Order flow in the south: Anatomy of the Brazilian FX market*

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Abstract

This paper studies the interaction between exchange rate dynamics, end-user order flows, and the balance of payments in Brazil, an emerging economy that has been subjected to many foreign exchange liquidity shocks, including sudden stops in capital flows. Analysis of a unique data set containing complete records of daily transactions between domestic dealers, customers, and the central bank from July 1999 to June 2003 reveals that the Central Bank of Brazil is the ultimate liquidity provider to financial customers, whose liquidity needs are correlated to short-run deviations of the Brazilian *real* (BRL) from its fundamental value. Although non-financial customers are also liquidity providers, their net positions are correlated to the fundamental value of the BRL itself, but not to deviations from it. This paper also contributes to the exchange rate determination puzzle by successfully linking end-user order flows into publicly available balance of payments data.

Keywords: Exchange rates, Microstructure, End-user order flow, Liquidity provision, 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) showed that a naïve random walk outperforms out-of-sample forecasts from a variety of macroeconomic models.[1] In a seminal paper, Evans and Lyons (2002) move away from models that rely solely on macroeconomic fundamentals and introduce order flow as a key determinant of exchange rate dynamics. They present an innovative model which distinguishes between three main types of FX market order flows: (i) the first type of customer-dealer order flow is motivated by end-user customers' liquidity needs; (ii) interdealer order flow is motivated by dealers' attempt to share their individual inventory risk (resulting from the first type of customer-dealer order flow) with other dealers; and (iii) the second type of customer-dealer order flow is motivated by dealers' attempt to share remaining aggregate inventory risk (that could not be shared with other dealers) with customers. In order to induce customers to share aggregate inventory risk, dealers have to offer customers an exchange rate adjustment. Since interdealer order flow helps each individual dealer to estimate the aggregate inventory imbalance that needs to be shared with customers, it is logical to expect it to also convey information about exchange rate dynamics. Using deutsche mark-dollar daily data, the authors provide evidence on the strong contemporaneous association between exchange rate returns and interdealer order flow, thus supporting their rationale.

Many subsequent works reinforce the importance of order flows for exchange rate dynamics. Killeen et al. (2006) and Breedon and Vitale (2010) are examples that highlight the substantial in-sample explanatory power of interdealer order flows on exchange rate movements for a variety of currency pairs. Bjønnes et al. (2005) and Marsh and O'Rourke (2005) focus on the relationship between different end-user customers, dealers, and exchange rate movements. Their findings suggest that the typical aggressive end-user customers who need liquidity are financial, while the typical passive end-user customers who are induced to provide liquidity are non-financial. Froot and Ramadorai (2005) and Fan and Lyons (2003) find similar results regarding the behavior of financial customers. Finally, Evans and Lyons (2005a) and Rime et

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

al. (2010) show that customer-dealer and interdealer order flows, respectively, are also powerful out-of-sample predictors of daily movements in exchange rates.

Despite the unquestionable empirical and theoretical contributions of the microstructure approach to exchange rates literature (see Osler (2008) and Sager and Taylor (2008) for surveys), half of the exchange rate determination puzzle still remains: how do order flows relate to developments in the macroeconomy? Recent research explores the potential links between order flows and publicly available macroeconomic variables. Evans and Lyons (2005b, 2008), Dominguez and Panthaki (2006) and Love and Payne (2008) show how macoeconomic news announcements are correlated to order flows. Froot and Ramadorai (2005) use order flows to forecast excess returns and Evans (2010) shows that order flows convey information not only about excess returns, but also about real-time estimates of GDP, CPI and M1.

This paper analyzes a unique data set from the Brazilian FX market containing complete records of daily transactions between domestic dealers, customers, and the central bank from July 1999 to June 2003. The combination of an inflation targeting regime with a high degree of capital mobility leaves Brazil with no alternative but to let market forces determine exchange rates. However, the many foreign exchange liquidity shocks that Brazil has been subjected to, including sudden stops in capital flows, have forced the Central Bank of Brazil (BCB) to intervene in the spot FX market, sometimes quite sizeably, during times of financial distress. Therefore, the study of the interaction between exchange rate dynamics and end-user order flows from the Brazilian FX market provides invaluable insights to our understanding of foreign exchange liquidity provision and central bank intervention.

Three main contributions arise from the results of this paper. First, evidence from the Brazilian FX market suggests that financial customers are typically net demanders of foreign exchange liquidity while non-financial customers are typically net providers, therefore confirming stylized facts already documented for other major currency pairs. Using terminology from Sager and Taylor (2006), financial agents are the "push" customers and non-financial agents are the "pull" customers. Vector error correction model (VECM) estimates show that net positions of non-financial customers cointegrate negatively with the long-run Brazilian

real (BRL) price of the US dollar (USD). However, contrary to the findings of Bjønnes et al. (2005), financial order flow is positively correlated to short-run deviations of the BRL from its fundamental value and not to the fundamental value itself. Hence, financial order flow is a "weak flow" under the definitions of Froot and Ramadorai (2005). Given the many external shocks that the Brazilian economy has endured during the sample period, the finding that financial order flow is mainly driven by liquidity changes ("weak flow-centric" view) rather than by private information ("strong flow-centric" view) is not surprising.

Second, VECM estimates also reveal that the BCB is the ultimate liquidity provider to financial customers. Similar to financial order flows, central bank flows are also correlated to short-run deviations of the exchange rate relative to its long-run trend. However, the correlation is negative, thereby implying that the BCB tends to sell USD when the BRL is undervalued relative to its fundamental price. Moreover, a formal test shows that the short-run liquidity provided by the central bank exactly matches financial customers needs. The absence of a long-run relationship between cumulative central bank flows and the exchange rate in the data confirms that the BCB interventions in the spot FX market were succesful in providing liquidity without influencing the long-run value of the exchange rate during the sample period.

Third, this paper also contributes to the exchange rate determination puzzle by succesfully linking end-user order flows with publicly available macroeconomic variables. Brazilian regulation mandates all foreign exchange transactions arising from cross-border economic activities to be performed only through authorized dealers and obligates dealers to provide detailed information regarding each foreign exchange transaction to the BCB. These two peculiar characteristics of the Brazilian FX market regulatory framework (which will be described in more details below) makes it possible to map Brazilian FX market flows into the country's balance of payments accounts.

The rest of the paper is organized as follows. Section 2 describes the main players and the regulatory framework of the Brazilian FX market. Section 3 presents the data set. Section 4 shows results of cointegration analysis between exchange rate and order flows. Section

5 provides empirical evidence on the mapping between FX market flows and the Brazilian balance of payments accounts. Section 6 concludes.

2 The Brazilian FX Market

2.1 Main Players

There are three main players in the Brazilian FX market: dealers, customers, and the BCB. Dealers are financial institutions authorized to act as intermediaries in the FX market. They have the right to hold overnight foreign exchange positions, if they wish to do so. Customers are the end-users in the foreign exchange transaction. They can be divided into two groups according to the nature of the economic activity underlying the foreign exchange transaction: financial customers are investors who are allocating their wealth between domestic and foreign bonds and non-financial customers are agents engaged in international trade in goods and services. Finally, the BCB's participation in the Brazilian FX market is not limitted to its roles of supervisor and regulator.[2] The BCB also has the ability to buy or sell foreign exchange from dealers under the general guideline that such interventions be *"occasional, limited, and designed to counter disorderly market conditions."*[3] Although no official definition is provided, one largerly accepted interpretation of *"disorderly market conditions"* is that BCB interventions aim at dampening excessive volatility, preventing overshooting, slowing the rate of change in the exchange rate, or serving as liquidity provider of last resort, but without affecting the exchange rate long-run trend.

The Brazilian FX market is organized as a decentralized multiple dealer market. Dealers trade with customers in the retail (also known as primary) FX market, and trade with other dealers in the wholesale (secondary, interdealer) FX market. Although there is no official

[2] The BCB shares the roles of supervisor and regulator with the National Monetary Council (CMN).

[3] On January 18, 1999, Former Finance Minister of Brazil, Mr. Pedro Malan, sent the IMF a 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."

location where dealers can meet other dealers, a limited number of brokers unofficially serve as small "exchanges" to provide more liquidity and efficiency to this decentralized market. Therefore, only a small fraction of interdealer trading is direct. Dealers only behave as market makers–standing ready to quote bid and ask prices at which they are firmly willing to buy and sell foreign currency–when trading with other dealers. In the retail market, dealers may condition their quotes on whether the customer wants to buy or sell foreign currency and also on the transaction volume. Trades between dealers and the BCB resemble interdealer transactions when interventions are secret. In the case of publicly pre-announced interventions, they are generally conducted as regular auctions.

2.2 Regulatory Framework

Since Brazil first received a foreign loan in 1824, its sovereign debt history has been marked by many periods of turbulance.[4] Reinhart et al. (2003, p. 7) document that during the 1824-1999 period, Brazil had fully or partially defaulted on its foreign debt seven times and had spent about 25.6% of those 175 years in a state of either default or debt restructuring. Such background had an important influence on the organizational and regulatory frameworks implemented on the Brazilian FX market. Tight controls over all foreign exchange activities were deemed necessary under the premise that foreign currency was a scarce commodity. In 1999 (starting year of the data set), several aspects of the Brazilian FX market regulation still reflected the scars of past balance of payments difficulties. For example, repatriation of Brazilian export revenues, the main source of funds used to rebalance external accounts, was mandatory. In the case of noncompliance, fines could reach up to 200% the value of export proceeds.

In order to avoid foreign currency evasion, a heavy bureaucratic burden was imposed on both customers and dealers. First, all foreign exchange transactions had to be performed through authorized dealers. Second, customers were required to provide proper documentation regarding the economic activity underlying the foreign exchange transaction. Third, it was mandatory for dealers to register each foreign exchange transaction by filling the "foreign

[4] See Abreu (2006) for a detailed analysis of the Brazilian foreign debt early history from 1824-1931.

exchange contract"–a form designed by the BCB that included information regarding the price, volume, counterparty's identity, and the nature of the underlying economic activity associated to the transaction (if the counterparty was an end-user). Finally, dealers were also required to record each "foreign exchange contract" in the Sisbacen–an electronic system of collection, storage, and exchange of information that connects the BCB to all other agents operating in a Brazilian financial market, including the FX market.

Information recorded by dealers into the Sisbacen is only available to the BCB and not to other market participants. This information allows the BCB to establish a single link between non-financial customers' foreign exchange transactions and official records of shipment of exported products and customs clearance of imported goods. The information recorded in the Sisbacen regarding financial customers transactions also helps the BCB enforce its rigid controls over foreign capital invested in the country and Brazilian capital invested abroad.

In recent years, Brazil's external vulnerability has been significantly reduced. Starting in 2005, the BCB and the National Monetary Council (CMN) began implementing a set of regulatory changes that has moved the BRL slowly but surely towards being fully convertible. Exporters now have full discretion regarding the revenues obtained with their exports of goods and services. For transactions up to US$ 3,000, the use of the "foreign exchange contract" form is exempted and presentation of documentation related to the underlying economic activity is no longer required. Finally, Brazilian and international banks are allowed to settle specific transactions using the BRL.

3 Data Description

3.1 Endogenous variables

The data set contains daily aggregates of all end-user transactions registered in the Sisbacen by dealers from the Brazilian FX spot market. The sample spans a total of four years, from July 1, 1999 to June 30, 2003. Order flows are aggregated into three different categories, one for each type of end-user: financial customers, non-financial customers, and the central bank. They are measured in US$ billion and are attributed a signal according to the end users' point

of view: a positive order flow indicates that customers or the central bank purchased foreign currency from dealers.

The BRL/USD exchange rate series used in this paper is the PTAX. The PTAX is the fixing rate for USD-linked instruments—bonds and derivatives—settled onshore and offshore and is released daily by the BCB. The PTAX is calculated as the weighted average of effective transaction rates in the interdealer FX spot market, with weights given by the volume of each transaction. Outliers are excluded from the calculations.

[Insert Figures 1 and 2 about here]

Figures 1 and 2 plot the BRL/USD exchange rate series against the cumulative financial and non-financial customer flows, respectively.[5] Both graphs seem to suggest that the behavior of customer flows from the Brazilian FX market is in line with stylized facts that have already been documented for other major currency pairs: the net position of financial customers is positively correlated with the value of foreign currency while the net position of non-financial customers is negatively correlated with the value of foreign currency. This pattern is usually interpretted as evidence that financial customers are net consumers of liquidity while non-financial customers are net suppliers.

[Insert Figure 3 about here]

Figure 3 plots the BRL/USD exchange rate series against the cumulative central bank flow and reveals that the BCB intervention in the Brazilian FX market is very active during the sample period. Under the general guideline of countering "disorderly market conditions" (described in the previous section), the BCB has intervened not only by selling foreign currency to domestic dealers, but also by purchasing foreign currency from them. In other words, throughout the sample period, the BCB has buffered both positive and negative liquidity shocks.

A couple of BCB intervention cases highlighted by figure 3 are worth noting. In the second half of 2000, there are two circumstances in which the BCB had to absorb excessive foreign

[5] In figures 1 to 3, cumulative order flow is measured on the right axis, but the scale was ommitted per BCB request.

currency liquidity. The first circumstance occurred in August 2000, when stocks of Petrobras– a Brazilian oil company–were issued at the NYSE as ADRs. The second occurred in November 2000, when the Spanish bank Santander Central Hispano acquired the Brazilian state owned bank, Banespa, during a privatization auction. In each episode, the total amount purchased by the BCB exceeded US$ 2 billion. The graph also shows that the second half of 2001 combined high volatility in the Brazilian FX market (generated by contagion of the Argentinean crisis, which culminated with the end of the convertibility of the Argentinean peso on January 2001, and the September 11 attacks) with large BCB sales of USD. Finally, the pre-electoral period of 2002 is also associated with high exchange rate volatility and large provision of foreign currency by the BCB.

Finally, figure 3 also suggests that the overall correlation between central bank order flows and movements of the BRL/USD exchange rate is negative, hinting that the BCB, like non-financial customers, is also a net supplier of foreign exchange liquidity.

3.2 Predetermined variables

The data set also includes measures of overnight interest rate differential and sovereign risk premium. They are treated as predetermined variables since there are reasons to believe that they are not contemporaneously affected by daily fluctuations of the exchange rate nor by end-user order flows.

[Insert Figure 4 about here]

The interest rate differential is calculated as the difference between the Selic and the Fed Funds effective annualized rates. Targets for the Selic rate are set by Brazil's Monetary Policy Committee (Copom) eight times a year. The Copom sets a target for the Selic rate it judges will enable the inflation target to be met. One could argue that in an inflation targeting regime, the monetary policy rate reacts indirectly to exchange rate movements because of the effects of the latter variable on consumer prices. Although this pressure may indeed exist at the quarterly or monthly frequency, it does not exist at the daily frequency.

Finally, the risk premium is proxied by the spread of the C-Bond–the most liquid Brazilian Brady bond in the sample period–over a Treasury of equivalent maturity and is measured in annualized percentage rates (a 1% risk premium is equivalent to a 100 basis-points spread). Risk premium reflects markets' assessment of the probability that a country might default on its debt obligations. Following this rationale, many studies emphasize fiscal variables as the most important determinants of risk premium not only in emerging economies (Eichengreen and Moody, 2000), but also in OECD countries (Alesina et al., 1992) and among US states (Bayoumi et al., 1995).

[Insert Tables 1 and 2 about here]

Table 1 presents summary statistics for all variables. Table 2 shows that the Augmented Dickey-Fuller and the Phillips-Perron tests suggest that the exchange rate, the cumulative customer and central bank flows, the domestic and foreign interest rates, and the risk premium are all integrated of order 1 series.

4 Cointegration Analysis

4.1 Empirical Strategy

The empirical strategy follows Bjønnes el al (2005), Killeen et al. (2006), and Berger et al. (2008) in the use of cointegration techniques to model the relationship between order flows and exchange rates. Let y_t be the vector of endogenous variables, which includes the (log of the) daily spot exchange rate, s_t, the cumulative financial customer flow, X_t^{FI}, the cumulative non-financial customer flow, X_t^{NF}, and the cumulative central bank flow, X_t^{CB}:

$$y_t = \left[\begin{array}{cccc} s_t & X_t^{FI} & X_t^{NF} & X_t^{CB} \end{array} \right]' \tag{1}$$

Also, let Z_t be the vector of predetermined macroeconomic variables, which includes the Selic/Fed Funds interest rate differential, $r_t - r_t^*$, and the C-Bond spread as the measure of

Brazilian sovereign risk premium, ξ_t:

$$z_t = \begin{bmatrix} r_t - r_t^* & \xi_t \end{bmatrix}' \tag{2}$$

The following VECM is estimated:

$$\Delta y_t = \Lambda \Pi' y_{t-1} + \sum_{p=1}^{P} A_i \Delta y_{t-i} + B_0 \Delta z_t + \sum_{q=1}^{Q} B_q D_{q,t} + u_t \tag{3}$$

where $D_{q,t}$ is a set of dummy variables that includes controls for each weekday and for each month and u_t is a normally distributed error vector with zero mean and nonsingular covariance matrix Σ_u. Matrices Λ and Π are both $4 \times n$, each with rank $n < 4$ given by the number of cointegrating equations.

An important feature of VECM estimation procedures is to allow separate analysis between long-run equilibrium relationships and short-run dynamics. The columns of the $4 \times n$ matrix Π are known as cointegrating vectors and each describe a linear combination of the non-stationary series that is stationary. Hence, each cointegrating equation is interpreted as a long-run equilibrium relationship between the endogenous variables. Moreover, each column of Λ contains a set of the adjustment coefficients associated to each error correction term of the VECM. Therefore, they describe how deviations from long-run relationships feed back into short-run movements of the endogenous variables.

4.2 Estimation Output

Table 4 presents the estimation output of the VECM described in (3). Following the suggestions of Wald's lag exclusion test and Johansen's cointegration test, the VECM is estimated with two lags of the vector of endogenous variables and two cointegrating equations. While the first cointegrating equation is normalized on the exchange rate, the second cointegrating equation is normalized on the cumulative financial customer flow. It is interesting to note that among both cointegrating equations, the only long term relationship that is statistically significant is that between the exchange rate and cumulative non-financial customer flow. The coefficient

of 0.0090 estimated for the cumulative non-financial customer flow in the first cointegrating equation imples that a 1% depreciation of the BRL long-run equilibrium level is associated with a permanent reduction of the cumulative non-financial flow by US$ 1.11 billion.

[Insert Table 4 about here]

Although both cointegrating equations suggest that neither financial nor central bank cumulative flows are related to the long term equilibrium exchange rate level, the adjustment coefficients associated to the first error correction term reveal that both types of flows are nonetheless significantly related to exchange rate deviations from the trend. A 1% undervaluation of the BRL relative to its long term equilibrium price is associated to financial customers pressure' to purchase US$ 0.23 billion from FX dealers and the central bank' pressure to sell US$ 0.24 billion to FX dealers. Table 4 also shows that the adjustment coefficients associated to the second error correction term are statistically significant in the non-financial flow and central bank flow equations. However, these coefficients are not economically significant. A US$ 1 billion cumulative financial flow deviation from its long term equilibrium is related to a US$ 0.08 billion decrease in the non-financial flow and a US$ 0.07 billion increase in the central bank flow.

With respect to the predetermined variables included, the estimation output shows that changes in risk premium are highly correlated with changes in the exchange rate: a 1% increase in the C-Bond spread increases the BRL price of one USD by 1.29%. Changes in risk premium are also shown to be negatively related with non-financial flows: a 1% increase in the C-Bond spread reduces non-financial flows by US$ 0.07 billion. Finally, it is worth noting that changes in the Selic/Fed Funds interest rate differential have no significant effect on the depreciation rate or any of the end-user flows.

[Insert Table 5 about here]

Table 5 presents the estimation output of a restricted version of the VECM. The restriction imposed forces deviations of the BRL relative to its long term equilibrium price to be associated with exact opposite coefficients for the financial customer flow and the central bank flow. In

other words, the sum of the adjustment coefficients of the financial and the central bank flows with respect to exchange rate deviations from the cointegrating equation is restricted to zero. The LR test statistic of 0.0007 with a p-value of 97.86% suggests that the restriction is not binding. Moreover, all estimated coefficients are practically the same. First, a 1% depreciation in the BRL long-run equilibrium value continues to be related to a permanent reduction of US$ 1.11 billion in the cumulative non-financial flow. Second, a 1% undervaluation of the BRL relative to its long-run equilibrium level is associate to a positive financial flow of US$ 0.24 and a symmetric negative central bank flow of US$ 0.24. Third, adjustment coefficients associated with deviations of the cumulative financial flow relative to its long-run equilibrium value that are statistically significant have estimated magnitudes that are not economically relevant. Fourth, a 1% increase in the C-Bond spread increases the BRL price of one USD by 1.29% and reduces non-financial flows by US$ 0.07 billion. Finally, changes in the Selic/Fed Funds interest rate differential have no significant effect on the depreciation rate or any of the end-user flows.

4.3 Discussion

This section presents empirical evidence on the behaviour of main customers in the Brazilian FX market. Financial customers are constantly reallocating their wealth between domestic and foreign assets. The rebalancing of their portfolios generates daily liquidity needs that push the BRL price away from its equilibrium value, therefore explaining the positive adjustment coefficient of financial flows with respect to deviations of the exchange rate. Non-financial customers, on the other hand, are engaged in international trade activities. A permanent depreciation of the BRL, *ceteris paribus*, makes Brazilian goods and services cheaper for foreigners to purchase, thus stimulating net exports. When foreign currency net export revenues are exchanged for domestic currency in the Brazilian FX market, the negative long-run relationship between non-financial customer flows and the exchange rate is explained.

These results have both similarities and differences relative to the stylized facts already documented for other major currency pairs. The main similarity is that, using terminology

from Sager and Taylor (2006), evidence from the Brazilian FX market also indicates that financial agents are the "push" customers and that non-financial agents are the "pull" customers. However, there seems to be an important timing difference between the demand and the supply of foreign exchange liquidity. VECM results suggest that while financial customers have short-run liquidity needs, non-financial customers provide liquidity over the long run. If this is the case, who provides short-run liquidity in the Brazilian FX market?

The answer is the BCB. The estimated negative adjustment coefficient of central bank flows with respect to deviations of the exchange rate shows that the central bank is pulled to the FX market like non-financial customers, however on the short-run. Moreover, a formal test cannot reject the hypothesis that the short-run liquidity provided by the central bank exactly matches financial customers needs It is also interesting to see that there is no long-run relationship between cumulative central bank flows and the exchange rate, which implies that during the sample period the BCB intervention was indeed only aimed at countering liquidity shocks and not at influencing the long-run value of the exchange rate.

5 FX Market Flows and the Balance of Payments

5.1 The Double-Entry Accounting System

The balance of payments systematically summarizes all economic activities between residents and non-residents. Section 2 of this paper highlighted that Brazilian regulation mandates all foreign exchange transactions arising from these cross-border economic activities to be performed only through authorized dealers. Additionally, it obligates dealers to record detailed information regarding each foreign exchange transaction into the Sisbacen. Thus, in principle it should be possible to use information collected by the Sisbacen to map Brazilian FX market flows into the country's balance of payments accounts.

However, the mapping is not trivial. While customer flows 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 accounting system. In other words, each end-user foreign exchange transaction is always associated with two simultaneous balance of payments entries. Identification

of the first entry of a customer-dealer transaction is straightforward. It is automatically given by the nature of the underlying economic activity generating the need for foreign exchange, such as *direct investment* or *portfolio investment* for financial customers, or *exports* or *imports* for non-financial customers. The second entry is associated to the change in the dealer's foreign cash balances resulting from the transaction. For example, when a Brazilian exporter exchanges its USD revenues for BRLs with a domestic dealer, there will be an increase in the latter's foreign currency holdings. According to the fifth edition of the Balance of Payments Manual (BPM5) issued by the International Monetary Fund (IMF), changes in cash balances should be registered in the *financial account* in the entry *other investments - currency and deposits - banks*.

In the case of central bank interventions, the first balance of payments entry refers to the change in the country's international reserves and is registered in *reserve assets*. The second entry is once again associated to the change in cash balances held by dealers, and is registered in *other investments - currency and deposits - banks*. However, it is important to note that not all changes in *reserve assets* reflect central bank interventions. For example, if Brazil receives a loan from the IMF, there will be an increase in its international reserves but no change in domestic dealers' cash balances. This implies that no entry in *other investments - currency and deposits - banks* will be associated to the increase in *reserve assets*. In such cases, the second balance of payments entry will be recorded in *other investments - loans - monetary authority*.

5.2 Rearranging the Balance of Payments

Using the BPM5 structure as starting point, reorganize the balance of payments into two main accounts. The first account, BP_t^{CB}, contains the changes in central bank's cash balances due to interventions and consists of a combination of *reserve assets* with all other entries from the balance of payments associated with either the *monetary authority* or the *general government*.[6] The second account, BP_t^{IM}, contains the overall measure of balance of payments imbalance,

[6] In the case of Brazil, the most important entries to be combined with *reserve assets* are *other investments - loans - monetary authority* and *other investments - loans - general government*.

which corresponds to the sum of the *current account*, the *capital account*, and the *financial account* subtracted from changes in cash balances held by dealers (*other investments - currency and deposits - banks*) and all other entries associated either with the *monetary authorities* or the *general government* that were already included in BP_t^{CB}. Also, let ΔX_t^{FI} be the financial customer flow, ΔX_t^{NF} be the non-financial customer flow, and ΔX_t^{CB} be the central bank flow. The following relationships should hold:

$$BP_t^{CB} = \Delta X_t^{CB} \tag{4}$$

$$BP_t^{IM} = \Delta X_t^{FI} + \Delta X_t^{NF} \tag{5}$$

Figures 5 and 6 illustrate relationships (4) and (5), respectively. In both graphs, end-user order flow data is aggregated into monthly series in order to match the highest frequency at which the balance of payments data is available. Also, since monthly behavior of each series is very volatile each graph shows 3-month moving averages. These figures suggest that Brazilian FX market flows are highly, though not perfectly, correlated to their balance of payments equivalents.

One known source of difference between end-user flows and balance of payments accounts relates to the timing of the transaction recordings. Foreign exchange transactions are recorded on the same day that the trading occurs. On the other hand, balance of payments transactions are recorded based on the principle of accrual accounting. Generally, accrual accounting signifies that an economic activity between a resident and a non-resident is accounted for in the balance of payments when both parties record it in their books. In practice, this distinction is more relevant for trade in goods. For example, when a resident purchases foreign goods from a non-resident, the non-financial flow is generated on the day the resident purchases foreign currency to pay for his imports, while an entry on the balance of payments account *imports* is recorded only after the imported goods have cleared customs.

In order to provide formal empirical evidence on the equivalency between FX market flows

and balance of payments accounts, the following equations are estimated:

$$BP_t^{CB} = \beta_0^{CB}\Delta X_t^{CB} \quad (6)$$

$$BP_t^{IM} = \beta_{-1}^{IM}\left(\Delta X_{t-1}^{FI} + \Delta X_{t-1}^{NF}\right) + \beta_0^{IM}\left(\Delta X_t^{FI} + \Delta X_t^{NF}\right) + \beta_1^{IM}\left(\Delta X_{t+1}^{FI} + \Delta X_{t+1}^{NF}\right) \quad (7)$$

Equation (6) tests relationship (4) by regressing the change in central bank's cash balances due to interventions on central bank flows. Equation (7) tests relationship (5) by regressing balance of payments imbalances on financial and non-financial flows. However, because timing issues related to trade in goods are relevant for BP_t^{IM}, equation (7) also includes one lag and one forward of the sum of financial and non-financial flows. In both equations the constant is excluded and the null hypothesis that the coefficient (or sum of the coefficients) associated with FX market flows equals one is tested.

[Insert Table 3 about here]

Table 3 presents the results. We can see that the coefficient associated to central bank flows has an estimated value of 1.12 and is statistically different from zero but not from one. We can also note that the coefficients associated with the lag and the contemporaneous sum of financial and non-financial flows are statistically significant and that the sum of all coefficients equals 0.82 and is not statistically different from one.

6 Conclusion

This paper analyzes a unique data set from the Brazilian FX market containing complete records of daily transactions between domestic dealers, customers, and the central bank from July 1999 to June 2003. First, results provide invaluable insights to our understanding regarding foreign exchange liquidity provision in an emerging economy with floating exchange rates that has been subjected to many liquidity shocks, including sudden stops in capital flows. VECM estimates suggest that non-financial customers are typically net suppliers of foreign exchange liquidity with their net positions correlated to the BRL fundamental value and that

financial customers are the typical liquidity demanders with changes in their net positions correlated to short-run deviations of the BRL from its fundamental value. Additionally, VECM estimates reveal that the BCB is the ultimate liquidity provider to financial customers. Central bank flows are also correlated to short-run deviations of the exchange rate relative to its fundamental value, but in such a way that exactly match financial customers needs. No cointegration between cumulative central bank flows and the exchange rate implies that the BCB interventions were succesful in countering disorderly market conditions without affecting the exchange rate long-run trend. Finally, this paper also contributes to the exchange rate determination puzzle by describing how specific aspects of the Brazilian FX market regulatory framework makes it possible to map Brazilian FX market flows into the country's balance of payments accounts.

References

[1] Abreu, M., 2006. Brazil as a debtor, 1824-1931. Economic History Review 59, 765-787.

[2] Alesina, A., De Broeck, M., Prati, A., Tabellini, G. 1992. Default Risk on Government Debt in OECD Countries. Economic Policy 15, 427-451.

[3] Bayoumi, T., Goldstein, M., Woglom, G., 1995. Do Credit Markets Discipline Sovereign Borrowers? Evidence from US States. Journal of Money, Credit, and Banking 27, 1046-1059.

[4] Berger, D., Chaboud, A., Chernenko, S., Howorka, E., Wright, J., 2008. Order flow and exchange rate dynamics in electronic brokerage system data. Journal of International Economics 75, 93-109.

[5] Breedon, F., Vitale, P., 2010. An empirical study of portfolio-balance and information effects of order flow on exchange rates. Journal of International Money and Finance, in press.

[6] Bjønnes, G., Rime, D., Solheim, H., 2005. Liquidity provision in the overnight foreign exchange market. Journal of International Money and Finance 24, 175-196.

[7] BCB, 2009. Simplification measures in the foreign exchange area. Central Bank of Brazil.

[8] Cheung, Y., Chinn, M., Pascual, A., 2003. Empirical exchange rate models of the nineties: Are any fit to survive? Journal of International Money and Finance 24, 1150-1175.

[9] Dominguez, K., Panthaki, F., 2006. What defines 'news' in foreign exchange markets? Journal of International Money and Finance 25, 168-198.

[10] Eichengreen, B., Mody, A., 2000. What explains changing spreads on emerging market debt? In: Edwards, S. (Ed.). Capital Flows and the Emerging Economies: Theory, Evidence, and Controversies. NBER Conference Report series, University of Chicago Press, Chicago and London, 107-134.

[11] Evans, M., 2010. Order flows and the exchange rate disconnect puzzle. Journal of International Economics 80, 58-71.

[12] Evans, M., Lyons, R., 2002. Order flow and exchange rate dynamics. Journal of Political Economy 110, 170-180.

[13] Evans, M., Lyons, R., 2005a. Meese-Rogoff redux: micro-based exchange-rate forecasting. American Economic Review 95, 405-414.

[14] Evans, M., Lyons, R., 2005b. Do currency markets absorb news quickly? Journal of International Money and Finance 24, 197-217.

[15] Evans, M., Lyons, R., 2008. How is macro news transmitted to exchange rates? Journal of Financial Economics 88, 26-50.

[16] Fan, M., Lyons, R., 2003. Customer trades and extreme events in foreign exchange. In: Mizen, P. (Ed.). Monetary History, Exchange Rates and Financial Markets: Essays in Honor of Charles Goodhart. Edward Elgar, Northampton, MA, 160-179.

[17] Froot, K., Ramadorai, T., 2005. Currency returns, intrinsic value, and institutional-investor flows. Journal of Finance 60, 1535-1566.

[18] IMF, 1999. Camdessus welcomes constructive discussions with Brazil. IMF News Brief No. 99/3.

[19] Killeen, W., Lyons, R., Moore, M., 2006. Fixed versus flexible: Lessons from EMS order flow. Journal of International Money and Finance 25, 551-579.

[20] Love, R., Payne, R., 2008. Macroeconomic news, order flows and exchange rates. Journal of Financial and Quantitative Analysis 43, 467-488.

[21] Marsh, I., O'Rourke, C., 2005. Customer order flows in foreign exchange markets: Do they really contain information? Manucript.

[22] Meese, R., Rogoff, K., 1983. Empirical exchange rate models of the seventies. Journal of International Economics 14, 3-24.

[23] Osler, C., 2008. Foreign exchange microstructure: A survey of the empirical literature. In: Meyers, R. (Ed.). Encyclopedia of Complexity and System Science. Springer.

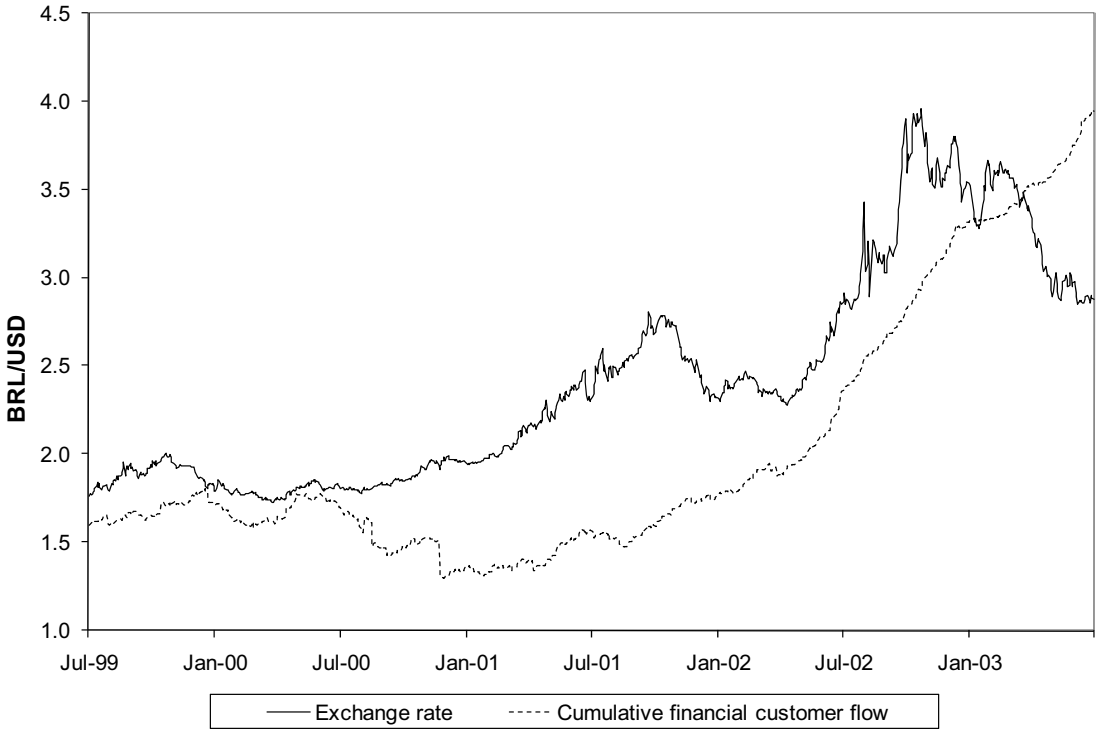
[24] Reinhart, C., Rogoff, K., Savastano, M., 2003. Debt intolerance. In: Brainard, W., Perry, G. (Eds.). Brookings papers in economic activity 1, pp. 1-74.

[25] Rime, D., Sarno, L., Sojli, E., 2010. Exchange rate forecasting, order flow and macroeconomic information. Journal of International Economics 80, 72-88.

[26] Sager, M., Taylor, M., 2006. Under the microscope: the structure of the foreign exchange market. International Journal of Finance and Economics 11, 81-95.

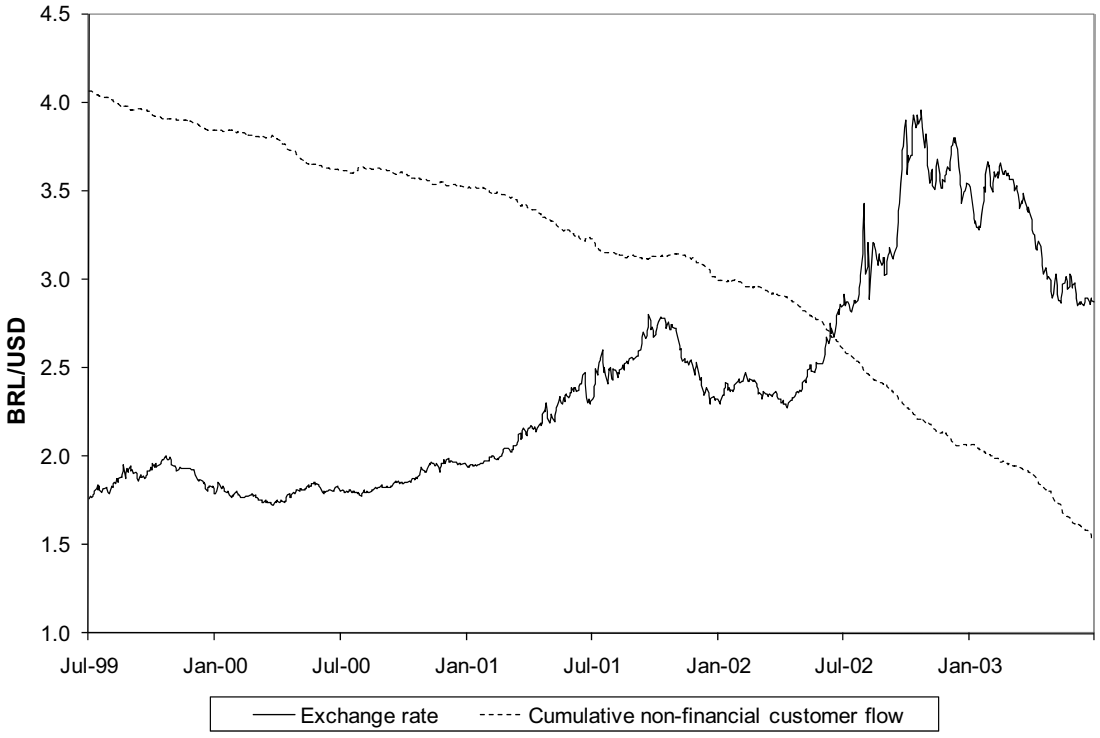
[27] Sager, M., Taylor, M., 2008. Commercially available order flow data and exchange rate movements: caveat emptor. Journal of Money, Credit and Banking 4, 583-625.

Figure 1: Cumulative financial customer flow and exchange rate



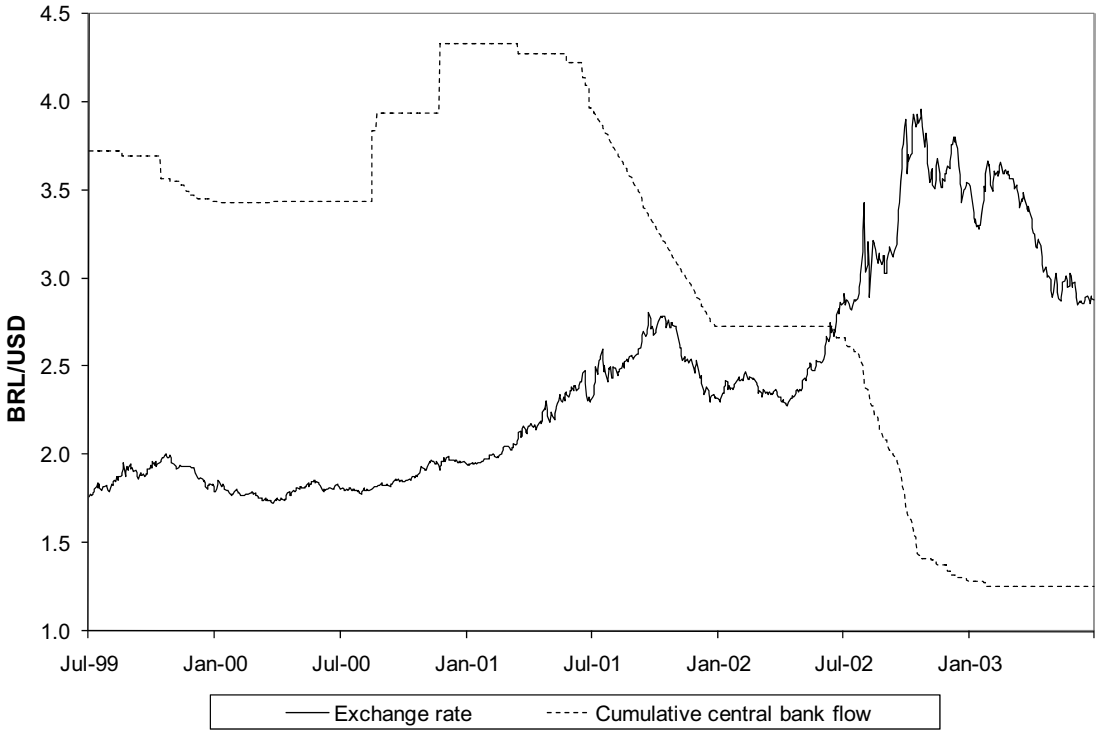
Note: daily data, from July 1st, 1999 to June 30th, 2003. Cumulative order flow is measured on the right axis, but scale is omitted per request of the Central Bank of Brazil. Cumulative order flow in date *t* is the sum of all daily flows from date 0 (July 1st, 1999) to date *t*. Positive (negative) customer flows indicates that customer purchased (sold) foreign currency from (to) domestic dealers. Exchange rate is defined as the amount of Brazilian *reais* necessary to purchase one US dollar.

Figure 2: Cumulative non-financial customer flow and exchange rate



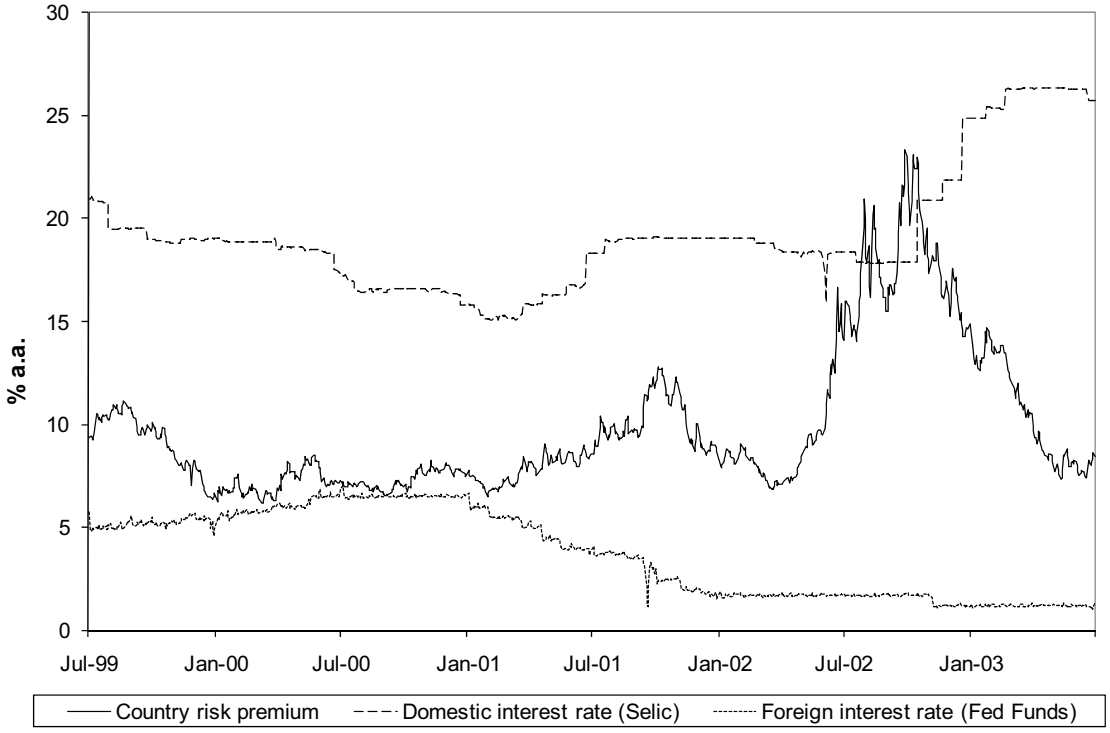
Note: daily data, from July 1st, 1999 to June 30th, 2003. Cumulative order flow is measured on the right axis, but scale is omitted per request of the Central Bank of Brazil. Cumulative order flow in date *t* is the sum of all daily flows from date 0 (July 1st, 1999) to date *t*. Positive (negative) customer flow indicates that customer purchased (sold) foreign currency from (to) domestic dealers. Exchange rate is defined as the amount of Brazilian *reais* necessary to purchase one US dollar.

Figure 3: Cumulative central bank flow and exchange rate



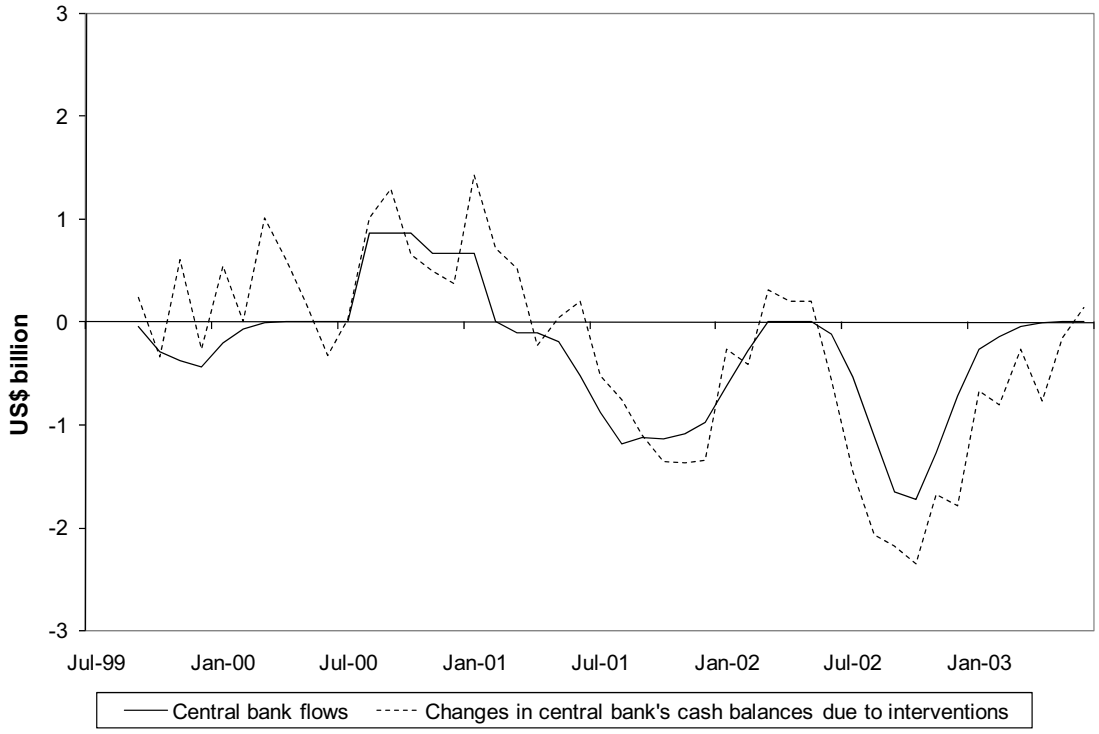
Note: daily data, from July 1st, 1999 to June 30th, 2003. Cumulative order flow is measured on the right axis, but scale is omitted per request of the Central Bank of Brazil. Cumulative order flow in date *t* is the sum of all daily flows from date 0 (July 1st, 1999) to date *t*. Positive (negative) central bank flow indicates that central bank purchased (sold) foreign currency from (to) domestic dealers. Exchange rate is defined as the amount of BRL necessary to purchase one USD.

Figure 4: Pre-determined variables



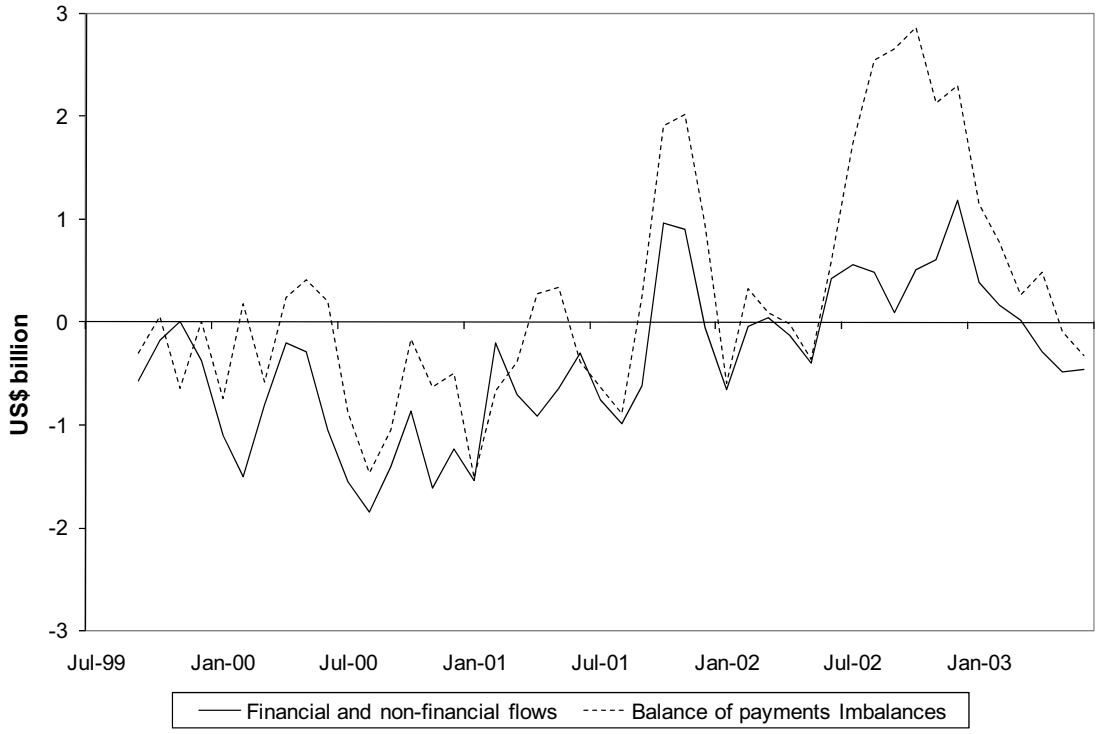
Note: daily data, from July 1st, 1999 to June 30th, 2003. Sovereign risk premium is proxied by the spread of the C-Bond over a Treasury of equivalent maturity. All variables measured in % a.a. (a 1% risk premium is equivalent to a 100 basis-point spread).

Figure 5: Central bank flows and changes in central bank's cash balances due to interventions



Note: 3-month moving average of monthly data from July 1999 to June 2003. Positive (negative) central bank flow indicates that central bank purchased (sold) foreign currency from (to) domestic dealers.

Figure 6: Financial and non-financial flows and balance of payments imbalances



Note: 3-month moving average of monthly data from July 1999 to June 2003. Positive (negative) customer flow indicates that customer purchased (sold) foreign currency from (to) domestic dealers.

Table 1: Summary statistics

Variable	Mean	Mean (absolute)	Minimum	Maximum	Std. Dev.
Depreciation rate	0.050%	0.060%	-8.930%	4.870%	1.080%
Financial flow	0.040	0.051	-2.626	1.138	-0.206
Non-financial flow	-0.058	-0.050	-0.585	0.298	-0.096
Central bank flow					
Full sample (1003 obs.)	-0.013	0.022	-0.665	2.040	-0.105
Non-zero only (236 obs.)	-0.054	0.467	-0.665	2.040	-0.212
Δ(Selic interest rate)	-0.004%	0.000%	3.000%	-1.410%	0.181%
Δ(Fed Funds interest rate)	-0.004%	0.000%	1.440%	-1.120%	0.140%
Δ(C-Bond spread)	-0.004%	-0.010%	2.340%	-2.200%	0.367%

Note: summary statistics of daily data from July 1st, 1999 to June 30th, 2003. Order flows are measured in USD billion. Positive (negative) order flow indicates that customer purchased (sold) foreign currency from (to) domestic dealers. Exchange rate is defined as the amount of BRL necessary to purchase one USD. Selic interest rate, Fed Funds interest rate and C-Bond spread are measured in % a.a.

Table 2: Unit root tests

	Augmented Dickey-Fuller		Phillips-Perron	
Variable	**Level**	**1st difference**	**Level**	**1st difference**
Exchange rate	-1.019	-23.686	-1.066	-25.673
	(0.748)	(0.000)	(0.731)	(0.000)
Cumulative financial flow	5.270	-26.442	4.755	-28.371
	(1.000)	(0.000)	(1.000)	(0.000)
Cumulative non-financial flow	5.570	-10.893	5.327	-25.564
	(1.000)	(0.000)	(1.000)	(0.000)
Cumulative central bank flow	0.893	-10.525	0.934	-31.768
	(0.996)	(0.000)	(0.996)	(0.000)
Selic interest rate	0.223	-30.026	0.281	-29.991
	(0.974)	(0.000)	(0.977)	(0.000)
Fed Funds interest rate	0.224	-15.925	-0.647	-42.083
	(0.974)	(0.000)	(0.857)	(0.000)
C-bond spread	-1.760	-28.806	-1.611	-28.681
	(0.401)	(0.000)	(0.477)	(0.000)

Note: unit root tests are performed on daily data from July 1st, 1999 to June 30th, 2003. All tests allow for an intercept but not a time trend. Null hypothesis is: variable has a unit root. P-values are given in parenthesis under test statistics.

Table 3: Equivalency between end-user flows and balance of payments accounts

	(change in central banks' cash balance)$_t$	(balance of payments imbalance)$_t$
(central bank flow)$_t$	1.1188***	-
	(0.1511)	-
(financial and non-financial flows)$_{t-1}$	-	0.1634*
	-	(0.0894)
(financial and non-financial flows)$_t$	-	0.6752***
	-	(0.1396)
(financial and non-financial flows)$_{t+1}$	-	-0.0209
	-	(0.1496)
H_0: sum of coefficients equals 1	0.62	0.82
	(0.4357)	(0.3711)
R-squared	45.5%	32.9%

Note: both equations estimated by OLS using monthly data from July 1999 to June 2003. Constant was excluded from both regressions. Robust standard errors are given in parenthesis under the coefficients. P-value is given in parenthesis under test statistic. The symbols ***, **, and * denote that the individual coefficient is significant at the 1%, 5%, and 10% significance level, respectively.

Table 4: Vector error correction model estimation output

Cointegrating Equation	Equation 1	Equation 2
$(\text{exchange rate})_{t-1}$	1	0
	-	-
$(\text{cumulative financial flow})_{t-1}$	0	1
	-	-
$(\text{cumulative non-financial flow})_{t-1}$	0.0090***	-0.3966
	(0.0023)	(0.3501)
$(\text{cumulative central bank flow})_{t-1}$	-0.0022	-0.4610
	(0.0069)	(1.0541)
constant	-0.6623	-17.8280
	-	-

Error Correction	$(\text{depreciation rate})_t$	$(\text{financial flow})_t$	$(\text{non-financial flow})_t$	$(\text{central bank flow})_t$
$(\text{error correction term 1})_{t-1}$	0.0025	0.2345***	0.0014	-0.2364***
	(0.0037)	(0.0767)	(0.0331)	(0.0403)
$(\text{error correction term 2})_{t-1}$	0.0000	0.0006	-0.0008***	0.0007***
	(0.0000)	(0.0005)	(0.0002)	(0.0003)
$(\text{depreciation rate})_{t-1}$	0.1432***	0.9981	0.1808	-0.3587
	(0.0307)	(0.6421)	(0.2772)	(0.3373)
$(\text{depreciation rate})_{t-2}$	-0.1537***	0.8563	0.2624	0.0411
	(0.0306)	(0.6408)	(0.2766)	(0.3366)
$(\text{financial flow})_{t-1}$	0.0003	0.0694*	-0.0142	0.0094
	(0.0018)	(0.0375)	(0.0162)	(0.0197)
$(\text{financial flow})_{t-2}$	-0.0006	0.0412	-0.0176	-0.0162
	(0.0018)	(0.0374)	(0.0161)	(0.0196)
$(\text{non-financial flow})_{t-1}$	-0.0135***	-0.1761**	0.2214***	0.0360
	(0.0037)	(0.0776)	(0.0335)	(0.0408)
$(\text{non-financial flow})_{t-2}$	-0.0009	0.0367	0.0823**	-0.0097
	(0.0038)	(0.0787)	(0.0340)	(0.0413)
$(\text{central bank flow})_{t-1}$	0.0021	-0.0734	0.0243	0.0201
	(0.0034)	(0.0712)	(0.0308)	(0.0374)
$(\text{central bank flow})_{t-2}$	0.0011	0.0957	0.0202	-0.0061
	(0.0034)	(0.0710)	(0.0307)	(0.0373)
$\Delta(\text{Selic/Fed Funds differential})_t$	-0.1063	3.6459	1.3506	-1.7783
	(0.1356)	(2.8387)	(1.2255)	(1.4913)
$\Delta(\text{C-Bond spread})_t$	1.2879***	1.6453	-6.5003***	(1.2936)
	(0.0814)	(1.7048)	(0.7360)	(0.8956)
R-squared	28.1%	13.4%	24.6%	8.2%

Note: VECM(2) estimated with daily data from July 1st, 1999 to June 30th, 2003. Intercept but no trend included in both cointegrating equation and VAR. Coefficients associated with the constant and dummy variables in the VAR are omitted from the table. Standard errors are given in parenthesis under the coefficients. The symbols ***, **, and * denote that the individual coefficient is significant at the 1%, 5%, and 10% significance level, respectively.

Table 5: Restricted vector error correction model estimation output

Cointegrating Equation	Equation 1	Equation 2
$(\text{exchange rate})_{t-1}$	1	0
	-	-
$(\text{cumulative financial flow})_{t-1}$	0	1
	-	-
$(\text{cumulative non-financial flow})_{t-1}$	0.0090***	-0.3915
	(0.0023)	(0.3486)
$(\text{cumulative central bank flow})_{t-1}$	-0.0022	-0.4556
	(0.0069)	(1.0494)
constant	-0.6622	-17.6976
	-	-

Error Correction	$(\text{depreciation rate})_t$	$(\text{financial flow})_t$	$(\text{non-financial flow})_t$	$(\text{central bank flow})_t$
$(\text{error correction term 1})_{t-1}$	0.0025	0.2363***	0.0012	-0.2363***
	(0.0037)	(0.0403)	(0.0329)	(0.0403)
$(\text{error correction term 2})_{t-1}$	0.0000	0.0006	-0.0008***	0.0007***
	(0.0000)	(0.0004)	(0.0002)	(0.0003)
$(\text{depreciation rate})_{t-1}$	0.1432***	0.9980	0.1808	-0.3587
	(0.0307)	(0.6421)	(0.2772)	(0.3373)
$(\text{depreciation rate})_{t-2}$	-0.1537***	0.8562	0.2625	0.0410
	(0.0306)	(0.6408)	(0.2766)	(0.3366)
$(\text{financial flow})_{t-1}$	0.0003	0.0694*	-0.0142	0.0094
	(0.0018)	(0.0375)	(0.0162)	(0.0197)
$(\text{financial flow})_{t-2}$	-0.0006	0.0412	-0.0176	-0.0162
	(0.0018)	(0.0374)	(0.0161)	(0.0196)
$(\text{non-financial flow})_{t-1}$	-0.0135***	-0.1761**	0.2214***	0.0360
	(0.0037)	(0.0776)	(0.0335)	(0.0408)
$(\text{non-financial flow})_{t-2}$	-0.0009	0.0367	0.0824	-0.0097
	(0.0038)	(0.0787)	(0.0340)	(0.0413)
$(\text{central bank flow})_{t-1}$	0.0021	-0.0733	0.0243	0.0201
	(0.0034)	(0.0712)	(0.0308)	(0.0374)
$(\text{central bank flow})_{t-2}$	0.0011	0.0957	0.0202	-0.0061
	(0.0034)	(0.0710)	(0.0307)	(0.0373)
$\Delta(\text{Selic/Fed Funds differential})_t$	-0.1063	3.6461	1.3505	-1.7784
	(0.1356)	(2.8387)	(1.2255)	(1.4913)
$\Delta(\text{C-Bond spread})_t$	1.2879***	1.6457	-6.5003***	(1.2935)
	(0.0814)	(1.7048)	(0.7360)	(0.8956)
LR test for binding restriction		0.0007 (0.9786)		
R-squared	28.1%	13.4%	24.6%	8.2%

Note: VECM(2) estimated with daily data from July 1st, 1999 to June 30th, 2003. Intercept but no trend included in both cointegrating equation and VAR. Coefficients associated with the constant and dummy variables in the VAR are omitted from the table. Standard errors are given in parenthesis under the coefficients. P-value is given in

parenthesis next to LR test statistic. The symbols ***, **, and * denote that the individual coefficient is significant at the 1%, 5%, and 10% significance level, respectively.