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Order Flow in the South: Anatomy of the Brazilian FX Market

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Abstract

This paper explores a unique dataset that contains 100% of the customer flows from domestic dealers in the Brazilian FX retail market. We present two sets of results. First, we find a strict link between currency flows from the FX market and the Balance of Payments. Second, we examine the long-run and short-run behaviors of each of the main players in the FX market. Our VECM estimates show that while the commercial customer flow is negatively related to exchange rate trend, the financial and the central bank intervention customer flows are positively related to exchange rate deviations from the long run trend. Our impulse response function also show that dealers charge a premium in order to provide unexpected overnight liquidity; that customers have "stabilizing" feedback trading; and that the central bank not only provides liquidity but also leans-against-the-wind when intervening.

Keywords: Microstructure, Emerging Economies, Exchange Rates, Dealers, Liquidity, Central Bank Intervention.

JEL Codes: F31, F41, G15.

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1 Introduction

The behavior of nominal exchange rates has been a major challenge to explain since Meese and Rogoff (1983) evidence that a naïve random walk would outperform a variety of models based on macroeconomic fundamentals in terms of out-of-sample forecast.¹ A new line of research, known as the microstructure approach to exchange rates, highlights the importance of the order flows from the FX market. Order flow can be defined as a measure of buying pressure, and the theoretical reason for its effect on the exchange rate dynamics is because it contains information that is unknown to market participants. The empirical evidence is unquestionable, both in-sample and out-of-sample. Using daily deutsche mark/dollar exchange rates and interdealer order flows covering approximately 54% of the market, Evans and Lyons (2002) estimate micro-based models and obtain an R^2 above 60 percent. They find that a US\$ 1 billion of net dollar purchases in the interdealer market increases the deutsche mark price of a dollar by 0.5%. But the most striking result is provided by Evans and Lyons (2005). They find that, over a 3 year forecasting sample, the micro-based model consistently out-performs both the random walk in terms of (true, ex-ante) out-of-sample prediction.

In this paper, we present a unique dataset that contains 100% of the customer flows from domestic dealers in the Brazilian FX retail market, one of the largest emerging economies. Our dataset identifies the type of customer that is trading with the domestic dealer: commercial customers (whose demand for foreign currency is generated by a trade in goods with non-residents), financial customers (whose demand for foreign currency is generated by a trade in assets with non-residents), or the central bank. The data is aggregated by each type of counterparty on a daily basis, spanning a total period of 4 years, from the 1st of July of 1999 until the 30th of June of 2003.

¹More recently, Cheung, Chinn and Pascual (2003) reinforced this result by testing a wider set of exchange rate models.

We explore this unique dataset in order to contribute to the microstructure approach to exchange rates in two ways. First, we find a strict link between currency flows in the FX market and the Balance of Payments. Second, we adopt a Hasbrouck (1991) style empirical analysis in order to identify the long-run and short-run behaviors of the Brazilian FX market participants. Our estimation strategy is to estimate first a vector error correction model (VECM) between the exchange rate, the cumulative financial flow, the cumulative commercial flow and the central bank intervention flow. The VECM results will help us examine not only the long-run equilibrium relationships among the endogenous variables but also how deviations from the long run equilibrium feedback into short run movements. Then, we develop an identification strategy that, using the VECM residuals, will allow us to properly estimate the reaction of each of the main players in the FX market to structural innovations.

Using this identification strategy, we capture the effect of unexpected customer order flows on the exchange rate, or equivalently, we estimate the premium dealers charge in order to provide unexpected overnight liquidity. Then we move to the customers and we identify the nature of their feedback trading. Although there is evidence that, for the major FX markets, the direction of the causality runs predominantly from the order flow to the exchange rate², this is not the case of the Brazilian FX market – and possibly of other emerging markets – where causality runs both ways, meaning that order flows are also induced by price changes. Moreover, this feedback effect could potentially go either way. On the one hand, Milton Friedman’s “stabilizing speculators” would decrease their demand for foreign currency if its price were going up. On the other hand, speculators that attempt to profit through the analysis of an asset’s momentum in a particular direction (trend traders) would increase their demand for foreign currency, trying to take advantage of the upward trend in its price,

²Killeen, Lyons and Moore (2005) find no evidence of Granger causality running from the exchange rate to the interdealer order flow in the french franc/deutsch mark market.

making it even more expensive, and therefore producing a positive feedback effect. Finally, we analyze the Central Bank interventions in the FX market by estimating its “reaction” function.

Our VECM estimates for the Brazilian FX market show us that while the commercial customer flow is negatively related to the exchange rate trend, the financial customer flow is positively related to exchange rate deviations from the long run trend. These results are in line with stylized facts documented by the FX microstructure literature for other major exchange rates. A good review of this discussion can be found in a recent survey by Osler (2008). What is interesting though, is that the adjustment coefficient of the central bank intervention flow is negative, revealing that when the Brazilian real moves away from its long run trend, central bank interventions try to bring it back to its equilibrium value. Another interesting result from our VECM is the statistical significance of the coefficient associated with the interest rate differential on the exchange rate equation: a 10% a.a. interest rate differential tends to appreciate the Brazilian real by approximately 40% a.a. This result is not surprising, since investors have been doing carry trades between the Brazilian real and other currencies during the sample period.

Then, by imposing identifying restrictions on the residuals of the VECM models, taking advantage of the information we have about the type of customer that is trading with the dealer, we estimate the short-run reactions of the FX market participants to structural innovations of the system’s variables. We find that dealers from the Brazilian FX market do charge a premium to provide unexpected overnight liquidity. More specifically, in order to meet a US\$ 10 million customer order flow, the dealers increase the FX price by approximately 0.03%. The magnitude of the effect of the customer flow on the real/dollar exchange rate is about 5 times the effect of the interdealer flow on the deutsche mark/dollar price estimated by Evans and Lyons (2002). Although both estimates are not perfectly comparable, since we use customer flow and Evans and Lyons use inter-dealer order flow, there are still

reasons to expect a larger effect in our dataset. First, the real/dollar market is a much smaller FX market than the dollar/deutsche mark market, both in terms of volume or liquidity, and it is natural for the price impact of a trade to be larger in the less liquid market, where it is harder to enter or exit a position. Second, the exchange rate in an emerging economy is much more volatile than in a developed economy, which means that it is a riskier asset, and therefore a larger price change is required for a risk averse agent to hold it. We also find that the feedback trading is “stabilizing”: a 1% depreciation rate of the domestic currency decreases the financial customer flow by US\$ 77.8 million and the commercial flow by US\$ 45.3 million. Furthermore, we find that the central bank tends to sell foreign currency to dealers when the exchange rate is depreciating (lean-against-the-wind) or when there is a positive excess demand for FX from financial customers (liquidity provision). The estimates tell us that a 1% increase in the price of foreign currency is associated with a US\$ 25.7 million sell from the central bank to dealers and that a US\$ 100 million financial customer flow is associated with a US\$ 22.6 million sell from the central bank to dealers, with both coefficients being significant at 1%. Finally, we cannot reject at the 10% significance level the null hypothesis that our identifying assumptions are valid.

There are a few papers that are closely related to this one. Payne (2003) and Berger et al (2005) also look at dealers and the impact of their orders on foreign exchanges. Fan and Lyons (2003) are the first to study the behavior of end-user customer flows in the FX market. Froot and Ramadorai (2005) explore the interactions between currency returns and institutional-investor currency flows, using a sample of 18 countries, of which the majority are emerging markets. Bjønnes, Rime and Solheim (2005), with a similar dataset that contains 90-95% of all transactions from the Swedish krona market, presents evidence that non-financial customers are the main liquidity providers in the overnight foreign exchange market. Beine et al (2002), Chari (2002), Dominguez (2002), and Pasquariello (2005) focus primary on the impact of central bank interventions. However, this paper differs significantly from all other

works since it takes into account the simultaneity in the determination of the exchange rate and the behavior of dealers, financial and commercial customers and the central bank.

The rest of this paper is organized as follows. Section 2 presents the dataset and some of its characteristics. Section 3 discusses the link between FX market flows and the Balance of Payments. Section 4 estimates the behavior of each of the main FX market participant. Section 5 concludes.

2 Dataset

2.1 Description

The dataset used in this paper contains 100% of the customer flows between domestic dealers from the Brazilian FX market and three types of counterparties: commercial customers (whose demand for FX is generated by a trade in goods with non-residents), financial customers (whose demand for FX is generated by a trade in assets with non-residents), and the central bank. The data is aggregated by each type of counterparty on a daily basis, spanning a total period of 4 years, from the 1st of July of 1999 until the 30th of June of 2003.

The dataset was obtained from the SISBACEN, an electronic system of collection, storage and exchange of information that connects the Brazilian central bank and all other agents operating in a Brazilian financial market, including the FX market. The central bank closely monitors all activities involving capital flows. For instance, it requires all dealers operating at the Brazilian FX market to input into the SISBACEN on daily basis information about the characteristics of each of their transactions in that market. These characteristics include the price, the volume, the type of counterparty – another dealer, the central bank or a customer – and, if the counterparty is a customer, the nature of the underlying economic transaction that generated the demand for exchanging foreign currency. The detailed information input

by the FX dealers into the SISBACEN is only observed by the central bank. At the end of the trading day, the official daily exchange rate is released by the Central Bank through SISBACEN a couple of hours after the market has closed. And after some considerable delay, some summary data aggregated in a lower time frequency is released to the dealers also through the SISBACEN.

The Brazilian FX market is a decentralized multiple dealer market. The trading between dealers and commercial and financial customers occurs in the retail FX market. This market is also called the “primary” market, since its net transactions affect the country’s aggregate inventory of foreign currency. Trading between dealers and the central bank does not affect the country’s inventory, since both are domestic agents, but it does affect the dealers’ market-wide FX inventory level. Interdealer trading does not affect the country nor the market-wide inventory.

When trading with customers, dealers do not behave as market makers, that is, they are not required to quote a firm bid and ask price at which they are ready to buy or sell FX at any time while the market is open. They may condition their quote on whether the customer wants to buy or sell and also on the size of the transaction. Customers, in order to trade FX with dealers, need to have proper justification – they have to show documentation with respect to the underlying economic transaction with a non-resident that is generating the need to exchange foreign currency. Dealers, as opposed to customers, have the right to hold FX positions and do not need justification, nor formal documentation, to trade foreign currency. Although there is no official location where dealers can meet other dealers, a limited number of brokers unofficially serve as small “exchanges”, providing more liquidity and efficiency to this decentralized market. Therefore, only a small fraction of the trading is direct.

Since the customers (and their underlying economic activities) are the agents who initiate the transaction with the dealers, we will sign each transaction from their point of view. This

means that if customer flow is positive, it represents pressure from customers to buy FX or, equivalently, pressure on dealers to sell FX. The same procedure will be taken with the transactions between dealers and the central bank. It is the central bank who initiates the transactions with dealers; therefore a positive intervention flow represents pressure from the central bank to buy FX from dealers or, equivalently, pressure from dealers to sell FX.

During our sample period, the Central Bank was quite active. The general guideline of the currency management regime was to “respond promptly to significant movements of the exchange rate” and to “counter disorderly market conditions.”³ Along those lines, there were two periods of very intense Central Bank sales of foreign currency. The first period was the second half of 2001, a time of very high volatility generated by the September 11th attack and the Argentinean crisis (which culminated with the end of the convertibility of the Argentinean peso on January of 2001) and the September 11 attack. The second was the pre-electoral period of 2002. On the other hand, there were two months of very large USD purchases (over US\$ 2 billion) when the Central Bank had to absorb excess foreign currency liquidity in the FX market: in August of 2000, when stocks of Petrobras (a Brazilian oil company) were issued at NYSE as ADR’s; and in November of 2000: when the Spanish bank Santander Central Hispano acquired the Brazilian state owned Banespa during a privatization auction.

We can use our dataset to estimate the relative size of the Brazilian FX customer market. According to the 2001 BIS Triennial Central Bank Survey, the daily average turnover on global FX spot market during the month of April was US\$ 387 billion. According to our data, the daily average customer order flow of the Brazilian FX market (not including the

³See IMF News Brief 99/3. On January 18, 1999, Finance Minister of Brazil, Mr. Pedro Malan, sent the IMF an statement which contained, among other things, the general guidelines of Central Bank interventions in the FX market:

“The Central Bank issued this morning a communiqué announcing that the exchange rate will now be determined by market forces. Monetary policy will aim at preserving low inflation achieved under the Real Plan and, in the short term, will respond promptly to significant movements of the exchange rate. Central bank interventions in the foreign exchange markets will be occasional, limited, and designed to counter disorderly market conditions.”

Brazilian interdealer FX market) for the same period was US\$ 1.07 billion, which implies that the average daily turnover of the Brazilian real in April 2001 was only 0.28% of the total global turnover.

The dataset also includes the foreign interest rate, the domestic interest rate, and a measure of the Brazilian country-risk premium, all three in first difference. The foreign interest rate is the daily annualized Fed Funds rate, the domestic interest rate is the daily annualized Selic rate, and the risk premium is measured as the spread of the C-Bond (the most liquid Brazilian Brady bond in the sample period) over the Treasury, measured in annualized rates, so a 1% risk premium is equivalent to a 100 basis-points spread of the yield of the C-bond in % a.a. over the yield of a Treasury bill with equivalent maturity, also in % a.a. Table 1 presents summary statistics. All FX flows are measured in US\$ billions.

2.2 Endogeneity and Overnight Liquidity

Figure 1 shows the relationship between the Brazilian exchange rate, defined as the domestic price for one US dollar, and the cumulative customer order flow in Brazil, where the cumulative customer order flow in a date t is defined as the sum of all customer flows between date 0 (July 1, 1999) and date t . Two features are noteworthy in this graph:

- a. First, we can see that the correlation between the cumulative customer flow and the exchange rate is negative (and significant at the 1% significance level).
- b. Second, market-wide customer flow each day does not net to zero, which means that dealers of the Brazilian FX market do not simply behave as intermediaries matching buyers and sellers during the day. If, for example, at the end of a given day there are more buyers than sellers, the dealers may supply the extra liquidity overnight.

The negative correlation between cumulative customer order flow and the exchange rate gives us a taste of the role played by endogeneity: on the one hand, demand pressures for

FX affect the exchange rate, on the other hand, exchange rate changes affect the price of foreign goods and assets and therefore affect the customer order flow. Therefore, the negative correlation found in our sample is more likely to be explained from the point of view of the agents who are demanding the FX liquidity: as the domestic currency slowly depreciates, customers' demand for foreign currency slowly decreases, as a result, for example, of smaller imports and higher exports. This is the opposite result compared to two Evans and Lyons (2002) and Fan and Lyons (2002).⁴ These studies find a positive correlation between order flows and the exchange rate and interpret it from the FX liquidity suppliers point of view: pressure to buy FX increases the price charged by dealers.

In order to get a more formal sense on the presence of endogeneity in our dataset, we run bivariate Granger causality tests between exchange rate movements and each type of order flow separately (commercial, financial and interventions). The test results tell us that we can reject the null hypothesis that exchange rate movements do not Granger cause the commercial nor the financial flows at the 1% significance level. Also, we can reject the null hypothesis that exchange rate movements do not Granger cause intervention flows at the 10% significance level (see table 2 for detailed results⁵). This result differs from Killeen, Lyons and Moore (2005), which find no evidence of Granger causality running from the french franc/deutsch mark exchange rate to the interdealer order flow of the same market.⁶

We have also noticed from figure 1 that customer flows from the retail market does not net to zero at the market-wide level at the daily frequency. This means that dealers are

⁴Evans and Lyons (2002) find a strong positive correlation at the daily frequency between the exchange rate and interdealer order flow for the deutsche mark/dollar and yen/dollar markets and Fan and Lyons (2003) find a positive correlation at the monthly frequency between the exchange rate and customer order flow for the euro/dollar and yen/dollar markets.

⁵Table 2 also suggests that Granger causality does not seem to run from some types of flows to the depreciation rate. This result should not be overstated. In our empirical section, we will present evidence of statistically significant contemporaneous causality, which is not capture by the Granger causality test.

⁶However, we must bear in mind that these results are only an indication of the presence of endogeneity since Granger causality measures precedence and informational content rather than contemporaneous reverse causality in the sense of "feedback trading".

providing liquidity overnight, by absorbing the change in the country’s FX inventory that is generated by the customers underlying economic transactions (in goods and assets) with non-residents. If dealers find it optimal to do so, then we should expect them to be making profits from these overnight liquidity provision. We calculate these “speculative” profits⁷ using the methodology described in Hau (2005), which allows us to estimate whether the price of FX in average goes up (profits) or down (losses) when dealers hold more FX than the usual.⁸ The result tells us that for each dollar that the dealers supplied overnight, they made a daily profit of 0.035%, or a 9.3% annualized profit rate.

3 FX Market Flows and the Balance of Payments

We mentioned that customers from the Brazilian FX market need to provide proper documentation with respect to the underlying economic transaction with a non-resident that is generating the need to buy or sell foreign currency. Since the Balance of Payments summarizes in a systematic way all economic transactions between residents and non-residents, we should be able to link our customer flow data with the Balance of Payments. This link, however, is not automatic. While the customer flow may differ from zero in any given period, the net balance of all entries in the Balance of Payments is always equal to zero due to the “double entry” system. Therefore, in order to find this link, we must identify the Balance of Payments entries that are associated with a change in the country’s FX inventory.

⁷These are not the only source of the dealers’ profits. One component of the dealers’ profits in the FX market comes from its role as an intermediation, by matching a buyer with a seller and profiting from the bid-ask spread. Another important source of profits comes from the dividends “paid” by the foreign currency (the interest rate differential). We are interested at the FX dealers “speculation” profits, that is, the profits that arise only from the change in the price of the asset he is trading.

⁸Let X_t be the daily cumulative customer flow. Now imagine that there is a representative dealer through the sample period, so that the daily market wide customer flow equals the change on its daily holdings of FX. Define $Q_t = -\sum_{t=1}^T X_t$ as his inventory of FX. Let $\bar{Q} = \frac{1}{T} \sum_{t=1}^T Q_t$ be the long run average inventory and $\tilde{Q}_t = Q_t - \bar{Q}$ be the daily deviation of the representative dealer from its long run average. Finally, let s_t be the exchange rate. The total profit of the representative dealer is given by $\Pi = \sum_{n=1}^T Q_t \Delta s_{t+1}$.

According to the fifth edition of the Balance of Payments Manual issued by the International Monetary Fund (BPM5), the change in cash balances held by FX dealers is registered in the “Financial Account” in the entry “Other Investments - Currency and Deposits”. This account registers the second entry of a transaction between non-dealer residents and non-residents that was paid with foreign currency that was bought or sold with dealers from the FX market. The first entry will depend on the nature of the transaction, whether it was in the goods market (e.g.: export, import . . .) or in the assets market (e.g.: direct investment, portfolio investment . . .). Still according to the BPM5, when the central bank purchases foreign currency from a dealer, there is a decrease in dealers’ cash holdings, and a corresponding increase in the central bank’s cash balances, that will be accounted in “Reserve Assets” . However, not all changes in “Reserve Assets” reflect a central bank’s intervention. If the central bank receives a loan of US\$ 10 billion from the International Monetary Fund, there will be an increase in reserve assets even though no intervention in the FX market occurred. This means that there will be no entry in “Other Investments - Currency and Deposits” associated with the increase in the “Reserve Assets”. The second entry of this operation in the Balance of Payments will be in “Other Investments - Loans - Monetary Authority”. Once we eliminate all entries associated with loans received by the central bank from its reserve assets account, we are left with the changes in its balances due to interventions.

Figure 2 compares the customer flow from the FX retail market with the measure of payment imbalances calculated using the Balance of Payments (the sum of the current account, the capital account and the financial account as long as we subtract from the financial account all the cash holdings of the dealers from the FX market and also the loans made by the central bank with international organizations). Figure 3 compares the central bank intervention flows from the FX market with its increase in reserve assets due to interventions in the FX market measured by the Balance of Payments. In both graphs, the data on FX market flows was aggregate into a monthly series in order to match the highest frequency

at which data on the Balance of Payments is available. Also, we show the 3 months moving average of each series so that we could facilitate the visual comparison (monthly behavior is too volatile). While these figures point out to a close relationship between our dataset and the Balance of Payments, formal tests cannot reject the equality between each FX market flow and its Balance of Payments equivalent (see appendix for details).

4 FX Market Players' Behavior

4.1 Estimation Strategy

Hasbrouck (1991) suggests to model trades and quote revisions from an econometric perspective as a system characterized by auto- and cross-correlations of a very general nature. Under his framework, the information impact of a trade is formally defined as the impact on prices resulting from the unexpected component of the trade. A vector autoregression (VAR) is the primary statistical technique employed to identify trade innovations. Our estimation strategy will follow a Hasbrouck-style analysis with one difference. We will identify the impact of unexpected FX liquidity provision on the exchange rate using a vector error correction model (VECM)⁹ instead of a VAR.

Let y_t be the vector of endogenous variables, including the (log of the) daily spot exchange rate s_t , the cumulative financial customer flow X_t^F , the cumulative commercial customer flow X_t^C , and the cumulative central bank intervention flow X_t^I :

$$y_t = \begin{bmatrix} s_t & X_t^F & X_t^C & X_t^I \end{bmatrix}' \quad (1)$$

Also, let the vector of pre-determined macroeconomic variables be Z_t , which includes the

⁹King et al (1991) introduced the idea of imposing restrictions to identify structural innovations on VECM.

interest rate differential $r_t - r_t^*$, and changes on the Brazilian risk premium Δrp_t .¹⁰

$$Z_t = \begin{bmatrix} r_t - r_t^* & \Delta rp_t \end{bmatrix}' \quad (2)$$

We will estimate the following model:

$$\Delta y_t = \alpha \beta' y_{t-1} + \sum_{p=1}^P A_p \Delta y_{t-p} + B_0 Z_t + \sum_{q=1}^Q B_q D_{q,t} + u_t \quad (3)$$

where α and β are both $4 \times r$ matrices each with rank $r < 4$, $D_{q,t}$ is a set of dummy variables that includes controls for each day of the week and each month of the year, and u_t is a normally distributed error vector with zero mean and nonsingular covariance matrix Σ_u . If we let e_t be the vector of structural innovations, with zero mean and diagonal covariance matrix Σ_e , then:

$$u_t = A_0^{-1} e_t \quad (4)$$

The advantage of a VECM over a VAR is to allow us to examine the long run equilibrium relationships separately from the short run dynamics. The columns of the $4 \times r$ matrix β , also

¹⁰The fact that we treat the domestic interest rate and the country risk premium as pre-determined variables means that we do not believe that daily fluctuations on exchange rates or in the customer flows cause any effect on any of these two variables in the same day. First, the short term interest rate did not react directly to the movements of the exchange rate or the customer flows because the monetary policy regime in Brazil during the whole sample period was (and still is) an Inflation Targeting regime. However, one could still argue that the short term interest rate reacts indirectly to the exchange rate because of the effects of the latter on the inflation rate through the price of the imported final and intermediary goods. Although this pressure may indeed exist at the quarterly or monthly frequency, it does not exist in the daily frequency. The reason is because the Brazilian Central Bank conducts its monetary policy in a very similar way to the Federal Reserve. It has a monetary policy committee that resembles the FOMC, which meets on average once every month, when they decide what should be the level of short term interest rate during the next 30 days. After that, they manage to keep short rates close to the targeted level by constantly adjusting the money supply. The dashed line in figure 4 confirms the very little daily variability in the behavior of the domestic interest rate. In the same figure, we also present the country risk premium (solid line), which indeed presents a lot of daily variability. However, this variable is perceived as a measure of the markets' assessment of the probability that a country might default on its debt obligations. Therefore, we follow Blanchard (2004) and Favero and Giavazzi (2004) who present theoretical and empirical arguments that the most important determinant of the country risk premium is the agents perception about the fiscal policy, which could be summarized by the debt over GDP ratio, or the primary surplus.

known as cointegrating vectors, describe linear combinations of the non-stationary series that are stationary. Hence, they are interpreted as the long-run equilibrium relationships among the endogenous variables. The elements of α , the adjustment coefficients of the VECM, describe how deviations from the long run equilibrium feedback into short run movements. Finally, with a proper identification of A_0 , the matrix of contemporaneous relations, impulse response functions can be constructed to trace the effect of a one-time unexpected shock to one of the innovations on current and future short run movements of the endogenous variables.

Of particular interest to us is the effect of unexpected shocks on dealers' overnight FX positions, Q_t , on the exchange rate dynamics. Since our data captures the whole market, the daily change on dealers' FX holdings is given by:

$$\Delta Q_t = -\Delta (X_t^F + X_t^C + X_t^I) \quad (5)$$

which suggests the following restriction on the A_0 matrix: $\alpha_{12}^0 = \alpha_{13}^0 = \alpha_{14}^0$. A second set of restrictions is derived from the idea that financial customer flow and the commercial customer flow do not affect each other contemporaneously, $\alpha_{23}^0 = \alpha_{32}^0 = 0$, nor are they affected by the central bank intervention flow, $\alpha_{24}^0 = \alpha_{34}^0 = 0$. This does not mean that the commercial customer flow and the financial customer flow are not correlated with each other nor with the central bank intervention flow at the daily frequency. Indeed, common sources of shocks may affect all three types of flows simultaneously, such as changes in the exchange rate, in the interest rate differential, in the country risk premium and also past shocks of the endogenous variables. However, once we control for these potential sources of common shocks, the amount of foreign currency demanded because of the trade in goods with non-residents should be related to the marginal utility of these goods, which is not a direct function of the amount of foreign currency demanded because of the trade in assets

with a non-resident or with the intervention flows.¹¹ A similar argument is applied for the amount of foreign currency demanded because of the trade in assets with non-residents: it should be a function of the present discounted value of the future dividends that these assets pay and some measure of risk aversion. These two sets of restrictions imply on the following format for the matrix of contemporaneous relations:

$$A_0 = \begin{bmatrix} 1 & \alpha_{12}^0 & \alpha_{12}^0 & \alpha_{12}^0 \\ \alpha_{21}^0 & 1 & 0 & 0 \\ \alpha_{31}^0 & 0 & 1 & 0 \\ \alpha_{41}^0 & \alpha_{42}^0 & \alpha_{43}^0 & 1 \end{bmatrix} \quad (6)$$

4.2 Estimation Output

Following the suggestions of the Johansen's cointegration test and the lag exclusion Wald test, we estimated a VECM with two lags of the vector of endogenous variables and one cointegrating equation. Table 3 reports the estimation details.

Equation (7) reproduces the coefficients of the cointegrating equation from table 3, with the symbol “***” denoting significance at the 1% level. We can notice that the only significant coefficient in the cointegrating vector is the one associated with the cumulative commercial customer flow: a 1% increase in the long run equilibrium of the exchange rate level permanently reduces the cumulative commercial customer flow by US\$ 0.93 billion:

$$\beta = \begin{bmatrix} 1 & -0.0056 & 0.0108*** & 0.0042 \end{bmatrix}' \quad (7)$$

¹¹A frequent example that is mentioned as a potential violation of this assumption is a situation in which a firm imports goods and pays for them by selling some of the foreign bonds from its portfolio. This example does not violate assumption (b). The reason is because the focus here is on the currency flows (FX market), and not in the flows of goods and assets (Balance of Payments): although in this example the trade in goods is associated with the trade in assets, it does not generate any currency flows in the FX market and therefore it has no effect on the exchange rate.

Does this imply that neither the cumulative financial order flow nor the cumulative Central Bank intervention flows are related to the exchange rate? Certainly not. Equation (8) presents the adjustment coefficients also reported on table 3, once again with the symbol “***” denoting significance at the 1% level. Now the picture is inverted: the two types of customer flows that were not affected by the exchange rate long run trend are both significantly related to exchange rate deviations from the trend. When the exchange rate is 1% above its long run trend, it generates a US\$ 55 million pressure to buy FX from financial customers and a US\$ 46 million pressure to sell from the Central Bank.

$$\alpha = \left[\begin{array}{cccc} 0.0024 & 0.1804^{***} & 0.0323 & -0.2185^{***} \end{array} \right]' \quad (8)$$

The above results are in line with stylized facts documented by the FX microstructure literature for other major exchange rates. A nice discussion can be found in a recent survey by Osler (2008). Commercial customer flows are motivated by the trade in goods between residents and non-residents. A permanent depreciation of the exchange rate, *ceteris paribus*, makes domestic goods cheaper for foreigners to purchase, thus stimulating net exports. As exporters exchange their foreign currency revenues for domestic currency, they generate a pressure to sell at the domestic FX market, explaining the negative long run relationship. Financial customers, on the other hand, are consumers of overnight liquidity. If the Brazilian real is depreciated above the equilibrium value implied by the long-run cointegrating relations, that is probably a reflection of political and/or economic uncertainties regarding the country’s future prospects. In such scenario, financial customers will increase their demand for foreign currency so they can purchase assets from safer economies. However, the most interesting thing to notice is that the central bank, as he observes this “fly to quality” movement, tries to provide the extra liquidity demanded by financial customers. The estimated adjustment coefficients suggest that for each extra USD demanded by financial customers

the central bank sells on average 83 cents on the FX market.

Another interesting feature of table 3 is the statistical significance of the coefficient associated with the interest rate differential on the exchange rate equation: if the annualized Brazilian Selic rate is 10% above the Fed Funds rate, the Brazilian real tends to appreciate by 0.1345% overnight, or 40.30% a.a. This result is not surprising, since investors have been doing carry trades between the Brazilian real and other currencies during the sample period.

Based on the residuals of the VECM(2) and on the identifying restrictions discussed in the previous subsection, we estimated the matrix of contemporaneous relations A_0 and noticed from the results that all coefficients were significant at the 1% significance level except for one: the central bank intervention flow is not affected by the behavior of the commercial customer flow. Therefore, we can naturally set an additional restriction, $a_{43}^0 = 0$, which turns the system into an over-identified one:

$$A_0 = \begin{bmatrix} 1 & \alpha_{12}^0 & \alpha_{12}^0 & \alpha_{12}^0 \\ \alpha_{21}^0 & 1 & 0 & 0 \\ \alpha_{31}^0 & 0 & 1 & 0 \\ \alpha_{41}^0 & \alpha_{42}^0 & 0 & 1 \end{bmatrix} \quad (9)$$

The following equations present the endogenous relationships implied by the estimated coefficients. All coefficients are significant at the 1% significance level (see standard errors in table 4):

$$\Delta s_t = 0.032 (\Delta X_t^F + \Delta X_t^C + \Delta X_t^I) + e_{1t} \quad (10)$$

$$\Delta X_t^F = -7.78 \Delta s_t + e_{2t} \quad (11)$$

$$\Delta X_t^C = -4.53 \Delta s_t + e_{3t} \quad (12)$$

$$\Delta X_t^I = -2.57 \Delta s_t - 0.23 X_t^F + e_{4t} \quad (13)$$

First, the estimated slope α_{12}^0 associated with the supply curve is 3.2%. This means that dealers from the Brazilian FX market do charge a premium to provide unexpected overnight liquidity. More specifically, in order to meet a US\$ 10 million customer order flow, the dealers increase the FX price by 0.03%. Second, the coefficient α_{21}^0 refers to the contemporaneous response of the financial customer flow to exchange rate movements: a 1% appreciation increases customers' demand for foreign exchange associated with the trade of assets by US\$ 77.8 million. Third, the coefficient α_{31}^0 refers to the response of the commercial customer flow to exchange rate movements: a 1% appreciation increases the customers' demand for foreign exchange associated with the trade of goods by US\$ 45.3 million. Interestingly, these two coefficients associated to the response of customer flow to price changes are negative, which means that the short run “feedback trading” in the Brazilian FX market is stabilizing. Finally, we can notice that the central bank tends to sell FX to dealers when the exchange rate is depreciating or when there is a positive excess demand for FX from financial customers. While the former indicates a “leaning-against-the-wind” type of reaction, the latter is evidence of the Central Bank’s “liquidity provisor” role in the FX market. The estimates tell us that a 1% depreciation is associated with a US\$ 25.7 million sell from the central bank to dealers and a US\$ 100 million financial customer flow is associated with a US\$ 23 million sell from the central bank to dealers, with both coefficients being significant at 1%.

Since the system is overidentified, we can test the null hypothesis that all restrictions imposed on the matrix of contemporaneous relations A_0 are valid. The p-value associated to this test is 0.188, which means that we cannot reject the null hypothesis. In other words, the data does not reject all restrictions imposed in order to identify the coefficients.

With the matrix A_0 estimated, we can look at the dynamic effects of the innovation shocks. Figure 5 shows two sets of three impulse response functions. The three graphs on the first (left) column are the responses of the depreciation rate to a one standard deviation shock on the financial customer flow, the commercial customer flow and the central bank

intervention flow. All three impulse responses present the same pattern. A positive shock of one standard deviation in any of the customer flows represents an increase in customers' demand for foreign currency. In response to the buying pressure the exchange rate depreciates immediately (the depreciation is statistically significant). In the following period, due to the dynamic pattern given by our identification of the VECM(2), the initial depreciation becomes a small appreciation. A few periods later, the effect on the depreciation rate disappears, but the effect on the level is permanent.

The set of graphs on the second (right) column of figure 5 shows the dynamic effects of a one standard deviation exchange rate depreciation shock on the financial customer flow, on the commercial customer flow and on the central bank intervention flow, also based on the same identification of the VECM(2). Once again, all impulse responses present similar patterns. A positive shock of one standard deviation means that the exchange rate is depreciating. The immediate effect is a decrease in all three types of customer flows. In the following period, the effect of the shock on both flows is already non-significant, and the impulse response converges to zero.

5 Conclusion

The objective of this paper is to contribute to the understanding of the FX retail market, its relationship with the Balance of Payments, the long-run and short-run behavior of its main participants (dealers, customers and the central bank) and how it impacts the exchange rate dynamics. We present a unique dataset that contains 100% of the customer flows between domestic dealers from the Brazilian FX retail market and three types of counterparties: commercial customers (whose demand for FX is generated by a trade in goods with non-residents), financial customers (whose demand for FX is generated by a trade in assets with non-residents), and the central bank. The data is aggregated by each type of counterparty

on a daily basis, spanning a total period of 4 years, from the 1st of July of 1999 until the 30th of June of 2003.

First, we find a strict link between currency flows in the FX market and the Balance of Payments. Second, we examine the long-run and short-run behaviors of each of the main players in the FX market. Our VECM estimates for the Brazilian FX market show us that while the commercial customer flow is negatively related to exchange rate trend, the financial customer flow is positively related to exchange rate deviations from the long run trend. These results are in line with stylized facts documented by the FX microstructure literature for other major exchange rates. What is interesting though, is that the central bank intervention flow is negatively related to exchange rate deviations from the trend, revealing that central bank interventions help bring the Brazilian real back to its long run equilibrium. Another interesting result from our VECM is the statistical significance of the coefficient associated with the interest rate differential on the exchange rate equation: a 10% a.a. interest rate differential tends to appreciate the Brazilian real by approximately 40% a.a. This result is not surprising, since investors have been doing carry trades between the Brazilian real and other currencies during the sample period.

Then, we find that in order to meet an unexpected US\$ 1 billion customer order flow, dealers increase the price of a US dollar by approximately 3.2%. The magnitude of the effect of customer flow on the real/dollar exchange rate is about 5 times the effect of interdealer flow on the deutsche mark/dollar price estimated by Evans and Lyons (2002). Although both estimates are not perfectly comparable, since we use customer flow and Evans and Lyons use inter-dealer order flow, there are still reasons to expect a larger effect in our dataset. First, the real/dollar market is a much smaller FX market than the dollar/deutsche mark, both in terms of volume or liquidity, and it is natural for the price impact of a trade to be larger in the less liquid market where it is harder to enter or exit a position. Second, the exchange rate in an emerging economy is much more volatile than in a developed economy,

which means that it is a riskier asset to hold, and therefore a larger price change is required for a risk averse agent to hold it.

We also find that an unexpected 1% depreciation of the domestic currency decreases the financial customer flow by US\$ 77.8 million and the commercial flow by US\$ 45.3 million, which means that the feedback effects are “stabilizing”. Finally, we estimate the central bank intervention function. We find that the central bank tends to sell FX to dealers when the exchange rate is depreciating (lean-against-the-wind) or when there is a positive excess demand for FX from financial customers (liquidity provision). The estimates tell us that a 1% depreciation is associated with a US\$ 25.7 million sell from the central bank to dealers, a US\$ 100 million financial customer flow is associated with a US\$ 22.6 million sell from the central bank to dealers, with both coefficients being significant at 1%. Given that the system is over-identified, we perform an overidentification test and we find that we cannot reject, at the 10% significance level, the null hypothesis that our identifying assumptions are valid.

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A Customer Flow and Balance of Payments Equivalent

There are different ways in which one can relate FX market flows with their Balance of Payments counterparties. The different possibilities are better illustrated if we reorganize the Balance of Payments, taking the BPM5 structure as a starting point. Let the “Current Account” and the “Capital Account” have the same definition as in the BPM5. Then, reorganize the “Financial Account” performing two changes. First, explicitly isolate the changes in cash balances held by dealers, originally in the “Financial Account – Other Investments – Currency and Deposits”, into a separate account called “Changes in balances held by dealers”. Second, the “Reserve Assets” account was combined with all other entries in the Balance of Payments associated with loans received by the central bank. This procedure isolates in one single account the change in the central bank’s inventories caused by interventions in the FX market. This new account is called “Changes in balances held by central bank due to interventions”.

After reorganizing the Balance of Payments, we can define three main variables. First, let X_t be the payments imbalance in a given month. This corresponds to the negative value of the summation of the “Current Account”, the “Capital Account” and the “Financial Account” subtracted from the “Changes in balances held by dealers” and from the “Changes in balances held by central bank due to interventions”. Second, let Y_t be the decrease in reserves held by the central bank due to interventions in a given month. Third, let Z_t represent a decrease in cash balances held by dealers in a given month. Although in theory $X_t + Y_t + Z_t$ should be equal to zero, in practice it is not: the residual is equal to the “Errors and Omissions” account.

We can also define the three variables associated to the FX market flow. Let x_t be the customer flow and y_t be the central bank interventions flow. From now on, we will refer to the economy’s total FX excess demand, the sum of customers and the central bank excess

demands for foreign currency, as the total customer flow, $z_t = x_t + y_t$. We will verify that:

- Relation 1: the payments imbalance in a given month, X_t , should be equal to the customer flow of the same month, x_t (figure 2).

- Relation 2: the decrease in reserves held by the central bank due to interventions in a given month, Y_t , should be related to the negative of the interventions flows of the same month, $-y_t$ (figure 3).

- Relation 3: the decrease in cash balances held by dealers in a given month, Z_t , should be related to the total customer flow of the same month z_t (figure 6).

These three relationships will be tested by regressing each of the Balance of Payments measures on its FX market flow equivalent. However, some adjustments have to be made since the time of recording of the Balance of Payments transactions and the time of recording of the FX market transactions are based on two different systems. Like any other financial market, the FX market flows are recorded on the same day that they were traded. On the other hand, Balance of Payments transactions are recorded based on the principle of accrual accounting . Roughly speaking, a transaction between a resident and a non-resident is accounted for in the Balance of Payments when both parties record it in their books or accounts, and it is accounted for in the FX market flow when an FX contract is signed between the non-dealer resident and the dealer, either because he bought foreign currency to make a payment, or because he sold foreign currency to receive a payment, or, if no cash flow was generated, because he needed to sign a symbolic contract.

In practice, these timing issues are more important for the trade in goods rather than the trade in assets. In order to accommodate these timing issues, instead of regressing each of the Balance of Payments measure using the contemporaneous FX market flow equivalent, we will also include one lag and one forward as regressors. The estimation output for all three possible relations is shown in table 6. First, we cannot reject at the 5% significance level the null hypothesis that the constants are equal to zero. Second, the estimated value for the

sum of the coefficients associated with the FX market flows are not only close to one (0.88, 1.13 and 0.99) but they are also statistically different from zero at the 1% significance level. Finally, we are unable to reject at the 10% significance level the joint hypothesis that the constant is equal to zero and the sum of the coefficients are different from one. This empirical evidence suggests that, except for timing issues, the relationship between FX market flows and the Balance of Payments flows holds for the Brazilian economy.

Table 1: Summary statistics

Variables	Mean	Mean(Absolute)	Minimum	Maximum	Std. Dev.
Depreciation rate	0.0005	0.0075	-0.0893	0.0487	0.0108
Financial flow	0.0404	0.1325	-2.6260	1.1379	0.2064
Commercial flow	-0.0577	0.0829	-0.5848	0.2984	0.0955
Intervention flow					
All data (1003 obs.)	-0.0126	0.0218	-0.6646	2.0401	-0.1053
Non-zero (236 obs.)	-0.0537	0.4673	-0.6646	2.0401	-0.2122
Δ (Selic interest rate)	0.0000	0.0004	-0.0141	0.0300	0.0018
Δ (Fed funds interest rate)	0.0000	0.0008	-0.0112	0.0144	0.0014
Δ (Risk premium)	0.0000	0.0022	-0.0220	0.0234	0.0037

Summary statistics of daily data from July 1, 1999 until June 30, 2003. Financial and commercial customer flows and intervention flows are measured in US\$ billions. Other variables measured in rates. A positive financial or commercial customer flow indicates that the customer purchased US dollars from dealers in the Brazilian FX market. A positive intervention flow indicates that the central bank purchased US dollars from dealers in the Brazilian FX market. Exchange rate is defined as the domestic price for one US dollar. The foreign interest rate is the daily annualized rate of the Fed Funds rate. The domestic interest rate is the daily annualized rate of the Brazilian Selic rate. The risk premium is the spread of the C-Bond (the most liquid Brazilian Brady bond in the sample period) over the Treasury, measured in annualized rates, so a 1% risk premium is equivalent to a 100 basis-points spread of the yield of the C-bond in % a.a. over the yield of a Treasury bill with the same maturity, also in % a.a.

Table 2: Bivariate Granger causality tests

Variable 1	Variable 2	p-value
Depreciation rate	Commercial customer flow	0.8%
Commercial customer flow	Depreciation rate	1.0%
Depreciation rate	Financial customer flow	0.5%
Financial customer flow	Depreciation rate	94.9%
Depreciation rate	Central bank intervention flow	6.3%
Central bank intervention flow	Depreciation rate	80.0%

Granger causality tests based on bivariate regressions using daily data from July 1, 1999 until June 30, 2003. The lag length of each bivariate VAR is based on the Schwarz information criterion. Null hypothesis is variable 1 does not Granger cause variable 2. Probability of rejection is reported under p-value.

Table 3: VECM(2) estimation output

Cointegrating Equation		Equation 1			
Exchange rate _{t-1}		1			
		-			
Cumulative Financial Flow _{t-1}		-0.0056			
		(0.0045)			
Cumulative Commercial Flow _{t-1}		0.0108			
		(0.0022)			
Cumulative Intervention Flow _{t-1}		0.0042			
		(0.0110)			
Error Correction		Depreciation rate_t	Financial flow_t	Commercial flow_t	Intervention flow_t
Error correction term _{t-1}		0.0024	0.1804	0.0323	-0.2185
		(0.0034)	(0.0722)	(0.0313)	(0.0378)
Depreciation rate _{t-1}		0.1419	0.9933	0.1821	-0.3589
		(0.0307)	(0.6435)	(0.2786)	(0.3374)
Depreciation rate _{t-2}		-0.1557	0.8928	0.2611	0.0242
		(0.0306)	(0.6432)	(0.2785)	(0.3373)
Financial flow _{t-1}		0.0004	0.0733	-0.0179	0.0086
		(0.0018)	(0.0375)	(0.0162)	(0.0197)
Financial flow _{t-2}		-0.0004	0.0440	-0.0231	-0.0163
		(0.0018)	(0.0372)	(0.0161)	(0.0195)
Commercial flow _{t-1}		-0.0137	-0.1948	0.2332	0.0412
		(0.0037)	(0.0773)	(0.0335)	(0.0405)
Commercial flow _{t-2}		-0.0009	0.0129	0.0924	-0.0020
		(0.0037)	(0.0783)	(0.0339)	(0.0411)
Intervention flow _{t-1}		0.0020	-0.0735	0.0249	0.0203
		(0.0034)	(0.0713)	(0.0309)	(0.0374)
Intervention flow _{t-2}		0.0011	0.0958	0.0189	-0.0057
		(0.0034)	(0.0711)	(0.0308)	(0.0373)
Interest rate differential _t		-0.0134	0.8663	-0.2373	-0.3350
		(0.0075)	(0.1578)	(0.0683)	(0.0828)
$\Delta(\text{Risk premium})_t$		1.2841	1.6863	-6.4723	-1.3160
		(0.0814)	(1.7090)	(0.7400)	(0.8962)
R-squared		28.2%	13.0%	23.8%	8.1%

Estimation output of the VECM specified by equation (3) with 2 lags. Coefficients estimated by OLS using daily data from July 1, 1999 until June 30, 2003. Coefficients associated with constant and dummy variables omitted from the table. Standard errors in parenthesis.

Table 4: Estimate of the matrix of contemporaneous relations

VECM(2)	Depreciation rate _t	Financial flow _t	Commercial flow _t	Intervention flow _t
Depreciation rate _t	1 -	-0.0319 (0.0069)	-0.0319 (0.0069)	-0.0319 (0.0069)
Financial flow _t	7.7822 (1.8750)	1 -	0 -	0 -
Commercial flow _t	4.5302 (0.3542)	0 -	1 -	0 -
Intervention flow _t	2.5710 (0.4271)	0.2256 (0.0204)	0 -	1 -

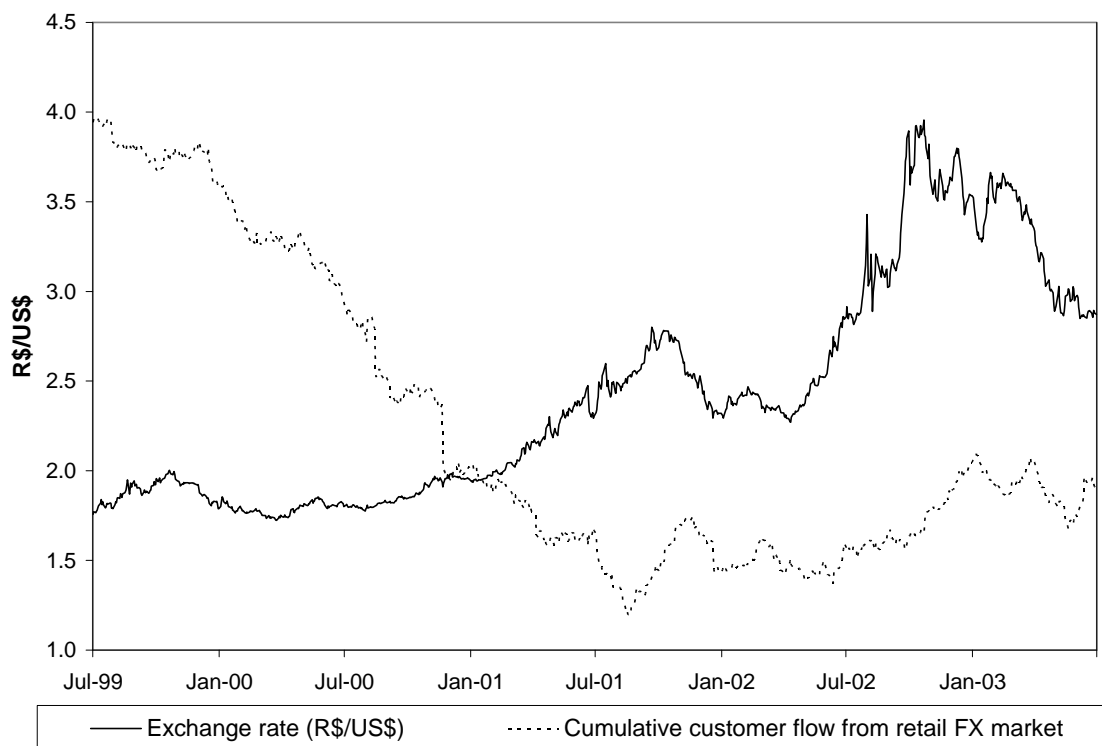
Estimated coefficients of the matrix of contemporaneous relations (standard errors in parenthesis) based on structural factorization of VECM(2) estimates presented in table 3. Entries on the table without standard errors are identifying restrictions imposed.

Table 5: Estimates of the relation between customer flow and balance of payments

Relation 1: $X_t = \beta_0 + \beta_1 x_t + \beta_2 x_{t-1} + \beta_3 x_{t+1} + \varepsilon_t$		
$\hat{\beta}_0$	$\hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_3$	$H_0: \beta_0 = 0 \text{ and } \beta_1 + \beta_2 + \beta_3 = 1$
0.15 (0.369)	0.88 (0.004)	2.29 (0.113)
Relation 2: $Y_t = \beta_0 - \beta_1 y_t + \varepsilon_t$		
$\hat{\beta}_0$	$\hat{\beta}_1$	$H_0: \beta_0 = 0 \text{ and } \beta_1 = 1$
-0.20 (0.077)	1.13 (<0.000)	2.28 (0.114)
Relation 3: $Z_t = \beta_0 + \beta_1 z_t + \beta_2 z_{t-1} + \beta_3 z_{t+1} + \varepsilon_t$		
$\hat{\beta}_0$	$\hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_3$	$H_0: \beta_0 = 0 \text{ and } \beta_1 + \beta_2 + \beta_3 = 1$
0.11 (0.613)	0.99 (<0.000)	0.26 (0.771)

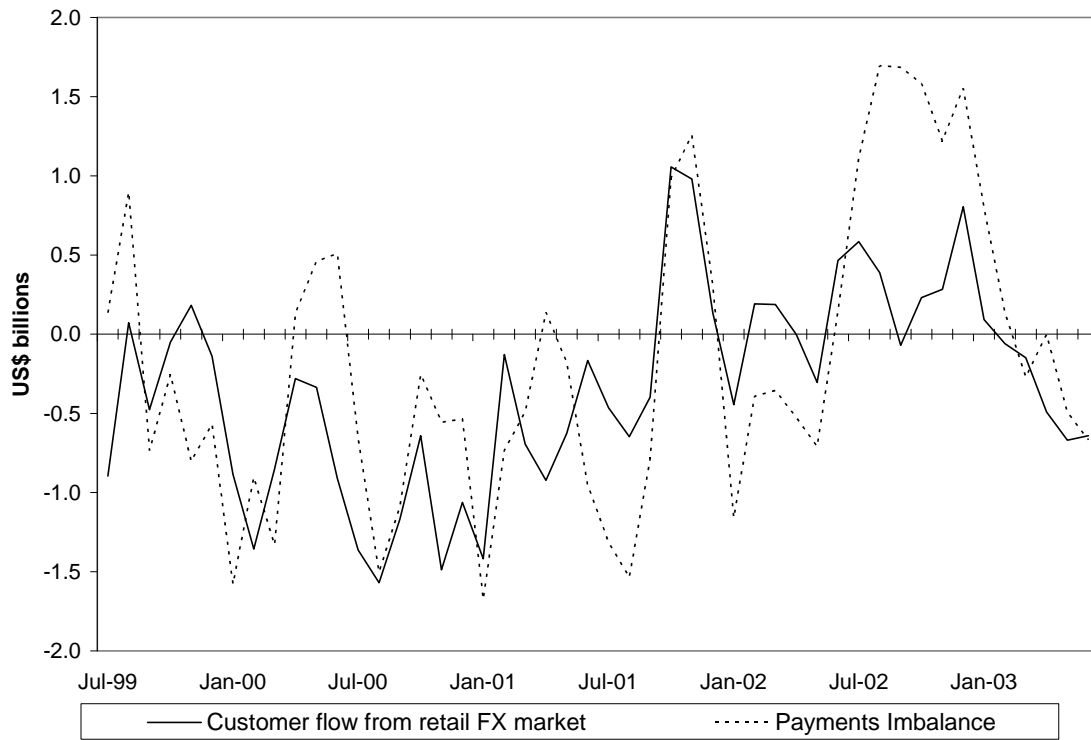
Monthly data from July 1999 until June 2003. FX market flows and balance of payments flows are in US\$ billion. Coefficient estimates in first two columns and F-static under null hypothesis in third column. P-values in parenthesis, based on Newey-West HAC standard errors.

Figure 1: Cumulative customer flow from retail FX market and exchange rate



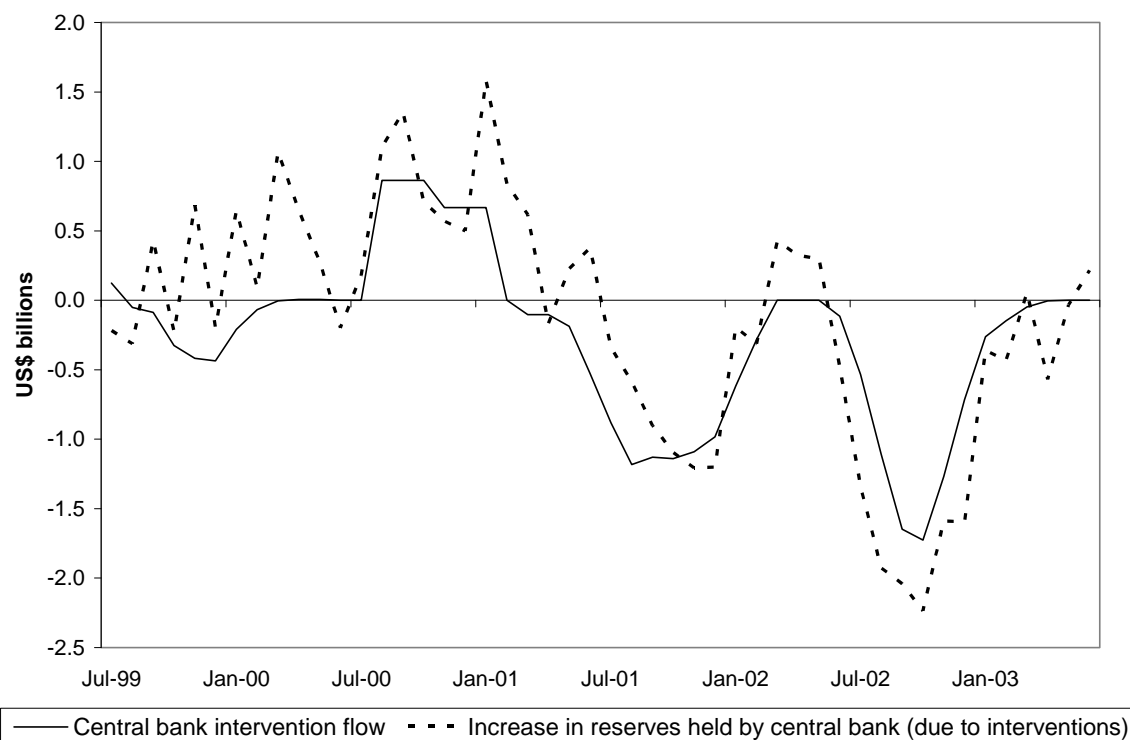
Daily data from July 1, 1999 until June 30, 2003. Cumulative customer flow from the retail market includes commercial and financial flows. Cumulative customer order flow in a date t is the sum of all customer flows between date 0 (July 1, 1999) and date t . Positive (negative) customer flow indicates that customers purchased (sold) US dollars from (to) dealers in the Brazilian FX market. Exchange rate is defined as the domestic price for one US dollar.

Figure 2: Customer flow from retail FX market and balance of payments imbalance



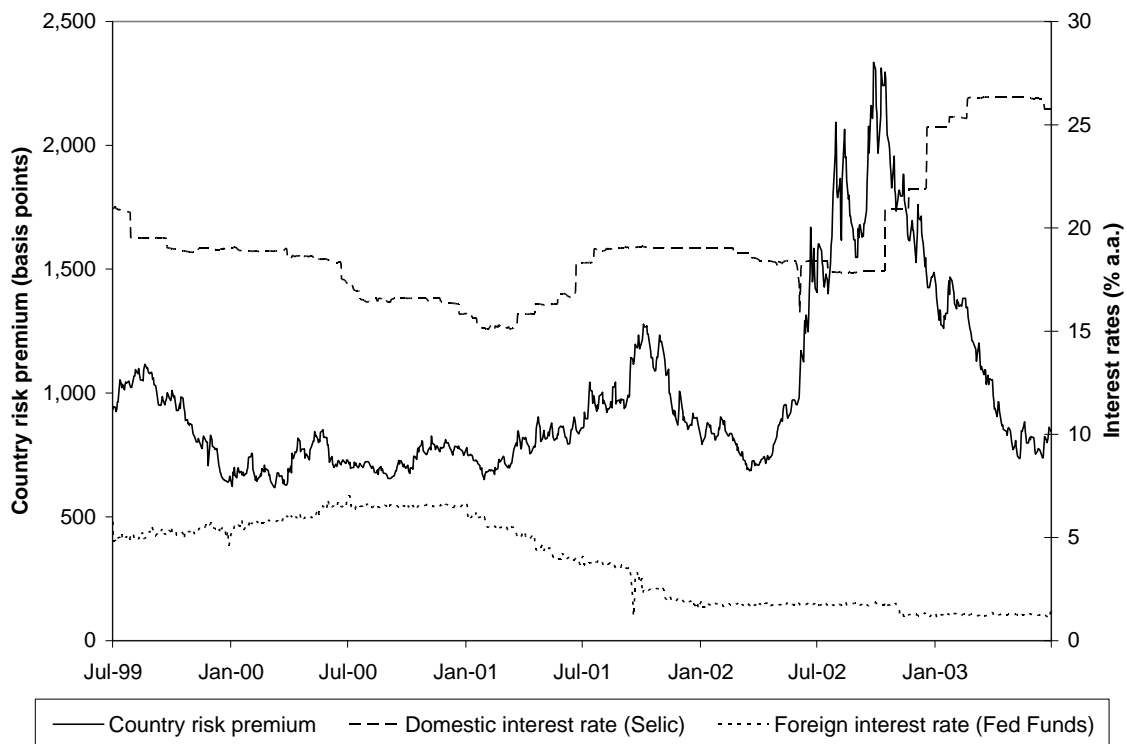
3 months moving average of monthly data from July 1999 until June 2003. Customer flow from the retail market includes commercial and financial flows. Balance of payments imbalance includes the current account, the capital account and the financial account subtracted from the change in FX cash balances held by dealers and central bank loans.

Figure 3: Central bank intervention flow and decrease in reserves held by central bank due to interventions



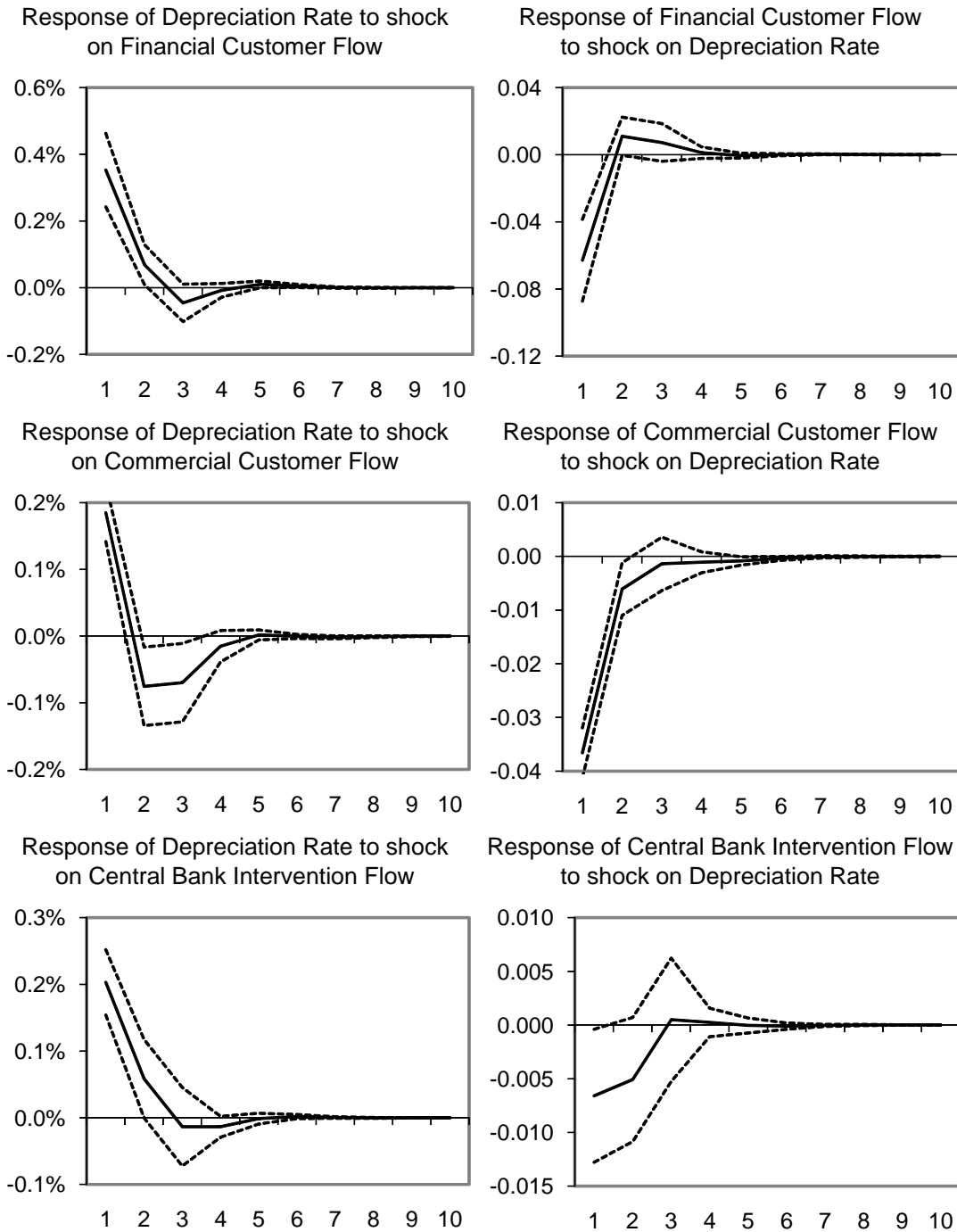
3 months moving average of monthly data from July 1999 until June 2003. Central bank intervention flows are central bank's net purchases of FX from dealers. Increase in reserves held by central bank due to interventions is obtained by subtracting through the balance of payments by subtracting from the reserve assets all loans made by the central bank with international organizations.

Figure 4: Country risk premium and domestic and foreign interest rates



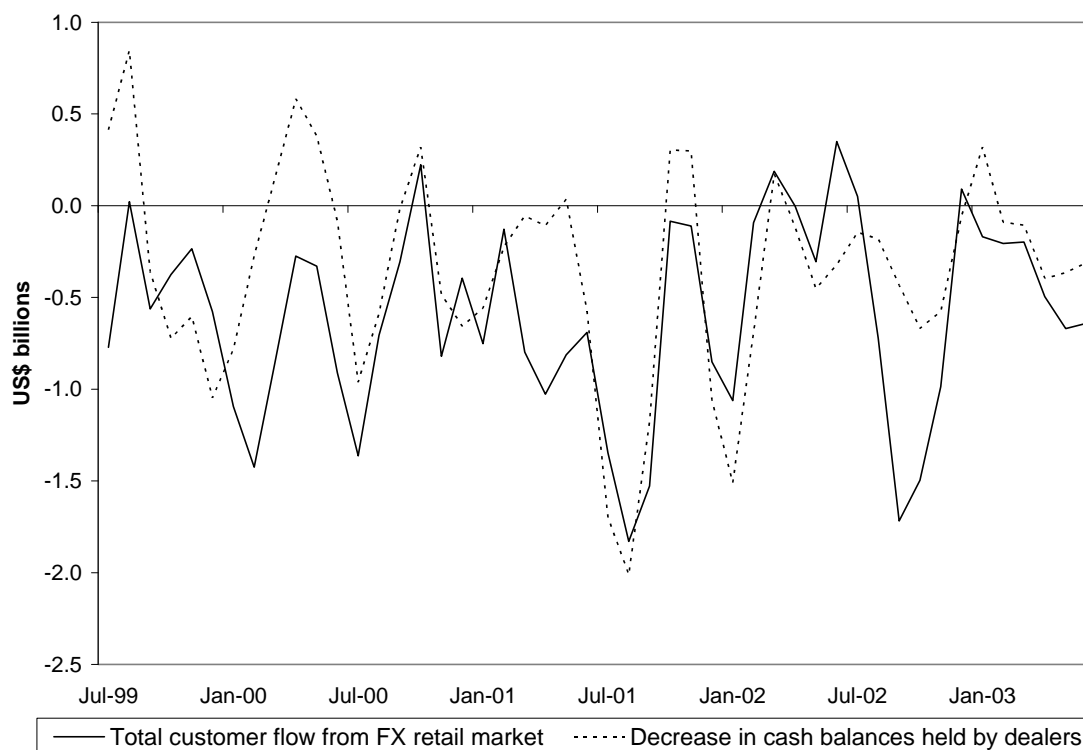
Daily data from July 1, 1999 until June 30, 2003. Country risk premium is the spread of the C-Bond (the most liquid Brazilian Brady bond in the sample period) over the Treasury, measured in annualized basis points. The domestic interest rate is the Brazilian Selic rate in % a.a. The foreign interest rate is the Fed Funds rate in % a.a.

Figure 5: Impulse Response Functions



Impulse response functions based on VECM(2) estimates presented on Table 4 and structural factorization described on Table 5.

Figure 6: Total customer flow from retail FX market and decrease in cash balances held by dealers



3 months moving average of monthly data from July 1999 until June 2003. Total customer flow from FX retail market is the sum of the commercial customer flow, the financial customer flow and the central bank intervention flows. Decrease in cash balances held by dealers is recorded in the “Financial Account – Other Investments – Currency and Deposits” according to the BPM5.