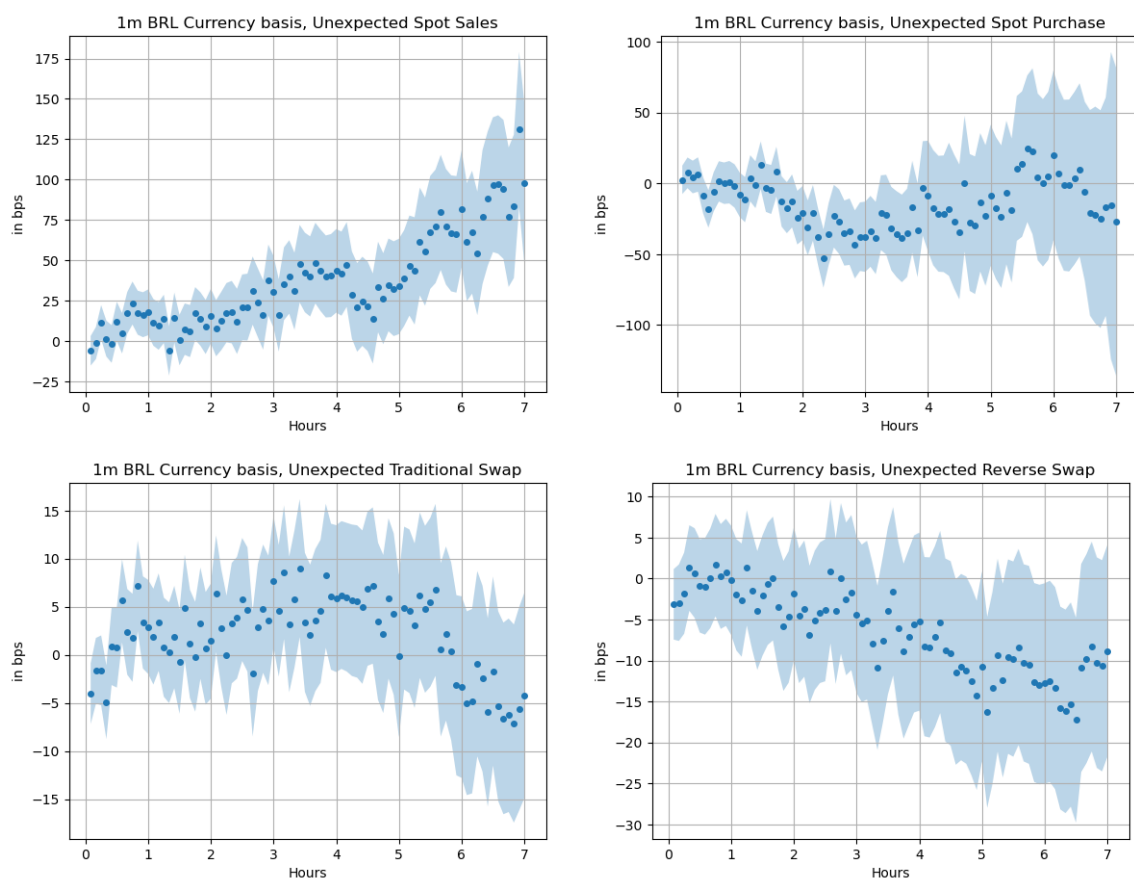


Figure 10: **Dynamic Response of 1m BRL/USD Currency Basis to BCB's Unexpected Interventions.** Spot sales(top left), spot purchase(top right), Traditional Swap(bottom left), and Reverse Swap(bottom Right)

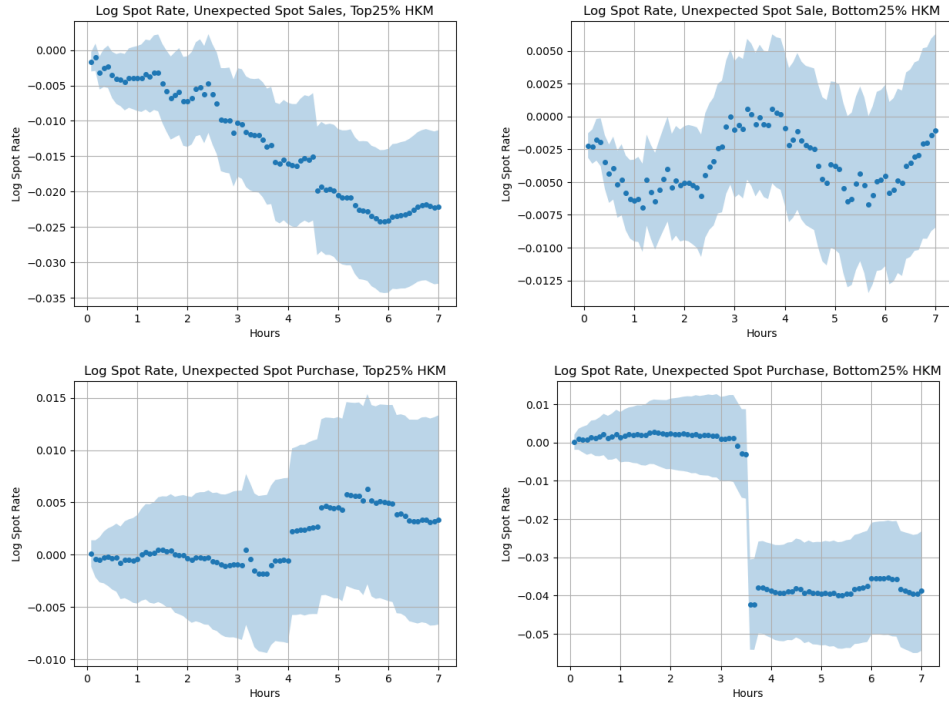


Figure 11: Heterogeneous Response of Log Spot Rate BCB's Spot interventions.

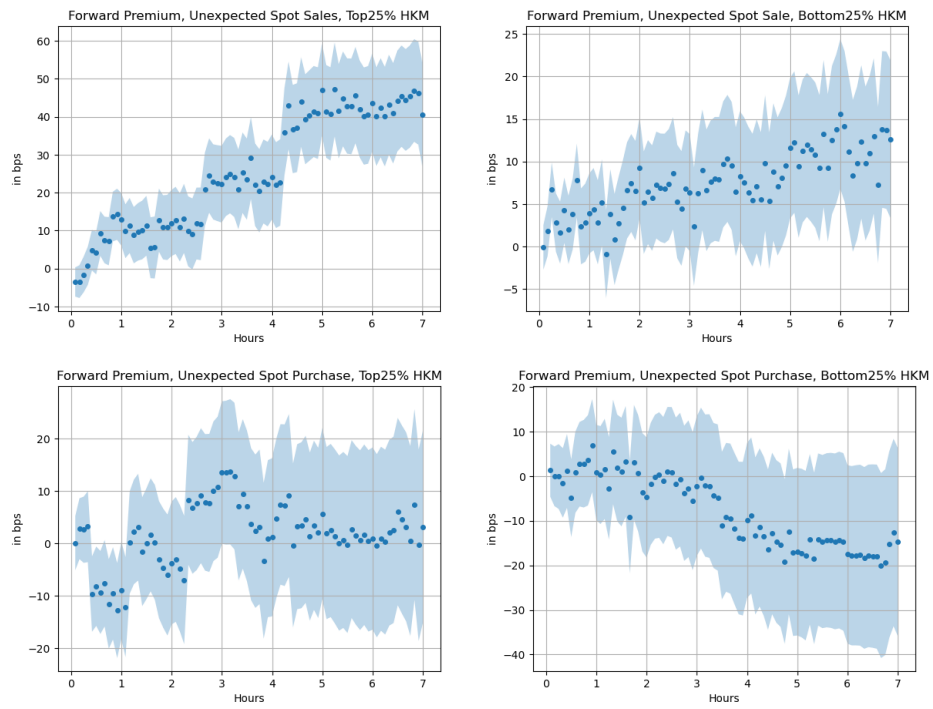


Figure 12: **Heterogeneous Response of 1 month Forward Premium to BCB's Spot interventions.**

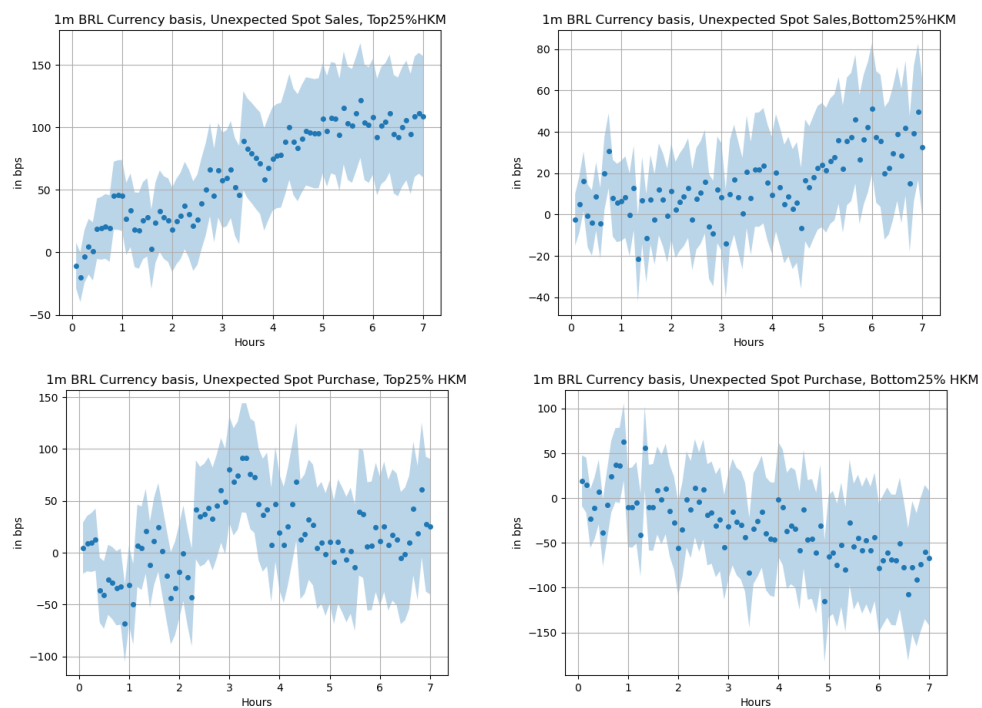


Figure 13: **Heterogeneous Response of 1 month Currency Bases to BCB's Spot interventions.**

Tables

	Spot Sale		Spot Purchase	
	Unexpected	Expected	Unexpected	Expected
Mean	0.17	0.48	0.19	NaN
S.D	0.22	0.39	0.24	NaN
Max	1.10	3.00	4.64	NaN
Count	385	87	1483	NaN

	Traditional Swap		Reverse Swap		Forward Purchase	
	Unexpected	Expected	Unexpected	Expected	Unexpected	Expected
Mean	0.43	0.25	0.35	0.20	0.39	0.16
S.D	0.41	0.24	0.45	0.28	1.05	0.17
Max	1.85	3.50	3.38	4.00	4.00	0.45
Count	345	5094	174	846	21	6

Table 1: **BCB's FX Intervention Summary Statistics.** This table shows mean, standard deviation, maximum, and the total number of counts for BCB's FX interventions. Sample period is from 1999-01-22 to 2023-04-27. Mean, S.D, and max are in billion US dollar.

Appendix

A Bid-Ask Spreads

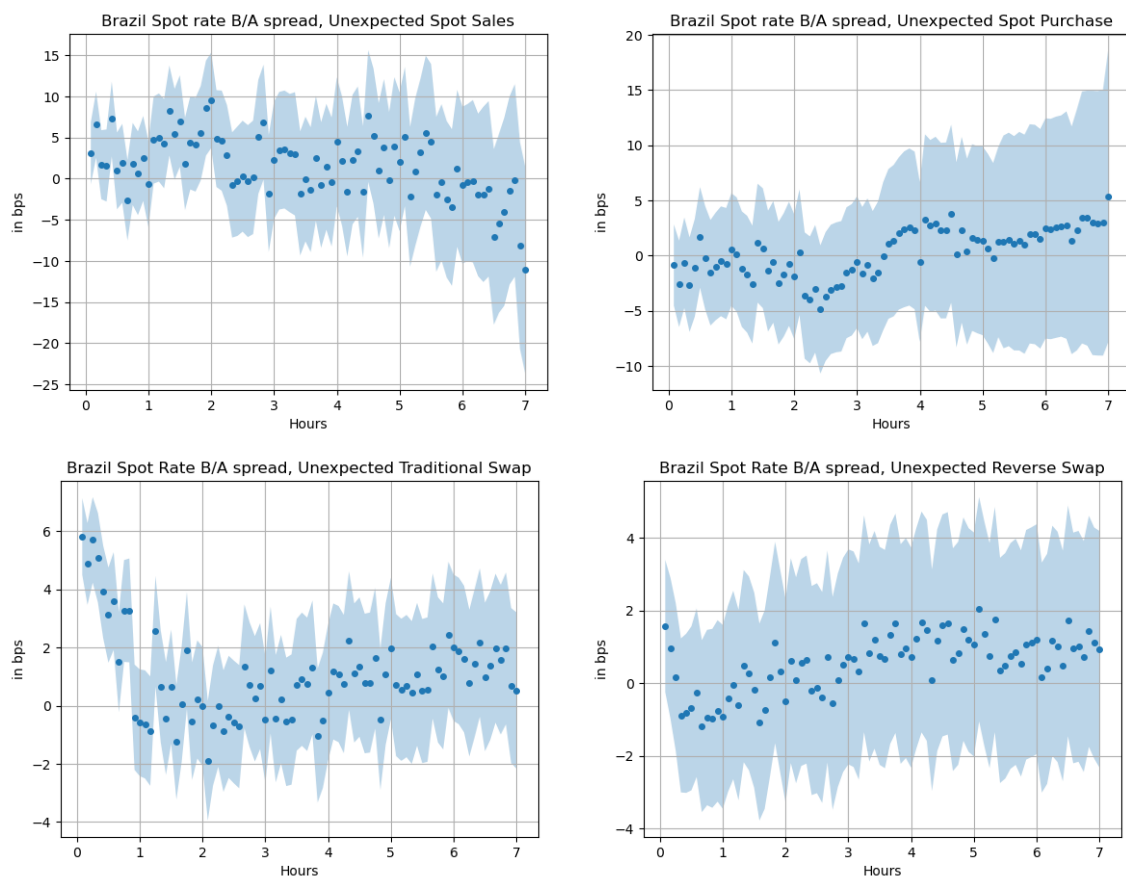


Figure A1: **Dynamic Response of Spot Rate Bid/Ask Spread to BCB's Unexpected Interventions.** Spot sales(top left), spot purchase(top right), traditional Swap(bottom left), and reverse Swap(bottom Right)