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

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Abstract

This paper contributes to the microstructure approach to the exchange rates research by taking a closer look on the FX retail market, the behavior of the customer flow and its impact on the exchange rate dynamics. We develop a model that presents two major distinctions relative to previous microstructure models. First, customer flow is not simply the realization of a random variable. Instead, it reacts to changes in the exchange rate. Second, dealers may optimally decide to hold overnight positions in the FX market. Using a Structural VAR approach, we estimate the predictions of the model using a dataset that covers 100% of the Brazilian FX retail market. We find that, in order to meet a US$ 1 billion customer order flow, dealers increase the domestic price of a dollar by approximately 2.7%. We also find that a 1% depreciation rate decreases the financial customer flow by US$ 111 millions and the commercial flow by US$ 46 millions.

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1 Introduction

Traditional exchange rate models put the focus of their analysis on the trade in goods and assets between residents and non-residents of a given economy. More specifically, they use as “building blocks” parity conditions that avoid large imbalances in those trades: while the purchasing power parity guarantees equilibrium in the market of freely traded goods, the uncovered interest parity guarantees equilibrium in the markets of freely traded assets. However, empirical failure of such models has been widely documented, and the behavior of nominal exchange rates has been a major challenge to explain since Meese and Rogoff (1983) evidence that a naïve random walk model would outperform a variety of models based on macroeconomic fundamentals in terms of out-of-sample forecast.[1]

A new line of research on exchange rates, known as the microstructure approach, has shifted the attention from the flow of goods and assets across national borders to the order flows from the FX market. Order flow is a measure of buying pressure. Evans and Lyons (2002), the best representative of this new class of models, develop a model that shows how interdealer order flow, or buying pressure from the wholesale FX market, aggregates and reviews information about customer order flow, or buying pressures from the retail FX market. The empirical result is quite impressive. They estimate their model using daily deutsche mark/dollar exchange rates and interdealer order flows covering approximately 54% of the market and obtain 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%.

Most of the previous studies on the microstructure approach are focused on the behavior of the interdealer order flow. The two exceptions are Fan and Lyons (2003), who analyze five years of monthly data covering the euro/dollar and the yen/dollar FX markets, and Bjonnes, Rime and Solheim (2005), with ten years of daily data on the Swedish krona FX market. Despite of this research bias, as Fan and Lyons (2003) put it, the interdealer order flow is in a sense only a “derivative” of the customer order flow, which means that the true “catalyst” of the FX market is the action in the retail market, and not from the wholesale market.[2]

This paper contributes to microstructure approach to the exchange rates literature by taking a closer look on the FX retail market, the behavior of the customer flow and its impact on the exchange rate dynamics. In order to do so, we use a dataset that is unique in at least two ways. First, it covers 100% of a country’s FX retail market. Second, while other

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

[2] Words in quotes are used in Lyons and Fan (2003).

studies are looking at the exchange rate between currencies from two developed countries, this is the first that covers an emerging economy. Our dataset contains transaction flows from the Brazilian FX retail market between dealers 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, and covers 100% of the official Brazilian FX market, one of the largest emerging economies.

Motivated by the observed behavior of the customer flow in our dataset, we write a model with two major changes relative to previous microstructure models. First, customer flow is not simply the realization of a random variable. Instead, we move towards a general equilibrium model where customers' demand for FX is influenced by many macroeconomic fundamentals, including contemporaneous changes in the exchange rate. Second, dealers' FX holdings at the end of each trading day are not exogenously set (to zero, for example). Instead, they may optimally decide to hold overnight positions in the FX market, depending on the expected overnight FX payoffs: the interest rate differential and the depreciation rate. This second modification implies that dealers from the Brazilian FX market do not simply behave as intermediaries, matching buyers with sellers within a trading day: if in a given day the volume that customers need to buy do not match the volume customers need to sell, the dealer may supply the extra liquidity if he thinks that it is optimal to do so. In other words, the FX liquidity supplied by dealers in our model is not limited to the intraday frequency: they are also allowed to provide overnight liquidity.

Our model describes a two-way relationship between customer flow and the exchange rate. On the one hand, the need for FX liquidity is decreasing on its price: the more appreciated is the exchange rate, the cheaper are foreign goods and assets and higher is the demand for foreign currency. On the other hand, there is a positively sloped FX supply curve that is explained by a portfolio balance effect. Since dealers are risk averse, they will charge a risk premium to supply the needed FX liquidity and end the trading day with an inventory level lower than initially desired. This premium takes the form of a price change and the exchange rate depreciates.

In order to estimate this endogenous relationship between customer flow and exchange rate, we use a Structural VAR approach, taking advantage of the information we have about the type of customer that is trading with in the dealer. The most important identifying assumption is that the financial customer flow and the commercial customer flow do not affect each other contemporaneously. This does not mean that the commercial customer flow and the financial customer flow are not correlated at the daily frequency. Macroeconomic variables such as the domestic and foreign interest rates, the country risk premium and, specially, the exchange rate may affect both types of flows simultaneously. However, once we control for these potential sources of common shocks, our model tells us that the decision to trade goods with non-residents is independent of the decision to trade assets with a non-resident. In the real world, these decisions are made by different types of agents, with different objectives: on one hand, the trade in assets is based on their expected payoffs (dividends and price changes); on the other hand, the trade in goods is based on the utility provided by the good, if it is a final good, or its contribution to the production of another good, if it is an intermediary good.

Given this identification strategy, we estimate that in order to meet a US$ 1 billion customer order flow, dealers increase the domestic price of a dollar by approximately 2.7%. We also find that a 1% depreciation rate decreases the financial customer flow by US$ 111 millions and the commercial flow by US$ 46 millions. 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 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.

The rest of this paper is organized as follows. Section 2 describes the model. Section 3 presents the dataset and some of its characteristics. Section 4 estimates the two-way effects between exchange rates and customer flows. Section 5 discusses the role of the FX derivatives market. Section 6 concludes.

2 Model

2.1 The Customer Flow

In this section we will model the currency flows in one small emerging economy. The world will be composed by one large developed country and J small emerging economies. We assume that each small emerging economy only trade goods and assets with the developed country, while the developed country trades goods and assets with all J emerging economies. This assumption simplifies calculations and can be easily relaxed. Each country, developed or emerging, issues one financial asset and produces two types of specialized goods, one final good and one intermediary good. These goods are specialized in the sense that they are not substitutes across countries. The final goods cannot be traded between countries (which means that each country consumes its own production). The trade in intermediary goods between the developed and the emerging countries determines the commercial flow in each country. Trade in assets between the small emerging economy and the developed country determines the financial flow.

2.1.1 The Small Emerging Economy

The jth small emerging economy is populated by an overlapping generation of a continuum of identical representative households with mass equal to 1. Each representative household lives for two periods, consuming in both periods, but receiving income only when young. There are also two continuums of identical representative firms, both with mass 1. The first set of representative firms produces the final consumption good and the second set of representative firms produces the intermediary good. We assume that for each young representative household there is one final good representative firm and one intermediary good representative firm.

Representative Households The domestic representative household from the jth small emerging economy needs FX to buy foreign assets so that he can smooth his consumption across both periods. Assume that the representative household born in period t receives income only when he is young. Available sources of income for the young representative agent are: the wage W_t^j received for supplying inelastically one unit of labor, a lump-sum transfer of profits Π_t^j from the firms and a lump-sum transfer T_t^j (that can be either positive or negative) from the government. In order to save for consumption when old, the young representative agent invests in two types of assets: the domestic risk free bond and the large developed country asset (that is going to be called foreign bond). For each unit of domestic currency that is invested in the domestic bond in period t, the young representative household receives $1+r_t^j$ units of domestic currency in period $t+1$. For each unit of domestic currency that is invested in the foreign bond in period t, the young representative household receives $1+r_t+s_{t+1}^j-s_t^j$ in period $t+1$, where S_t^j is the amount of domestic currency necessary to purchase one unit of foreign currency in period t and $s_t^j \equiv d\log S_t^j = dS_t^j/S_t^j$. We will assume by now that given all information available in period t the (log linearized) exchange rate s_{t+1}^j is normally distribute with mean $E_t\left(s_{t+1}^j\right)$ and conditional variance $Var_t\left(s_{t+1}^j\right)$. We will show at the end of the next section that this hypothesis is in fact true when we calculate the final solution for the exchange rate.

Each representative household chooses how much to consume in each period, $C_{y,t}^j$ and $C_{o,t+1}^j$, and how much to hold of the foreign asset, $B_t^{j,f}$, in order to maximize the expected present value of his consumption level in both periods, given a period utility function with constant absolute risk aversion, $u(C) = -\exp\left(-\rho^j C\right)$, subject to its budget constraint:

$$\max_{C_{y,t}^j, C_{o,t+1}^j} \quad u\left(C_{y,t}^j\right) + \beta E_t\left(u\left(C_{o,t+1}^j\right)\right) \tag{1}$$

$$\text{subject to } C_{o,t+1}^j = \left(1+r_t^j\right)\left(W_t^j + \Pi_t^j + T_t^j - C_{y,t}^j\right) + B_t^{j,f}\left(s_{t+1}^j - s_t^j + r_t - r_t^j\right) \tag{2}$$

The optimal demand of the representative household from the jth small emerging economy for the foreign bond is:

$$B_t^{j,f} = \frac{E_t\left(s_{t+1}^j\right) - s_t^j + r_t - r_t^j}{\rho^j Var_t\left(s_{t+1}^j\right)} \tag{3}$$

Representative Firms There are two types of representative firms in the jth emerging economy. One type produces the "domestic" intermediary good. This intermediary good is used as input in the final goods sector in both the domestic country and the large developed country. The amount of the "domestic" intermediary good that is exported to the developed country depends on the developed country final goods firm's problem.

The representative firm of the final good sector in the jth emerging economy produces the consumption good using as inputs both the "foreign" and the "domestic" intermediary goods. Let Y_t^j be the total amount of the final good produced in country j, P_t^f and P_t^j be the domestic prices of the "foreign" and "domestic" intermediary goods, and $K_t^{j,f}$ and

$K_t^{j,j}$ be the total amounts of the "foreign" and "domestic" intermediary goods demanded by the representative firm of the intermediary sector in country j. Given a Cobb-Douglas production function for the representative firm of the final good sector:

$$Y_t^j = A_t^j \left(K_t^{j,f}\right)^{\alpha^j} \left(K_t^{j,j}\right)^{1-\alpha^j} \tag{4}$$

where $0 < \alpha^j < 1$ and A_t^j is a productivity shock term, the optimal amount of the "foreign" intermediary good to be imported will be positively related to the final good domestic production and negatively related to the relative price in local currency:

$$K_t^{j,f} = \alpha^j \frac{Y_t^j}{P_t^f} \tag{5}$$

2.1.2 The Large Developed Country

The large developed country demand for the jth small emerging economy asset will be modeled as coming from a representative Global Investment Fund (GIF) specialized in investing in the J emerging markets. The large developed country demand for the jth small emerging country good will be modeled as coming from a representative firm that produces a consumption good using as inputs intermediary goods from all $J + 1$ countries.

Demand for Assets in the Developed Country The GIF manager of generation t receives an endowment of W_t units of the large developed country currency (dollars) and decides how much to invest in the $J + 1$ assets available: the large developed country asset and the J small emerging countries assets. For each dollar invested in the large developed country risk free bond in period t, the GIF receives in period $t + 1$ a gross return of $1 + r_t$. For each dollar invested in the jth emerging economy risky asset, the GIF receives in period t a gross return of $1 + r_t^j + s_t^j - s_{t+1}^j$.

The GIF manager of generation t chooses $B_t^f = \left[B_t^{f,1}, B_t^{f,2}, ..., B_t^{f,J}\right]'$, where $B_t^{f,j}$ is the amount invested in the jth small emerging economy asset (measured in units of the developed country currency), in order to maximize his expected utility written on his period $t + 1$ wealth, W_{t+1}, subject to its budget constraint. If we specialize the GIF manager utility function to have constant absolute risk aversion, we find in the solution that the GIF holdings of the jth emerging economy asset, $B_t^{f,j}$, is positively correlated to that country's asset expected excess return and negatively correlated with that country's asset conditional variance. Also, $B_t^{f,j}$ will be positively correlated with the excess return in a country $-j$ risky asset if the conditional covariance between the one period ahead exchange rates is positive. We can collect all other excess return terms except for the jth small emerging economy excess return in the variable ξ_t^j and write:

$$B_t^{f,j} = \phi^j \left(s_t^j - E_t \left(s_{t+1}^j \right) + \overline{r}_t^j - \overline{r}_t \right) + \xi_t^j \tag{6}$$

Demand for Goods in the Developed Country We will model the developed country's import for the jth emerging economy good as being generated by a representative firm that produces a consumption good using as inputs intermediary goods from all $J + 1$ countries.

Let Y_t^f be the total production of the final good in the developed country, $K_t^{f,f}$ be the amount of the intermediary good produced and used by the large developed country, and $K_t^{f,j}$ be the total amount of the jth emerging economy intermediary good used by the large developed country. Also, let $P_t^{f,*}$ and $P_t^{j,*}$ be the prices of the "developed" and "jth emerging" intermediary goods both measured in foreign currency (in other words, the international price of the intermediary goods) and assume that the production function of the representative firm is given by:

$$Y_t^f = A_t^f \left(K_t^{f,f} \right)^{\alpha} \prod_{j=1}^{J} \left(K_t^{f,j} \right)^{\gamma^j} \tag{7}$$

where $0 < \alpha < 1$, $0 < \gamma^j < 1$, $\sum_{j=1}^{J} \gamma^j = 1 - \alpha$ and A_t^f is a productivity shock term.

Total imports in the large developed country for "jth emerging" intermediary goods is a positive function of their total production of final goods and a negative function of real price of the intermediary good in foreign currency:

$$K_t^{f,j} = \gamma^j \frac{Y_t^f}{P_t^{j,*}} \tag{8}$$

2.1.3 Customer Flow in the Small Emerging Economy

The commercial flow is the excess demand for FX from customers that is generated by the trade in goods between a country and the rest of the world. For the small emerging economy j in our model, this is the value of the imports of intermediary goods from the large developed country minus the value of the exports of intermediary goods to the large developed country, measured in units of the foreign currency:

$$X_t^{C,j} = P_t^{f,*} K_t^{j,f} - P_t^{j,*} K_t^{f,j} \tag{9}$$

The financial flow is the excess demand for FX that is generated by the trade in assets between a country and the rest of the world. For the small emerging economy j in our model, it is composed by four terms:

$$X_t^{F,j} = B_t^{j,f} - (1 + r_{t-1}) B_{t-1}^{j,f} - B_t^{f,j} + \left(1 + r_{t-1}^j - s_t^j + s_{t-1}^j\right) B_{t-1}^{f,j} \tag{10}$$

The first two terms are the financial flow that is generated by domestic agents, where $B_t^{j,f}$ represents the amount young households are investing in the developed country and $(1 + r_{t-1}) B_{t-1}^{j,f}$ represents the amount that the old households are bring back from the developed country. The last two terms are the financial flow that is generated by the GIF, where $B_t^{f,j}$ is the amount that the young GIF manager is investing in the emerging economy and $\left(1 + r_{t-1}^j - s_t^j + s_{t-1}^j\right) B_{t-1}^{f,j}$ is the amount that the old GIF manager is bring back from the emerging economy.

Total customer flow in the small emerging economy j is simply the sum of the commercial flow, given by equation (9), and the financial flow, given by equation (10):

$$X_t^j = X_t^{C,j} + X_t^{F,j} \tag{11}$$

In order to simplify the expressions for total customer flow X_t^j described in equation (11) we can log linearize it with respect to the current exchange rate s_t^j, and all other macroeconomic variables such as the domestic and international interest rates, the domestic and international GDP, and the J small emerging economies excess return terms (for further simplification we will summarize all other domestic and international macroeconomic variables into one vector F_t^j):

$$X_t^j = \kappa_0^j + \kappa_1^j s_t^j + \kappa_2^j F_t^j \tag{12}$$

The important thing to notice in equation (12) is that the total customer flow is a negative function of the exchange rate:

$$\frac{\partial X_t^j}{\partial S_t^j} = -\left[\alpha^j \frac{Y_t^j}{\left(S_t^j\right)^2}\right] - \left[\frac{1}{\rho^j Var_t\left(s_{t+1}^j + r_t - r_t^j\right)} + \phi^j + B_{t-1}^{f,j}\right] \tag{13}$$

2.2 The FX Market

2.2.1 Description

In this section we will describe the interaction between customers and dealers in the FX market of a small emerging economy. Since we will be looking at just one small country, the superscript j that indexed each of the J emerging economies in the previous section will no longer be necessary. The trading model that we use has some key features of Lyons (1997): there are only two trading rounds, with the customer-dealer transactions being limited to the first round; trading with multiple partners is feasible; and it is a simultaneous trade model, which means that all demand schedules have to be submitted simultaneously. However, our model departs from Lyons (1997) and other FX microstructure models such as Evans and Lyons (2002) in a couple of ways. We have a competitive rational expectations equilibrium model: dealers can condition their orders on market clearing prices. Also, dealers receive an additional signal prior to the second round, after the first round is concluded. This signal tries to capture one characteristic of the inter-dealer trade in FX market: the readjustment of their desired FX holdings before the market closes using all new information that was collected during the day while markets were already open.

Our model also presents two important improvements relative to previous microstructure models. First, customer flow is not simply the realization of a random variable. In the previous subsection, we modeled this type of flow as a function of the exchange rate and other macroeconomic fundamentals. The second important improvement is that dealers FX holdings at the end of each trading day are not exogenously set (to zero, for example): dealers may optimally decide to hold overnight positions in the FX market. The desired amount will be determined by their profit functions and the expected overnight FX payoffs: the interest rate differential and the depreciation rate from one period to another.

This implies that the dealers in our model play two roles in the FX market: the first as intermediaries, matching buyers and sellers within a trading day, and the second as investors. Since the dealers' profits as investors in the FX market comes from the overnight payoff of their FX holdings, they behave in a manner very similar to the households from the previous subsection, which smoothed consumption using foreign assets generating the financial flow. However, it is important to notice that dealers differ from the financial investors since they may also profit from intra day transactions, that is, from potential movements of the exchange rate from the first trading round to the second. This will become clear in the next subsection when we present more specific details about the dealers problem.

2.2.2 Solution

There is an overlapping generation of a continuum of identical dealers in the FX market. Each dealer within his generation is indexed by $i \in [0,1]$ and "lives" for two periods. The young dealers are responsible for supplying the excess demand of the customer in a given period t. Let Q_t be the market wide level of FX inventory held by the dealers in period t and let X_t be the customer flow of the same period. Since a positive customer flow means that there is a positive excess demand for FX, we can write:

$$Q_t = Q_{t-1} - X_t \tag{14}$$

In each period t, trading occurs in two rounds. In the first round, each young dealer i trades with the old dealers and with its customers at the first round equilibrium price $s_{t,1}$. In the second and final trading round, each dealer i readjusts its inventory of FX by trading with other dealers. In the first round of the following period, $t+1$, the young dealer of generation t will sell all his positions, collect his profits, and exit the FX market. Let $Q^i_{t,1}$ and $Q^i_{t,2}$ be the FX holdings of dealer i after the first and the second trading rounds respectively. The dealer's profit function can be written as:

$$\Pi_{i,t} = Q^i_{t,1}\left(s_{t,2} - s_{t,1}\right) + Q^i_{t,2}\left(s_{t+1,1} + \overline{V} - s_{t,2}\right) \tag{15}$$

The first part of the profit function of dealer i from generation t is given by its first round holdings (the amount purchased from the old dealers and from his customers) times the change in the equilibrium exchange rate from the first to the second trading round, $s_{t,2} - s_{t,1}$. The second part is the payoff that he receives from its overnight FX holdings. This payoff is composed by the change in the exchange rate equilibrium price from the second round of period t until the first round of period $t+1$, $s_{t+1,1} - s_{t,2}$ (when he is going to sell his positions and exit the market), plus the constant overnight dividend $\overline{V}$ paid by the FX from period t to $t+1$. To simplify the calculations, we will assume from now on that $\overline{V} = 0$. All dealers maximize identical negative exponential utility defined over its profits, with constant coefficient of risky aversion θ.

Market clearing conditions imposes that the total amount of FX held by the young dealers at the end of the first round equals the total amount of FX sold by the old dealers exiting the market less the total amount demanded by customers:

$$\int_0^1 Q_{t,1}^i di = Q_{t-1} - X_t \tag{16}$$

Since dealers only trade with other dealers in the second and final round, the total amount of FX held by the dealers overnight has to be equal the total amount of FX at the end of the first round:

$$\int_0^1 Q_{t,2}^i di = Q_t \tag{17}$$

The information structure is the following. The realization of the macroeconomic fundamentals $F_t \sim N\left(\overline{F}, \sigma_F^2\right)$ is known before markets are opened. Customers observe it and decided how much FX they need to trade in the first round. After the first trading round and before the second trading round, each bank receives new information, in the form of a common signal. The signal, $F_t^c = F_{t+1} + \varepsilon_t^i$, with $\varepsilon_t \sim N\left(0, \sigma_\varepsilon^2\right)$, is correlated to the following period macroeconomic fundamentals and will affect the following period's customer flow.

Let $E_{t,j}\left(.\right)$ and $Var_{t,j}\left(.\right)$ be respectively the expectation and the variance of a random variable conditional on all information available in round j of period t. Given that, conditional on all information available at the first round, $s_{t,2}$ is normally distributed, and conditional on all information available at the second round, $s_{t+1,1}$ is also normally distributed, dealer i optimal FX holdings in each trading round will be given by:

$$Q_{t,1}^i = \frac{E_{t,1}\left(s_{t,2}\right) - s_{t,1}}{\theta Var_{t,1}\left(s_{t,2}\right)} \tag{18}$$

$$Q_{t,2}^i = \frac{E_{t,2}\left(s_{t+1,1}\right) + \overline{V} - s_{t,2}}{\theta Var_{t,2}\left(s_{t+1,1}\right)} \tag{19}$$

Proposition 1 *There are rational expectations equilibrium exchange rates for trading round 1 and trading round 2 within the class of functions of the form:*

$$s_{t,1} = \alpha_0 + \alpha_1 Q_{t-1} + \alpha_2 F_t \tag{20}$$

$$s_{t,2} = \beta_0 + \beta_1 Q_t + \beta_2 F_t^c \tag{21}$$

These prices are given by:

$$\alpha_0 = \beta_0 = -\kappa_0/\kappa_1 \tag{22}$$

$$\alpha_1 = \frac{\theta\kappa_2^2\sigma_F^2 + \kappa_1}{\theta\kappa_1\kappa_2^2\sigma_F^2} \tag{23}$$

$$\alpha_2 = -\frac{\theta\kappa_2^2\sigma_F^2 + \kappa_1}{\theta\kappa_1\kappa_2\sigma_F^2} \tag{24}$$

$$\beta_1 = -\frac{\beta_2}{\kappa_2\rho_F} - \theta\frac{\beta_2^2\sigma_\varepsilon^2}{\rho_F} \tag{25}$$

$$\beta_2 = -\frac{\theta\kappa_2^2\sigma_F^2 + \kappa_1}{\theta\kappa_1\kappa_2\left(\sigma_F^2 + \sigma_\varepsilon^2\right)} \tag{26}$$

Proof. *See appendix 2.* ■

Corollary 2 *The change in the exchange rate from the end of period $t-1$ to the end of period t can be written as:*

$$\Delta s_{t,2} = \beta_1 X_t + \beta_2 \Delta F_t^c \tag{27}$$

with $\beta_1 < 0$ and $\beta_2 > 0$ if the following condition is verified:

$$|\kappa_1| < \theta\kappa_2^2\sigma_F^2 \tag{28}$$

Proof. Equation (27) follows directly from equation (21) and equation (14). Also, since $\kappa_1 < 0$ and $\kappa_2 > 0$, then from equation (26) we can see that the only way $\beta_2 > 0$ is if condition (28) is satisfied. Finally, if $\beta_2 > 0$ then from equation (25) it is necessarily the case that $\beta_1 < 0$. ■

Keeping in mind that the exchange rate is defined as the amount of domestic currency necessary to purchase one unit of the foreign currency, $\beta_1 < 0$ and $\beta_2 > 0$ means that the exchange rate depreciates if there is pressure from customers to purchase FX from dealers ($X_t > 0$) or if the signal received by dealers indicates an increase in future customer demand ($\Delta F_t^c > 0$ could be interpreted, for example, as dealers becoming more pessimistic about the country risk premium in the following period). One final comment should be made about the condition that limits the sensitivity of the customer flow to exchange rate changes. Imagine an exogenous shock that increases the customer flow by $\overline{X}$. Given equation (27), this excess demand will depreciate the exchange rate. If κ_1 is negative, the exchange rate depreciation will feedback into the customer flow by reducing it. However, if the magnitude of the feedback effect is large enough, the decrease in the customer flow can be so strong that it will generate a negative customer flow larger than the initial shock $\overline{X}$, which will generate a subsequent appreciation of the exchange rate even larger in magnitude than the original depreciation.

3 Dataset

3.1 Description

The dataset used in this paper contains transaction flows between dealers 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, and covers 100% of the official Brazilian FX market, one of the largest emerging economies. If compared to other datasets presented in previous studies, this is unique in at least two ways. First, it is the only one that covers 100% of a country's FX market. Second, while other studies are looking at the exchange rate between currencies from two developed countries, this is the first that covers an emerging economy.

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 FX. The detailed information inputted by the FX dealers into the SISBACEN is only observed by the central bank. After some considerable delay, some summary data aggregated in a lower time frequency is released to the dealers 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 level FX inventory. 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, that is, 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. 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. All FX flows will be measured in US$ billions.

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.

3.2 First Look at the Data

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. 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). 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 give us a taste of the role played by endogeneity: on the one hand, exchange rate movements affect the price of foreign goods and assets and therefore affect the customer order flow; on the other hand, demand pressures for FX affect the exchange rate. This is the opposite result compared to two previous studies. Evans 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. These studies interpret the positive correlation from the FX liquidity suppliers point of view: pressure to buy FX increases the price charged by dealers. In our case, the negative correlation found in the sample period is more likely to be explained by the point of view of the agents who are demanding the FX liquidity: as the exchange rate slowly depreciates, customers' demand for foreign currency slowly decreases, as a result for example of smaller imports and higher exports. Figure 2 shows the behavior of the commercial customer flow during the sample period and its negative correlation with the exchange rate confirms our intuition. However, we can also notice that in periods where sharp increases in customer order flow are observed there are spikes in the exchange rate (second half of 2001 and second half of 2002, when lower confidence in the Brazilian economy generated large portfolio outflows), as a result of dealers setting a higher price to supply the excess demand for FX coming from the financial customers. This positive correlation between financial customer flow and the exchange rate can be seen in figure 3.

In order to get a more formal sense on the presence of endogeneity in our dataset, we present two sets of empirical evidence. First, we run bivariate Granger causality tests between exchange rate movements and each type of order flow separately (commercial, financial and interventions). The lag length of each bivariate VAR is based on the Schwarz information criterion. 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 results). 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. However, 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” .

The second set of evidence is provided by running single equation OLS regressions using the first difference of the log of the exchange rate as the dependent variable and the total customer flow from the retail market as a regressor. Note that this regression is comparable to Evans and Lyons (2002), even though their dependent variable is interdealer order flow and not customer order flow. In their model, interdealer order flow should be a multiple of the customer initiated transactions. Since in our dataset the transactions between dealers and customers were initiated by the customers, we should expect a similar result from their paper: a positive and significant coefficient indicating that pressure to buy increases the price of FX. However, our estimated coefficient is negative, and it is significant at the 1% significance level if we do not include any controls, and not significant at the 5% significance level if we also include the first differences of the domestic interest rate, the foreign interest rate and the measure of the Brazilian country risk premium (see table 3 for detailed results). What does this result mean? That pressure to buy in the retail FX market does not increase the FX price or that the demand for FX in the retail market decreases as a result of an increase in the price of FX? Almost certainly, both interpretations are wrong. The coefficient in the OLS regression is most likely biased towards zero because of the presence of endogeneity, and therefore it does not have any economic meaning.

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 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. Since the balance of payments summarizes in a systematic way all transactions between residents and non residents, a good way to check the quality of the dataset is to compare our customer flow data with its balance of payments equivalent. In order to do this comparison, we must find the balance of payments measure of change in the country’s inventory of FX. 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. The customer flow represents the amount of payments that exceeds revenues in the transactions between non-dealer residents with non residents. Therefore, it should equal to 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 (since the central bank is not a customer from the FX retail market).

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 billions 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 4 compares the customer flow from the FX retail market with the measure of payments imbalances calculated using the balance of payments. Figure 5 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 3).

A final issue still related to the fact that dealers supply liquidity overnight instead of netting out their inventories to zero is whether they are making profits or losses from these positions and from which counterparty are these profits or losses coming from. It is important to notice that these 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 arises only from the change in the price of the asset he is trading. We want to have an estimate of whether, when dealers hold more FX than the usual in a given day, does the price of FX in average goes up (profits) or down (losses) in the next day.

We calculate these "speculative" profits using the methodology described in Hau (2005). Let X_t^i be the daily aggregate demand of counterparty i (commercial customers, financial customers or the central bank). Now imagine that there is a representative counterparty i through the sample period and define $Q_t^i = \sum_{t=1}^{T} X_t^i$ as his inventory of FX. Let $\overline{Q}^i = \frac{1}{T}\sum_{t=1}^{T} Q_t^i$ be the long run average inventory and $\widetilde{Q}_t^i = Q_t^i - \overline{Q}^i$ be the daily deviation of the representative counterparty i from its long run average. Finally, let s_t be the exchange rate. The total profit of the representative counterparty i is given by:

$$\Pi^i = \sum_{n=1}^{T} \widetilde{Q}_t^i \Delta s_t \tag{29}$$

Since the dealer is the counterparty of these agents, then if representative counterparty i is making profits, it is the case that the dealers are having losses by trading with them. Therefore, the dealers' aggregate profit is the sum of the losses of the representative commercial customer, financial customer and central bank. Also note that if the dealers ended every day with the same average inventory, their aggregate "speculative" profits would necessarily be zero. The results tell us that the commercial customers are having losses, and that the financial customers and the central bank are having profits. However, the magnitude of commercial customers' losses is greater than the sum of the financial customers and the central bank profits. Therefore, dealers are also having profits. In order to have an idea of the relative size of the profits dealers make, we divide their overall profit by the average absolute size of the daily aggregate flow. The result is that for each dollar that the dealers supplied overnigth, they made a daily profit of 0.035%, or a 9.3% annualized profit rate.

4 Empirical Evidence

4.1 Estimation Strategy

Let Δs_t be the daily change in the spot exchange rate, X_t be the customer order flow and Z_t be a set of other macroeconomic variables to be specified later. The main objective of this section is to estimate the positive effect of customer flow on exchange rates, predicted by the model developed in this paper, incorporated by the coefficient α in the following equation:

$$\Delta s_t = \alpha X_t + \Phi Z_t + \varepsilon_t \tag{30}$$

However, in order to obtain a consistent estimate of α we have to take into account the simultaneous determination between customer flow and exchange rate:

$$\begin{bmatrix} 1 & \alpha_{12} \\ \alpha_{21} & 1 \end{bmatrix} \begin{bmatrix} \Delta s_t \\ X_t \end{bmatrix} = \Phi Z_t + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{bmatrix} \tag{31}$$

The identification strategy applied in this paper is to include in the vector Z_t all possible sources of common shocks that may affect simultaneously both variables and then to rely on the independency of the structural innovations. Since the vector of common shocks also includes as regressors lags of the endogenous variables, we estimate a Structural VAR, introduced by Sims (1986). However, independency of the structural innovations does not add enough restrictions for us to identify the system. The second part of the estimation strategy is to disaggregate X_t, the customer order flow, in X_t^F, the financial customer flow, and X_t^C, the commercial customer flow. At a first glance, this move does not seem to be effective since it adds more unknowns to be estimated into the system:

$$\begin{bmatrix} 1 & \alpha_{12} & \alpha_{13} \\ \alpha_{21} & 1 & \alpha_{23} \\ \alpha_{31} & \alpha_{32} & 1 \end{bmatrix} \begin{bmatrix} \Delta s_t \\ X_t^F \\ X_t^C \end{bmatrix} = \Phi Z_t + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \end{bmatrix} \tag{32}$$

With the assumption that innovations $\varepsilon_{i,t}$, $i = 1, 2, 3$, are independent we can identify only 3 out of the 6 endogenous coefficients in the system. But we can use non-sample information to impose further restrictions on these coefficients. Based on the model developed in this paper, two additional restrictions to be made are:

a. The contemporaneous effects of the financial customer flow and the commercial customer flow on the exchange rate are not different. In other words: $\alpha_{12} = \alpha_{13}$.

b. The financial customer flow and the commercial customer flow do not affect each other contemporaneously. In other words: $\alpha_{23} = 0$ and $\alpha_{32} = 0$;

Restriction (a) is justified by the fact that what generates the price effect in our model is the change in the dealers' aggregate inventory at the market wide level; and it does not matter where the change comes from. Restriction (b) does not mean that the commercial customer flow and the financial customer flow are not correlated at the daily frequency. Indeed, common sources of shocks may affect both types of flows simultaneously, such as changes in the exchange rate, in the domestic and foreign interest rates, in the country risk premium and also past shocks to customer flows. However, once we control for these potential sources of common shocks, our model tells us that the decision to trade goods with non-residents is independent of the decision to trade assets with a non-resident. In the real world, these decisions are made by different types of agents, with different objectives.

Given these two additional non-sample restrictions based on the theoretical model developed in this paper, our model becomes just-identified:

$$\begin{bmatrix} 1 & \alpha_{12} & \alpha_{12} \\ \alpha_{21} & 1 & 0 \\ \alpha_{31} & 0 & 1 \end{bmatrix} \begin{bmatrix} \Delta s_t \\ X_t^F \\ X_t^C \end{bmatrix} = \Phi Z_t + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \end{bmatrix} \tag{33}$$

4.2 Estimation Output

The set of exogenous variables included as regressors are the first differences of the domestic interest rate, Δr_t, the first difference of the foreign interest rate, Δr_t^*, and the first difference of the Brazilian risk premium (introduced in the previous section), Δrp_t, and two other sets of deterministic variables, weekday dummy variables and month dummy variables:

$$A_0 y_t = \sum_{j=1}^{p} A_j y_{t-j} + \sum_{j=0}^{p} B_j Z_{t-j} + \text{dummies}_t + \varepsilon_t \tag{34}$$

where the vectors of endogenous and exogenous variables are given by (table 4 shows that we can reject the presence of a unit root in all these variables):

$$y_t = \begin{bmatrix} \Delta s_t & X_t^F & X_t^C \end{bmatrix}' \tag{35}$$

$$Z_t = \begin{bmatrix} \Delta r_t & \Delta r_t^* & \Delta rp_t \end{bmatrix}' \tag{36}$$

and the matrices associated to the exogenous variables are:

$$A_1 = \begin{bmatrix} \alpha_{11}^i & \alpha_{12}^i \\ \alpha_{21}^i & \alpha_{22}^i \\ \alpha_{31}^i & \alpha_{32}^i \end{bmatrix} \tag{37}$$

$$B_j = \begin{bmatrix} b_{11}^j & b_{12}^j & b_{13}^j \\ b_{21}^j & b_{22}^j & b_{23}^j \\ b_{31}^j & b_{32}^j & b_{33}^j \end{bmatrix} \tag{38}$$

and the matrix of contemporaneous relations is:

$$A_0 = \begin{bmatrix} 1 & \alpha_{12}^0 & \alpha_{12}^0 \\ \alpha_{21}^0 & 1 & 0 \\ \alpha_{31}^0 & 0 & 1 \end{bmatrix} \tag{39}$$

Before we start our estimation procedure we should comment the fact that we treat the domestic interest rate and the country risk premium as exogenous variables. This 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 does 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 supply of money. The dashed line in figure 6 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) 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.

The first step of the estimation procedure is to choose the most appropriate value for p in equation (34), which gives us the lag length of the endogenous variables in the VAR. For simplicity, we also set the lag length of the exogenous variables equal to p. This choice is made by estimating 5 different versions of equation (34), each with a different value for p, varying from 1 to 5. Then, for each choice of p we compare the Akaike and Schwarz information criteria, we perform lag length exclusion tests on the endogenous variables and we test for serial correlation in the residual. All results indicate that the most appropriate choice is a value of p equal to 2 (see table 5 for detailed information criteria and tests statistics).

The second step is to estimate the reduced form VAR (estimated coefficients and standard errors presented in table 6). Finally, using the variance-covariance matrix of the reduced form residuals and the restriction discussed in the estimation strategy description, we can estimate the matrix A_0 in equation (34). 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 7):

$$\Delta s_t = 0.027\left(X_t^F + X_t^C\right) + e_{1t} \tag{40}$$

$$X_t^F = -11.06\Delta s_t + e_{2t} \tag{41}$$

$$X_t^C = -4.61\Delta s_t + e_{3t} \tag{42}$$

The estimated slope α_{12}^0 associated with the supply curve is 2.7%. This means that in order to meet a US$ 10 millions customer order flow, the dealers of the FX market increase the FX price by approximately 0.03%. The coefficient α_{21}^0 refers to the response of the financial customer flow to exchange rate movements: a 1% appreciation in the exchange rate increases customers' demand for foreign exchange associated with the trade of assets by US$ 111 millions. Finally, the coefficient α_{31}^0 refers to the response of the commercial customer flow to exchange rate movements: a 1% appreciation in the exchange rate increases the customers' demand for foreign exchange associated with the trade of goods by US$ 46 millions. These estimates are robust to the choice of the VAR lag length. In order to show that, table 7 also presents the estimated matrix of endogenous relationships A_0 for 5 different VAR's, with lag lengths varying from 1 to 5. As we change the lag length of the VAR, the estimated value for each coefficient only changes marginally (difference is less than 1 standard error) and all of them remain significant at 1%.

We can compare the coefficient of our supply curve with the Evans and Lyons (2002) finding that a US$ 1 billion of net dollar purchase in the wholesale FX market increases the deutsche mark price of a dollar by 0.54%. Although both estimates are not directly comparable, since we use customer flow and Evans and Lyons use inter-dealer order flow, a couple of reasons might explain why our coefficient is 5 times the other. First, because the real/dollar market is a much smaller FX market both in terms of volume or liquidity than the dollar/deutsche mark, it should be easier for a dealer to rebalance its portfolio in the latter FX market rather than in the former. Therefore, it is natural for the price impact of a trade to be larger in the smaller and less liquid market. Second, the exchange rate in an emerging economy is much more volatile than in a developed economy and the riskier is the asset, the larger is the price change required for a risk averse agent to hold it. To illustrate so, we compare the coefficient of variation of the real/dollar price with the coefficient of variation of the euro/dollar price during the sample period (we use the euro and not the deutsche mark since our sample period starts in the July 1st, 1999). The coefficient of variation is 25.2% for the real/dollar, about three times the coefficient of variation for the euro/dollar, of 8.6%.

We can also look at the summary statistics presented in table 1 so that we can have an idea whether the magnitude of the estimated price effect is compatible with the daily behavior of the exchange rate observed in the sample period. The standard deviation of the daily customer flow (financial plus commercial) is US$ 184 millions. A customer flow of this magnitude would depreciate the exchange rate in 0.50%, which is less than half of the daily standard deviation of the depreciation rate (1.08%). If we look at the average of the absolute values of daily movements in the variables we still find the same result. The average absolute value of the daily customer flow is US$ 134 millions. According to our estimate, a customer flow of this magnitude would depreciate the exchange rate by 0.36%, which is also less than half of the average daily absolute variation in the exchange rate (0.75%).

The magnitudes of the contemporaneous effects of the exchange rate on the financial and commercial flows are also compatible with their daily behavior during the sample period. The daily standard deviation of the depreciation rate is 1.08%. Our estimated coefficients tell us that 1.08% exchange rate depreciation decreases the financial flow by US$ 120 millions and the commercial flow by US$ 50 millions. These effects are also about half of the daily standard deviation of the financial flow (US$ 206 millions) and of the commercial flow (US$ 96 millions). Results do not change if we look at the average of the absolute value of the daily flows. The average of the absolute daily variation on the exchange rate is 0.75%. A depreciation of this magnitude decreases the financial flow US$ 83 millions and the commercial flow by US$ 35 millions. These effects are significantly smaller than the daily average of the absolute values of daily financial flow (US$ 133 millions) and commercial flow (US$ 83 millions).

In order to look at the dynamic effects of the shocks, figure 7 shows two sets of impulse response functions. The top two graphs are the responses of the depreciation rate to a one standard deviation shock on the financial customer flow (graph on the left) and on the commercial customer flow (graph on the right). Both impulse responses present the same pattern. A positive shock of one standard deviation in either the financial or the commercial 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 the SVAR, the initial depreciation becomes a small appreciation. A few periods later, the effect on the depreciation rate disappears. This means that the effect of the financial and commercial customer flows on the level of the exchange rate is permanent.

The lower set of graphs in figure 7 shows the dynamic effects of a one standard deviation exchange rate depreciation shock on the financial customer flow (graph on the left) and on the commercial customer flow (graph on the right), still based on the same SVAR. Once again, both 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 both the financial and the commercial 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.

4.3 Test of Overidentifying Restrictions

The estimates presented in this section were identified using two important theoretical restrictions on the coefficients: (a) the financial customer flow and the commercial customer flow do not affect each other contemporaneously; and (b) the contemporaneous effects of the financial customer flow and the commercial customer flow on the exchange rate are not different, since what matters is the aggregate change in dealers market wide inventory level. Since the system was just-identified, we were not able to test these restrictions. In this subsection, we include in the system central bank intervention flows so that we are able to perform a test of overidentifying restrictions.

Since we don't have any a priori theoretical restriction about the central bank behavior, we will first let it be affected by all other endogenous variables. However, based on our theoretical model, we will still assume the following restrictions:

a. The contemporaneous effects of the financial customer flow, the commercial customer flow and the central bank intervention flow on the exchange rate are not different.

b. The financial customer flow and the commercial customer flow do not affect each other contemporaneously and are not affected by the central bank intervention flows.

Restriction (a) is still justified by the fact that what generates the price effect in our model is the change in the dealers' aggregate inventory at the market wide level; and it does not matter where the change comes from. Restriction (b) means that, once we control for these potential sources of common shocks, the decision to trade goods with non-residents and the decision to trade assets with a non-resident are independent of each other and also independent of the central bank interventions.

With this set of restrictions, the system is still just identified:

$$A_0 y_t = \sum_{j=1}^{p} A_j y_{t-j} + \sum_{j=0}^{p} B_j Z_{t-j} + \text{dummies}_t + \varepsilon_t \tag{43}$$

where the vectors of endogenous and exogenous variables are now given by:

$$y_t = \begin{bmatrix} \Delta s_t & X_t^F & X_t^C & X_t^{CB} \end{bmatrix}' \tag{44}$$

$$Z_t = \begin{bmatrix} \Delta r_t & \Delta r_t^* & \Delta rp_t \end{bmatrix}' \tag{45}$$

and the matrix of contemporaneous relations is:

$$A_0 = \begin{bmatrix} 1 & \alpha_{12} & \alpha_{12} & \alpha_{12} \\ \alpha_{21} & 1 & 0 & 0 \\ \alpha_{31} & 0 & 1 & 0 \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & 1 \end{bmatrix} \tag{46}$$

Table 8 shows different sets of statistics that help us to once again choose the most appropriate lag length of the new VAR (which now includes central bank interventions). The Schwarz information criterion is the only statistic that indicates a lag length of 1. The Akaike information criterion, the lag length exclusion tests on the endogenous variables and the test for serial correlation in the residuals all suggest that we include two lags of the variables in the VAR. Table 9 shows the estimation output of the VAR(2). Based on the residuals of the VAR(2) and on the identifying restriction imposed, we estimate the matrix of contemporaneous relations A_0 in equation (43). Table 10 reports the obtained results. We can notice from the results that all coefficients are significant at the 1% significance level except for one: the central bank intervention flows are not affected by the behavior of the commercial customer flow. Therefore, we can naturally set an additional restriction, $a_{43} = 0$, which turns the system into an over-identified one:

$$A_0 = \begin{bmatrix} 1 & \alpha_{12} & \alpha_{12} & \alpha_{12} \\ \alpha_{21} & 1 & 0 & 0 \\ \alpha_{31} & 0 & 1 & 0 \\ \alpha_{41} & \alpha_{42} & 0 & 1 \end{bmatrix} \tag{47}$$

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 11):

$$\begin{aligned} \Delta s_t &= 0.030\left(X_t^F + X_t^C + X_t^{CB}\right) + e_{1t} && (48) \\ X_t^F &= -8.35\Delta s_t + e_{2t} && (49) \\ X_t^C &= -4.80\Delta s_t + e_{3t} && (50) \\ X_t^{CB} &= -2.67\Delta s_t - 0.23X_t^F + e_{4t} && (51) \end{aligned}$$

First, we can note that the results obtained in the previous subsection, without central bank interventions, are still very similar. In order to meet a US\$ 10 millions customer flow, the dealers increase the FX price by approximately 0.03%; and a 1% depreciation in the exchange rate decreases the demand for FX associated with the trade of assets by approximately US\$ 84 millions and the demand for foreign exchange associated with the trade of goods by approximately US\$ 48 millions. Second, 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: a 1% depreciation in the exchange rate is associated with a US\$ 28 millions sell from the central bank to dealers and a US\$ 100 millions financial customer flow is associated with a US\$ 23 millions 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 0.445, which means that we cannot reject the null hypothesis. In order words, the data does not reject all restrictions imposed in order to identify the coefficients.

5 Role of the FX Derivatives Market

When a dealer supplies its customers' foreign currency needs, there is a change in his cash balances that may or may not be in the desired direction. If it is not, the dealer will try to offset it until the end of the day through operations using not only the wholesale market but also the derivatives market. The derivative market allows the dealer to fully or partially share the risk of an unwanted position using FX derivatives, the most common being futures and swaps. However, the dealers' choice of which market to use does not significantly affect the relationship between the customer flow and its price effect. This claim is based on two main reasons.

The first reason is that a no arbitrage condition relates the FX spot price to the price of its derivatives. The two main products in the FX derivative market are swaps and future contracts, and the relation between their prices and the FX spot price is given by simple applications of the covered interest rate parity.[3] The second reason is that the derivatives market does not generate significant cash flows. This condition is important because the transactions in the wholesale FX market do not generate any cash flow since dealers are trading with themselves (even though they generate order flow, which is "signed" transaction flow). If the derivative market generated significant cash flows, then the choice of which market the dealer uses would no longer be innocuous. Given an initial amount of customer flow, if dealers fully shared the risks using only the wholesale market, the only flows of that day would be those of the original customer flows. However, if dealers decided to share the risks using only the derivative markets, and if the transactions of this market generated subsequent cash flows, the effects of these new flows would have to be taken into account and probably a different final price effect would be verified.

The only flows that are generated by the derivative market are those related to margin calls and daily mark-to-market price adjustments. This statement can be checked if we look closer at the two main derivative products, swaps and future contracts. Swaps do not generate any other cash flow, not even order flow, since they bundle two transactions that

[3] See Hull (2003) for a summary of no-arbitrage relations between the spot FX price and its derivatives' prices.

go in opposite directions. Future contracts do generate order flow and they could potentially generate cash flows in their liquidation date, when delivery should occur. However, all contracts in the Brazilian future market are financially liquidated, which means that delivery does not occur and payments are calculated with a transaction with the same characteristics, but with "reversed" direction.

In order to illustrate the insignificance of the cash flows generated by the FX derivatives market, we can present in figure 8 the balance of payments figures for the Brazilian economy between July 1999 and June 2003. The account "Financial Derivatives" includes the financial flows relative to the liquidation of assets and liabilities due to transactions in the derivative markets. It refers to the flows generated in all financial derivatives markets, and not only to the FX derivates market. Nevertheless, we can see from figure 5 that the flows from this account are practically insignificant relative to the change in dealers inventories, registered in the account "Other Investments – Currency and Deposits" .

6 Conclusion

The objective of this paper is to contribute to the understanding of the FX retail market, the behavior of the customer flow and its impact on the exchange rate dynamics. This contribution is both theoretical and empirical. First, we write a model with two major changes relative to previous microstructure models. First, customer flow is not simply the realization of a random variable. Instead, we move towards a general equilibrium model where customers' demand for FX is influenced by many macroeconomic fundamentals, including contemporaneous changes in the exchange rate. Second, dealers' FX holdings at the end of each trading day are not exogenously set (to zero, for example). Instead, they may optimally decide to hold overnight positions in the FX market, depending on the expected overnight FX payoffs: the interest rate differential and the depreciation rate. This second modification implies that dealers from the Brazilian FX market do not simply behave as intermediaries, matching buyers with sellers within a trading day: if in a given day the volume that customers need to buy do not match the volume customers need to sell, the dealer may supply the extra liquidity if he thinks that it is optimal to do so. In other words, the FX liquidity supplied by dealers in our model is not limited to the intraday frequency: they are also allowed to provide overnight liquidity. Our model describes a two-way relationship between customer flow and the exchange rate. On the one hand, the need for FX liquidity is decreasing on its price: the more appreciated is the exchange rate, the cheaper are foreign goods and assets and higher is the demand for foreign currency. On the other hand, there is a positively sloped FX supply curve that is explained by a portfolio balance effect. Since dealers are risk averse, they will charge a risk premium to supply the needed FX liquidity and end the trading day with an inventory level lower than initially desired. This premium takes the form of a price change and the exchange rate depreciates.

Then, we estimate the predictions of the model using a dataset contains transaction flows from the Brazilian FX retail market between dealers 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, and covers 100% of the official Brazilian FX market, one of the largest emerging economies. In order to identify the endogenous relationship between customer flow and exchange rate, we use a Structural VAR approach, taking advantage of the information we have about the type of customer that is trading with in the dealer. The most important specifying assumption is that the financial customer flow and the commercial customer flow do not affect each other contemporaneously. This does not mean that the commercial customer flow and the financial customer flow are not correlated at the daily frequency. Macroeconomic variables such as the domestic and foreign interest rate, the country risk premium and, specially, the exchange rate may affect both types of flows simultaneously. However, once we control for these potential sources of common shocks, our model tells us that the decision to trade goods with non-residents is independent of the decision to trade assets with a non-resident. In the real world, these decisions are made by different types of agents, with different objectives: on one hand, the trade in assets is based on their expected payoffs (dividends and price changes); on the other hand, the trade in goods is based on the utility of provided by the good, if it is a final good, or its contribution to the production of another good.

Given this identification strategy, we estimate that in order to meet a US$ 1 billion customer order flow, dealers increase the real price of a dollar by approximately 2.7%. We also find that a 1% depreciation rate decreases the financial customer flow by US$ 111 millions and the commercial flow by US$ 46 millions. 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.

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A Detailed Derivation of Customer Flow

A.1 The Small Emerging Economy

Households The representative household problem can be written as:

$$\max_{C_{y,t}^j, C_{o,t+1}^j} u\left(C_{y,t}^j\right) + \beta E_t\left(u\left(C_{o,t+1}^j\right)\right) \tag{52}$$

$$\text{subject to } C_{o,t+1}^j = \left(1+r_t^j\right)\left(W_t^j + \Pi_t^j + T_t^j - C_{y,t}^j\right) + B_t^{j,f}\left(s_{t+1}^j - s_t^j + r_t - r_t^j\right) \tag{53}$$

$$u(C) = -\exp\left(-\rho^j C\right) \tag{54}$$

The first order condition of the representative household problem with respect to $C_{y,t}^j$ derives the well-known Euler equation:

$$u'\left(C_{y,t}^j\right) = \beta\left(1+r_t^j\right)E_t\left(u'\left(C_{o,t+1}^j\right)\right) \tag{55}$$

and the first order condition with respect to $B_t^{j,f}$ determines the optimal demand of the representative household from the jth small emerging economy for the foreign bond:

$$B_t^{j,f} = \frac{E_t\left(s_{t+1}^j\right) - s_t^j + r_t - r_t^j}{\rho^j Var_t\left(s_{t+1}^j\right)} \tag{56}$$

Given equation the budged constraint and $B_t^{j,f}$, the optimal demand of the representative household from the jth small emerging economy for its own country's asset is:

$$B_t^{j,j} = W_t^j + \Pi_t^j + T_t^j - C_{y,t}^j - S_t^j B_t^{j,f} \tag{57}$$

Intermediary Goods Sector Since there is perfect competition in the intermediary good sector of the jth emerging country, the profit maximization problem of the firm in the intermediary good sector is:

$$\max_{L_t^j} P_t^j \delta_t^j \left(L_t^j\right)^{\eta^j} - W_t^j L_t^j \tag{58}$$

where W_t^j is the wage and P_t^j is the domestic price of the domestic intermediary good.

The first order condition of the firms' problem determines the demand for labor. Since the supply of labor in the jth emerging economy is perfectly inelastic (let's normalize the supply to one), setting the demand for labor equal to its supply $L^{s,j} = 1$ determines the equilibrium wage $\overline{W}_t^j$, and the total supply of the intermediary good $K_t^{s,j}$ for the jth emerging economy:

$$\overline{W}_t^j = \eta^j P_t^j \delta_t^j \tag{59}$$

$$K_t^{s,j} = \delta_t^j \tag{60}$$

Final Goods Sector Given perfect competition in the final good sector, the representative firm solves the following problem:

$$\max_{K_t^{j,f}, K_t^{j,j}} A_t^j \left(K_t^{j,f}\right)^{\alpha^j} \left(K_t^{j,j}\right)^{1-\alpha^j} - P_t^f K_t^{j,f} - P_t^j K_t^{j,j} \tag{61}$$

The first order conditions with respect to $K_t^{j,f}$ and $K_t^{j,j}$ determine the optimal demands of the jth small emerging economy for both types of intermediary goods:

$$K_t^{j,f} = \alpha^j \frac{Y_t^j}{P_t^f} \tag{62}$$

$$K_t^{j,j} = \left(1-\alpha^j\right) \frac{Y_t^j}{P_t^j} \tag{63}$$

Equations (62) and (63) say that the optimal demand for each intermediary good is negatively related to the its domestic price and positively related to the final good production in that country.

Government The government of the jth small emerging economy issues the one period bond. Given an exogenous interest rate, the government is ready to issue as many bonds as demanded both by domestic and foreign agents. It runs a balanced budget every period by transferring to (or collecting from) the young representative household the necessary resources. Let D_t^j be the total liabilities of the government in the jth small emerging economy (or the total amount of bonds issued) in period t. We can write the government's net transfer T_t^j to the young representative household as:

$$T_t^j = \Delta D_t^j - r_{t-1}^j D_{t-1}^j \tag{64}$$

A.2 The Large Developed Country

Demand for Assets in the Developed Country The GIF manager of generation t chooses $B_t^f = \left[B_t^{f,1}, B_t^{f,2}, ..., B_t^{f,J}\right]'$, where $B_t^{f,j}$ is the amount invested in the jth small emerging economy asset (measured in units of the developed country final good), in order to maximize his expected utility written on his period $t+1$ wealth, W_{t+1}, subject to its budget constraint. Defining $Z_t^j = 1 + r_t^j + s_t^j - s_{t+1}^j$, $Z_t' = \left[Z_t^1, Z_t^2, ..., Z_t^J\right]$ and $1_J' = [1, 1, ..., 1]_{1\times J}$, the budget constraint of the GIF of generation t is:

$$W_{t+1} = (1 + r_t)\left(W_t - 1_J' B_t^f\right) + Z_t' B_t^f \tag{65}$$

If we specialize the GIF manager utility function to have constant absolute risk aversion, its problem becomes :

$$\begin{aligned} & \max_{B_t^f} E_t\left(-\exp\left(-\rho W_{t+1}\right)\right) \\ \text{subject to} \quad : \quad & W_{t+1} = (1 + r_t)\left(W_t - 1_J' B_t^f\right) + Z_t' B_t^f \end{aligned} \tag{66}$$

The vector of gross returns is normally distributed, $Z_t \sim N\left(\overline{Z}, \Sigma_z\right)$ (note that we are still assuming that s_{t+1}^j, conditional on all information available in period t, is normally distributed). The normal-CARA set up allows us to write:

$$E_t\left(-\exp\left(-\rho W_{t+1}\right)\right) = -\exp\left\{-\rho\left[E_t\left(W_{t+1}\right) - \frac{\rho}{2} Var_t\left(W_{t+1}\right)\right]\right\} \tag{67}$$

where:

$$E_t\left(W_{t+1}\right) = (1 + r_t)\left(W_t - 1_J' B_t\right) + \overline{Z}' B_t^f \tag{68}$$

$$Var_t\left(W_{t+1}\right) = \left(B_t^f\right)' \Sigma_Z B_t^f \tag{69}$$

The first order condition of this problem is:

$$E_t\left(-\exp\left(-\rho W_{t+1}\right)\right)(-\rho)\left[\overline{Z} - (1 + r_t) 1_J - \rho \Sigma_Z B_t^f\right] = 0 \tag{70}$$

Solving the first order condition for the vector of asset holdings B_t^f yields the following solution:

$$B_t^f = (\rho\Sigma_Z)^{-1}\left[\overline{Z} - (1+r_t)\,1_J\right] = (\rho\Sigma_Z)^{-1}\begin{bmatrix} s_t^1 - E_t\left(s_{t+1}^1\right) + r_t^1 - r_t \\ s_t^2 - E_t\left(s_{t+1}^2\right) + r_t^2 - r_t \\ \vdots \\ s_t^J - E_t\left(s_{t+1}^J\right) + r_t^J - r_t \end{bmatrix} \tag{71}$$

Equation (71) says that the GIF holdings of the jth emerging economy asset, $B_t^{f,j}$, is positively correlated to that country's asset expected excess return, $s_t^j - E_t\left(s_{t+1}^j\right) + r_t^j - r_t$, and negatively correlated with that country's asset conditional variance. Also, $B_t^{f,j}$ will be positively correlated with the excess return in a country $-j$ risky asset, $s_t^{-j} - E_t\left(s_{t+1}^{-j}\right) + r_t^{-j} - r_t$, if the conditional covariance between the one period ahead exchange rates is positve. We can write the explicit expression for the GIF holdings of the jth emerging economy asset as:

$$B_t^{f,j} = \sum_{k=1}^{J} \phi^k\left(s_t^k - E_t\left(s_{t+1}^k\right) + r_t^k - r_t\right) \tag{72}$$

where the parameters ϕ^k, $k = 1, ..., J$, are functions of the entries of the matrix of variance-covariance Σ_Z of the one period ahead exchange rates. In order to further simplify equation (72) we can collect all other excess return terms except for the jth small emerging economy excess return in the variable ξ_t^j and write:

$$B_t^{f,j} = \phi^j\left(s_t^j - E_t\left(s_{t+1}^j\right) + r_t^j - r_t\right) + \xi_t^j \tag{73}$$

Demand for Goods in the Developed Country Assuming perfect competition in the developed country market of final goods, the representative firm's problem can be written as:

$$\max_{K_t^{f,f},K_t^{f,j}} A_t^f\left(K_t^{f,f}\right)^{\alpha}\prod_{j=1}^{J}\left(K_t^{f,j}\right)^{\gamma^j} - P_t^{f,*}K_t^{f,f} - \sum_{j=1}^{J} P_t^{j,*}K_t^{f,j} \tag{74}$$

The first order condition with respect to $K_t^{f,j}$ determines the total amount of the "jth emerging" intermediary good demanded by the large developed country:

$$K_t^{f,j} = \gamma^j\frac{Y_t^f}{P_t^{j,*}} \tag{75}$$

Equation (75) tells us that the total demand in the large developed for "jth emerging" intermediary goods is a positive function of their total production of final goods and a negative function of the international price of the intermediary good.

A.3 Market Clearing in the Small Emerging Economy

Asset Market Since the government of the jth small emerging economy is willing to issue as much one-period bonds as it is demanded from both domestic and foreign representative households, the government's total liabilities D_t^j will be equal to the total amount of the jth emerging economy asset demanded by its own residents $B_t^{j,j}$ and by the residents of the large developed country $B_t^{f,j}$:

$$D_t^j = B_t^{j,j} + B_t^{f,j} \tag{76}$$

where $B_t^{j,j}$ is given by equation (57) and $B_t^{f,j}$ is given by equation (73).

Intermediate Good Market Since there is free trade in the intermediary goods market, the domestic prices of the jth small emerging economy intermediary good, K_t^j, is simply its international prices calculated in terms of its final good:

$$P_t^j = S_t^j P_t^{j,*} \tag{77}$$

The international price of the jth small emerging economy intermediary good has to be such that the total amount supplied by the firm in the intermediary sector, given by $K_t^{s,j}$ in equation (60), equals the demand from the domestic and foreign firms in the final sector, given by $K_t^{j,j}$ equations (63) and by $K_t^{f,j}$ in equation (75):

$$\begin{aligned} \delta_t^j &= \left[(1-\alpha_j) \frac{Y_t^j}{S_t^j P_t^{j,*}} \right] + \left[\gamma_j \frac{Y_t^f}{P_t^{j,*}} \right] \\ &\Rightarrow \; P_t^{j,*} = \frac{1}{\delta_t^j} \left[(1-\alpha_j) \frac{Y_t^j}{S_t^j} + \gamma_j Y_t^f \right] \end{aligned} \tag{78}$$

Final Good Market Finally, the production of the final good in every period has to be equal to the consumption of the young and old representative households alive at that period plus the net consumption of the government, which equals its net transfers:

$$Y_t^j = C_{y,t}^j + C_{o,t}^j + T_t^j \tag{79}$$

B Proof of Proposition 1

To find the first and second trading rounds REE exchange rates, start with the following price conjectures:

$$\begin{aligned} s_{t,1} &= \alpha_0 + \alpha_1 Q_{t-1} + \alpha_2 F_t && (80) \\ s_{t,2} &= \beta_0 + \beta_1 Q_t + \beta_2 F_t^c && (81) \end{aligned}$$

Recall that dealer i optimal FX holdings in each trading round are be given by:

$$\begin{aligned} Q_{t,1}^i &= \frac{E_{t,1}\left(s_{t,2}\right) - s_{t,1}}{\theta Var_{t,1}\left(s_{t,2}\right)} && (82) \\ Q_{t,2}^i &= \frac{E_{t,2}\left(s_{t+1,1}\right) + \overline{V} - s_{t,2}}{\theta Var_{t,2}\left(s_{t+1,1}\right)} && (83) \end{aligned}$$

and the market clearing conditions impose:

$$\begin{aligned} \int_0^1 Q_{t,1}^i di &= Q_{t-1} - X_t && (84) \\ \int_0^1 Q_{t,2}^i di &= Q_t && (85) \end{aligned}$$

Given the price conjectures we can write the expectation of the second round exchange rate conditional on information available only up to the first round as:

$$\begin{aligned} E_{t,1}\left(s_{t,2}\right) &= \beta_0 + \beta_1 Q_t + \beta_2 E_{t,1}\left(F_t^c\right) \\ &= \beta_0 + \beta_1\left(Q_{t-1} + X_{i,t}\right) + \beta_2 \overline{F} \\ &= \beta_0 + \beta_1\left(Q_{t-1} + \kappa_0 + \kappa_1 s_{t,1} + \kappa_2 F_t\right) + \beta_2 \overline{F} && (86) \end{aligned}$$

and the variance of the second round exchange rate conditional on the same information set as:

$$Var_{t,1}\left(s_{t,2}\right) = \beta_2^2 Var_{t,1}\left(F_t^c\right) = \beta_2^2\left(\sigma_F^2 + \sigma_\varepsilon^2\right) \qquad (87)$$

Assuming for simplification that $\overline{F} = 0$, plugging the conditional expectation and the conditional variance into each bank i optimal first round customer flow demand given by equation (82) and imposing the market clearing condition given by equation (84), we arrive at:

$$s_{t,1} = \frac{\beta_0 + \left[\beta_1 - \theta\beta_2^2\left(\sigma_F^2 + \sigma_\varepsilon^2\right)\right]\left(Q_{t-1} - \kappa_0 - \kappa_2 F_t\right)}{1 + \left[\beta_1 - \theta\beta_2^2\left(\sigma_F^2 + \sigma_\varepsilon^2\right)\right]\kappa_1} \tag{88}$$

By comparing the above equation to the price conjecture for $s_{t,1}$ in equation (80), we can write α_0, α_1 and α_2 as functions of β_0, β_1, β_2 and other structural parameters:

$$\alpha_0 = \frac{\beta_0 - \left[\beta_1 - \theta\beta_2^2\left(\sigma_F^2 + \sigma_\varepsilon^2\right)\right]\kappa_0}{1 + \left[\beta_1 - \theta\beta_2^2\left(\sigma_F^2 + \sigma_\varepsilon^2\right)\right]\kappa_1} \tag{89}$$

$$\alpha_1 = \frac{\beta_1 - \theta\beta_2^2\left(\sigma_F^2 + \sigma_\varepsilon^2\right)}{1 + \left[\beta_1 - \theta\beta_2^2\left(\sigma_F^2 + \sigma_\varepsilon^2\right)\right]\kappa_1} \tag{90}$$

$$\alpha_2 = \frac{-\left[\beta_1 - \theta\beta_2^2\left(\sigma_F^2 + \sigma_\varepsilon^2\right)\right]\kappa_2}{1 + \left[\beta_1 - \theta\beta_2^2\left(\sigma_F^2 + \sigma_\varepsilon^2\right)\right]\kappa_1} \tag{91}$$

In the second round, banks can update their beliefs about the realizations of the future macroeconomic fundamentals F_{t+1} using the common signal F_t^c. Given $F_{t+1} \sim N\left(0, \sigma_F^2\right)$, we can apply the projection theorem to reach the following expressions:

$$E\left(F_{t+1}/F_t^c\right) = \frac{\sigma_F^2}{\sigma_F^2 + \sigma_\varepsilon^2} F_t^c = \rho_F F_t^c \tag{92}$$

$$Var\left(F_{t+1}/F_t^c\right) = \frac{\sigma_F^2\sigma_\varepsilon^2}{\sigma_F^2 + \sigma_\varepsilon^2} = \rho_F\sigma_\varepsilon^2 \tag{93}$$

Using the above expressions to calculate bank i period t second round expectations of period $t+1$ first round equilibrium exchange rate we get:

$$\begin{aligned} E_{t,2}\left(s_{t+1,1} + V_t\right) &= \alpha_0 + \alpha_1 Q_t + \alpha_2 E_{t,2}\left(F_{t+1}\right) + E_{t,2}\left(V_t\right) \\ &= \alpha_0 + \alpha_1 Q_t + \alpha_2\rho_F F_t^c + \overline{V} \end{aligned} \tag{94}$$

$$Var_{t,2}\left(s_{t+1,1} + V_t\right) = \alpha_2^2 Var_{t,2}\left(F_t\right) = \alpha_2^2\rho_F\sigma_\varepsilon^2 \tag{95}$$

Assuming for simplification that $\overline{V} = 0$, plugging the conditional expectation and variance into each bank i second round optimal foreign currency demand given by equation (83) and imposing the market clearing condition given by equation (85), we arrive at:

$$s_{t,2} = \alpha_0 + \left(\alpha_1 - \theta\alpha_2^2\rho_F\sigma_\varepsilon^2\right)Q_t + \alpha_2\rho_F F_t^c \tag{96}$$

By comparing the above equation to the price conjecture for $s_{t,2}$ in equation (81), we can write β_0, β_1 and β_2 as functions of α_0, α_1, α_2 and other structural parameters:

$$\beta_0 = \alpha_0 \tag{97}$$

$$\beta_1 = \alpha_1 - \theta\alpha_2^2\rho_F\sigma_\varepsilon^2 \tag{98}$$

$$\beta_2 = \alpha_2\rho_F \tag{99}$$

Combine equations (97) and (89) to find α_0 and β_0. Also, combining equations (90) and (91) gives us:

$$\alpha_2 = -\alpha_1\kappa_2 \tag{100}$$

Use equations (98), (99) and (100) to write α_1, α_2 and β_1 as functions of β_2. Then plug these expression into equation (90) and solve for β_2.

C Customer Flow and Balance of Payments Equivalent

There are different ways in which one can relate FX market flows with their balance of payments counterparts. 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 4).

- 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 5).

- 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 9).

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.

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 12. 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 ratea.d. 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 Granger causes variable 2. Probability of rejection is reported under p-value.

Table 3: Single equation OLS regressions

Specification	Coefficients				
	β_0	β_1	β_2	β_3	β_4
(1)	0.0005 (0.0004)	-0.0050 (0.0019)			
(2)	0.0005 (0.0003)	-0.0025 (0.0015)	-0.129 (0.122)	0.075 (0.194)	1.316 (0.140)

Coefficients estimates and Newey-West standard errors in parenthesis based on single equation linear regressions using daily data from July 1, 1999 until June 30, 2003. Specification (1) is $\Delta s_t = \beta_0 + \beta_1 X_t + \varepsilon_t$ and specification (2) is $\Delta s_t = \beta_0 + \beta_1 X_t + \beta_2 \Delta i_t + \beta_3 \Delta i_t^* + \beta_4 \Delta rp_t + \varepsilon_t$, where s_t is the exchange rate, X_t is the customer flow from the Brazilian FX retail market, i_t is the Brazilian short term interest rate (Selic), i_t^* is the Federal Funds rate and rp_t is the Brazilian country-risk premium.

Table 4: Unit root tests

	Augmented Dickey-Fuller			Phillips-Perron		
Variable	**none**	**constant**	**trend**	**none**	**constant**	**trend**
Depreciation rate	-23.893	-23.962	-23.953	-26.616	-26.660	-26.649
Financial flow	-6.301	-26.453	-27.550	-28.939	-28.377	-27.959
Commercial flow	-3.827	-10.898	-17.120	-25.144	-25.562	-25.148
Intervention flow	-10.222	-10.530	-10.727	-32.139	-31.784	-31.689
Δ(Domestic interest rate)	-30.021	-30.026	-30.194	-29.984	-29.991	-30.232
Δ(Foreign interest rate)	-21.594	-15.925	-15.977	-41.042	-42.083	-42.502
Δ(Risk premium)	-28.820	-28.806	-28.794	-28.697	-28.681	-28.667
Test 1% critical value	-2.567	-3.437	-3.967	-2.567	-3.437	-3.967

Test statistics of Augmented Dickey-Fuller and Phillips-Perron tests for unit roots. Null hypothesis is variable has a unit root.

Table 5: Choice of lag length p in VAR

	Lag length *p* in VAR				
	***p* = 1**	***p* = 2**	***p* = 3**	***p* = 4**	***p* = 5**
Information Criteria					
Akaike	-9.087	-9.226	-9.221	-9.194	-9.184
Scharz	-8.720	-8.769	-8.676	-8.561	-8.462
Lag Exclusion Test (χ^2 Wald statistic and p-values)					
Lag 1	106.14 (<0.001)	58.30 (<0.001)	59.69 (<0.001)	58.95 (<0.001)	58.92 (<0.001)
Lag 2	-	34.72 (<0.001)	41.09 (<0.001)	40.59 (<0.001)	44.85 (<0.001)
Lag 3	-	-	3.33 (0.950)	2.68 (0.976)	4.01 (0.911)
Lag 4	-	-	-	4.14 (0.902)	5.62 (0.777)
Lag 5	-	-	-	-	5.65 (0.774)
Autocorrelation Test (Q statistic and p-values)					
Lag 1	-	-	-	-	-
Lag 2	62.31 (<0.001)	-	-	-	-
Lag 3	65.30 (<0.001)	10.71 (0.602)	-	-	-
Lag 4	72.69 (<0.001)	15.87 (0.703)	7.06 (0.631)	-	-
Lag 5	77.93 (<0.001)	22.66 (0.703)	14.76 (0.679)	9.23 (0.416)	-
Lag 6	87.11 (<0.001)	33.75 (0.576)	24.84 (0.583)	20.89 (0.285)	13.32 (0.150)

For each VAR(*p*) with *p* from 1 to 5 (in each column) we present the Akaike and Schwarz information criteria, the Wald test for the joint significance of all endogenous variables at a given lag and the Box-Pierce/Ljung-Box Q-statistic for residual serial correlation up to the 6^{th} order. Null hypothesis in autocorrelation test is no serial correlation up to the lag indicated in each row. The test is valid only for lags larger than the VAR lag order. Null hypothesis in lag exclusion test is that all coefficients of the endogenous variables at the lag indicated in each row are jointly equal to zero.

Table 6: VAR(2) estimation output

	Equation		
Regressor	Depreciation rate$_t$	Financial flow$_t$	Commercial flow$_t$
Depreciation rate$_{t-1}$	-0.0044	0.9933	0.3629
	(0.0314)	(0.7003)	(0.3030)
Depreciation rate$_{t-2}$	-0.1262	0.9309	0.3321
	(0.0289)	(0.6450)	(0.2790)
Financial flow$_{t-1}$	-0.0003	0.0829	-0.0178
	(0.0014)	(0.0322)	(0.0139)
Financial flow$_{t-2}$	-0.0011	0.0081	-0.0178
	(0.0014)	(0.0322)	(0.0139)
Commercial flow$_{t-1}$	-0.0082	-0.1407	0.2165
	(0.0035)	(0.0779)	(0.0337)
Commercial flow$_{t-2}$	-0.0016	0.0620	0.0815
	(0.0035)	(0.0786)	(0.0340)
Δ(Domestic interest rate)$_t$	-0.1721	4.9230	2.0794
	(0.1555)	(3.4720)	(1.5021)
Δ(Domestic interest rate)$_{t-1}$	0.0089	-8.3597	-2.0088
	(0.2230)	(4.9800)	(2.1546)
Δ(Domestic interest rate)$_{t-2}$	0.1387	3.5230	-0.1496
	(0.1553)	(3.4683)	(1.5006)
Δ(Foreign interest rate)$_t$	0.2232	-2.1895	-0.7820
	(0.2130)	(4.7568)	(2.0580)
Δ(Foreign interest rate)$_{t-1}$	-0.0055	-2.4415	0.4957
	(0.2779)	(6.2070)	(2.6855)
Δ(Foreign interest rate)$_{t-2}$	-0.1986	3.4937	0.5047
	(0.2063)	(4.6078)	(1.9935)
Δ(Risk premium)$_t$	1.2080	1.3293	-6.4649
	(0.0770)	(1.7194)	(0.7439)
Δ(Risk premium)$_{t-1}$	-0.2305	0.3131	5.5659
	(0.1210)	(2.7035)	(1.1697)
Δ(Risk premium)$_{t-2}$	-0.9456	-0.8945	0.5304
	(0.0868)	(1.9377)	(0.8384)
R-squared	37.0%	14.2%	24.9%

Estimation output of the VAR specified by equation (34) 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. Each column corresponds to one equation in the VAR.

Table 7: Estimate of the matrix of contemporaneous relations

VAR(1)	Depreciation rate$_t$	Financial flow$_t$	Commercial flow$_t$
Depreciation rate$_t$	1	-0.0284	-0.0284
	-	(0.0065)	(0.0065)
Financial flow$_t$	10.2434	1	0
	(2.4472)	-	-
Commercial flow$_t$	4.1492	0	1
	(0.3377)	-	-
VAR(2)	Depreciation rate$_t$	Financial flow$_t$	Commercial flow$_t$
Depreciation rate$_t$	1	-0.0268	-0.0268
	-	(0.0061)	(0.0061)
Financial flow$_t$	11.0601	1	0
	(2.6512)	-	-
Commercial flow$_t$	4.6113	0	1
	(0.3582)	-	-
VAR(3)	Depreciation rate$_t$	Financial flow$_t$	Commercial flow$_t$
Depreciation rate$_t$	1	-0.0266	-0.0266
	-	(0.0061)	(0.0061)
Financial flow$_t$	11.2372	1	0
	(2.6897)	-	-
Commercial flow$_t$	4.5705	0	1
	(0.3598)	-	-
VAR(4)	Depreciation rate$_t$	Financial flow$_t$	Commercial flow$_t$
Depreciation rate$_t$	1	-0.0268	-0.0268
	-	(0.0061)	(0.0061)
Financial flow$_t$	11.3312	1	0
	(2.6950)	-	-
Commercial flow$_t$	4.5875	0	1
	(0.3585)	-	-
VAR(5)	Depreciation rate$_t$	Financial flow$_t$	Commercial flow$_t$
Depreciation rate$_t$	1	-0.0266	-0.0266
	-	(0.0061)	(0.0061)
Financial flow$_t$	11.3910	1	0
	(2.7277)	-	-
Commercial flow$_t$	4.6356	0	1
	(0.3598)	-	-

Estimated coefficients of the matrix of contemporaneous relations (standard errors in parenthesis) for VAR(p) with the lag length p ranging from 1 to 5. Structural factorization based on VAR(2) estimates presented in table 7. Entries on the table without standard errors mean that the coefficient was constraints to that value.

Table 8: Choice of lag length p in VAR

	Lag length *p* in VAR				
	***p* = 1**	***p* = 2**	***p* = 3**	***p* = 4**	***p* = 5**
Information Criteria					
Akaike	-11.074	-11.199	-11.182	-11.145	-11.132
Scharz	-10.565	-10.552	-10.397	-10.222	-10.070
Lag Exclusion Test (χ^2 Wald statistic and p-values)					
Lag 1	112.68 (<0.001)	65.53 (<0.001)	66.77 (<0.001)	66.35 (<0.001)	65.49 (<0.001)
Lag 2	-	39.25 (0.001)	45.88 (<0.001)	45.77 (<0.001)	50.20 (<0.001)
Lag 3	-	-	9.99 (0.867)	11.34 (0.788)	12.97 (0.675)
Lag 4	-	-	-	12.08 (0.739)	12.17 (0.732)
Lag 5	-	-	-	-	20.32 (0.206)
Autocorrelation Test (Q statistic and p-values)					
Lag 1	-	-	-	-	-
Lag 2	67.34 (<0.001)	-	-	-	-
Lag 3	79.97 (<0.001)	20.35 (0.205)	-	-	-
Lag 4	93.65 (<0.001)	31.38 (0.498)	15.63 (0.479)	-	-
Lag 5	114.35 (<0.001)	53.55 (0.270)	37.53 (0.230)	23.50 (0.101)	-
Lag 6	129.50 (<0.001)	71.23 (0.250)	53.72 (0.265)	40.75 (0.138)	18.80 (0.279)

For each VAR(*p*) with *p* from 1 to 5 (in each column) we present the Akaike and Schwarz information criteria, the Wald test for the joint significance of all endogenous variables at a given lag and the Box-Pierce/Ljung-Box Q-statistic for residual serial correlation up to the 6^{th} order. Null hypothesis in autocorrelation test is no serial correlation up to the lag indicated in each row. The test is valid only for lags larger than the VAR lag order. Null hypothesis in lag exclusion test is that all coefficients of the endogenous variables at the lag indicated in each row are jointly equal to zero.

Table 9: VAR(2) estimation output

	Equation			
Regressor	Depreciation rate$_t$	Financial flow$_t$	Commercial flow$_t$	Intervention flow$_t$
Depreciation rate$_{t-1}$	-0.0033	0.9413	0.3652	-0.3764
	(0.0314)	(0.7009)	(0.3037)	(0.3712)
Depreciation rate$_{t-2}$	-0.1255	0.9753	0.3364	-0.1452
	(0.0289)	(0.6457)	(0.2798)	(0.3420)
Financial flow$_{t-1}$	0.0005	0.0661	-0.0153	0.0162
	(0.0017)	(0.0373)	(0.0162)	(0.0198)
Financial flow$_{t-2}$	-0.0009	0.0362	-0.0163	-0.0111
	(0.0017)	(0.0372)	(0.0161)	(0.0197)
Commercial flow$_{t-1}$	-0.0081	-0.1435	0.2168	0.0073
	(0.0035)	(0.0779)	(0.0338)	(0.0413)
Commercial flow$_{t-2}$	-0.0015	0.0642	0.0821	-0.0323
	(0.0035)	(0.0787)	(0.0341)	(0.0417)
Intervention flow$_{t-1}$	0.0028	-0.0669	0.0089	0.0324
	(0.0032)	(0.0704)	(0.0305)	(0.0373)
Intervention flow$_{t-2}$	0.0007	0.0993	0.0066	0.0083
	(0.0032)	(0.0702)	(0.0304)	(0.0372)
Δ(Domestic interest rate)$_t$	-0.1696	5.0433	2.0937	-2.2721
	(0.1556)	(3.4723)	(1.5044)	(1.8388)
Δ(Domestic interest rate)$_{t-1}$	0.0093	-8.4837	-2.0117	1.3064
	(0.2231)	(4.9784)	(2.1569)	(2.6364)
Δ(Domestic interest rate)$_{t-2}$	0.1348	3.5159	-0.1658	1.2489
	(0.1554)	(3.4683)	(1.5027)	(1.8367)
Δ(Foreign interest rate)$_t$	0.2226	-2.2095	-0.7850	1.4529
	(0.2131)	(4.7547)	(2.0600)	(2.5179)
Δ(Foreign interest rate)$_{t-1}$	-0.0068	-2.3368	0.4940	-0.0048
	(0.2781)	(6.2046)	(2.6882)	(3.2857)
Δ(Foreign interest rate)$_{t-2}$	-0.1978	3.4028	0.5045	-0.8480
	(0.2064)	(4.6061)	(1.9956)	(2.4392)
Δ(Risk premium)$_t$	1.2059	1.3287	-6.4734	-1.0467
	(0.0771)	(1.7195)	(0.7450)	(0.9106)
Δ(Risk premium)$_{t-1}$	-0.2273	0.2471	5.5764	-0.1275
	(0.1212)	(2.7035)	(1.1713)	(1.4317)
Δ(Risk premium)$_{t-2}$	-0.9460	-0.8261	0.5310	0.7914
	(0.0868)	(1.9373)	(0.8393)	(1.0259)
R-squared	37.1%	14.4%	25.0%	7.8%

Estimation output of the VAR specified by equation (43) 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. Each column corresponds to one equation in the VAR.

Table 10: Estimate of the matrix of contemporaneous relations

VAR(2)	Depreciation rate$_t$	Financial flow$_t$	Commercial flow$_t$	Intervention flow$_t$
Depreciation rate$_t$	1	-0.0337	-0.0295	-0.0295
	-	(0.0076)	(0.0065)	(0.0065)
Financial flow$_t$	8.3654	1	0	0
	(1.9440)	-	-	-
Commercial flow$_t$	4.4545	0	1	0
	(0.3853)	-	-	-
Intervention flow$_t$	2.5313	0.2183	-0.0307	1
	(0.4137)	(0.0221)	(0.0411)	-

Estimated coefficients of the matrix of contemporaneous relations (standard errors in parenthesis) for VAR(2) specified in equation. Structural factorization based on VAR(2) estimates presented in table 9. Entries on the table without standard errors mean that the coefficient was constraints to that value.

Table 11: Estimate of the matrix of contemporaneous relations

VAR(2)	Depreciation rate$_t$	Financial flow$_t$	Commercial flow$_t$	Intervention flow$_t$
Depreciation rate$_t$	1	-0.0295	-0.0295	-0.0295
	-	(0.0065)	(0.0065)	(0.0065)
Financial flow$_t$	8.3526	1	0	0
	(2.0008)	-	-	-
Commercial flow$_t$	4.8084	0	1	0
	(0.3788)	-	-	-
Intervention flow$_t$	2.6733	0.2252	0	1
	(0.4660)	(0.0208)	-	-

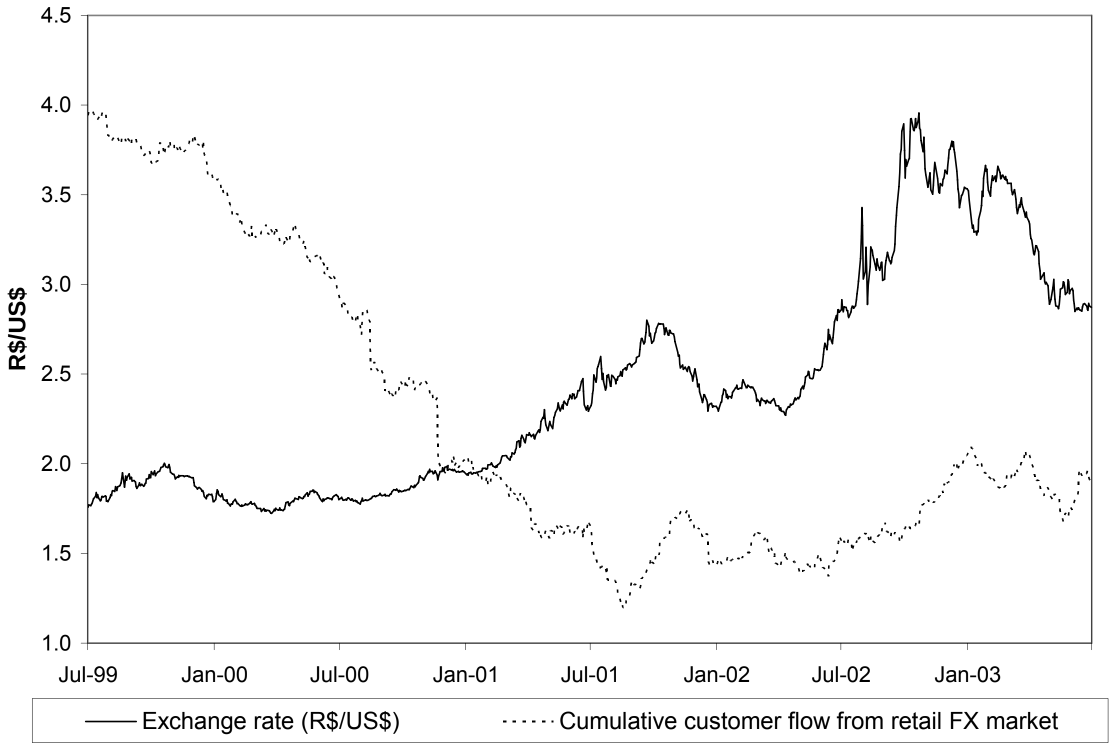
Estimated coefficients of the matrix of contemporaneous relations (standard errors in parenthesis) for VAR(2) specified in equation. Structural factorization based on VAR(2) estimates presented in table 9. Entries on the table without standard errors mean that the coefficient was constraints to that value.

Table 12: 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$_0$: $\beta_0 = 0$ and $\beta_1 + \beta_2 + \beta_3 = 1$
0.15	0.88	2.29
(0.369)	(0.004)	(0.113)
Relation 2:	$Y_t = \beta_0 - \beta_1 y_t + \varepsilon_t$	
$\hat{\beta}_0$	$\hat{\beta}_1$	H$_0$: $\beta_0 = 0$ and $\beta_1 = 1$
-0.20	1.13	2.28
(0.077)	(<0.000)	(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$_0$: $\beta_0 = 0$ and $\beta_1 + \beta_2 + \beta_3 = 1$
0.11	0.99	0.26
(0.613)	(<0.000)	(0.771)

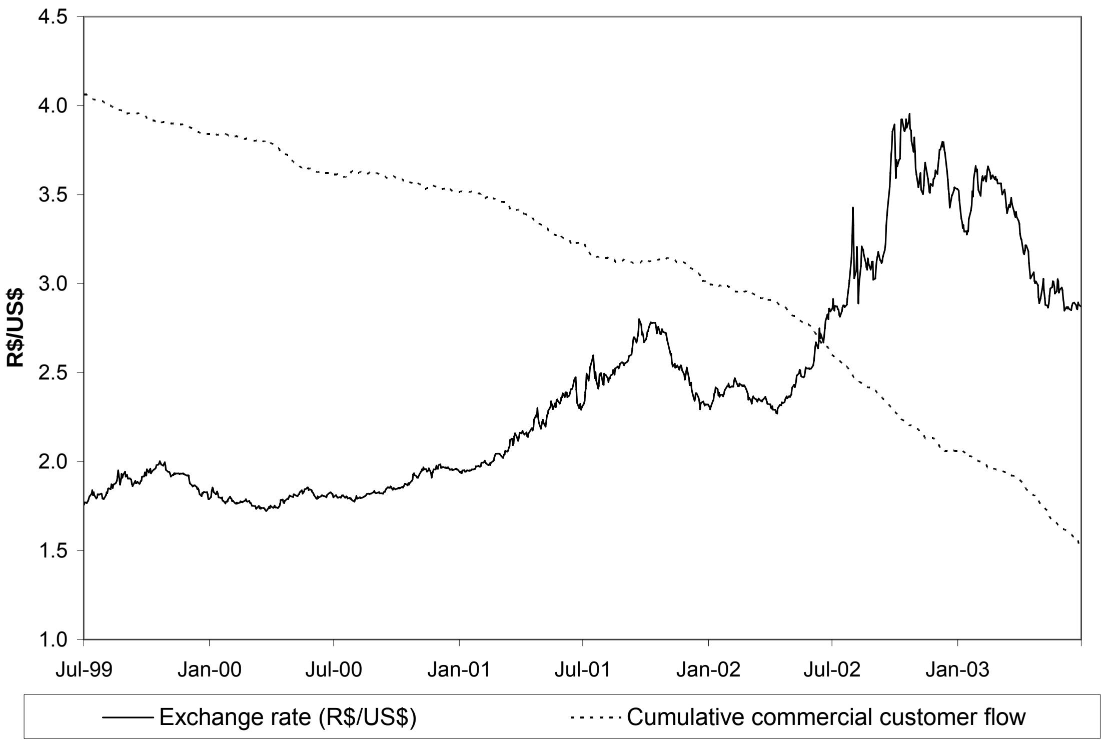
Monthly data from July 1999 until June 2003. FX market flows and balance of payments flows are in US$ billion. Coefficient estimates in first two columns and F-static under null hypothesis in third column. P-values in parenthesis, based on Newey-West HAC standard errors.

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



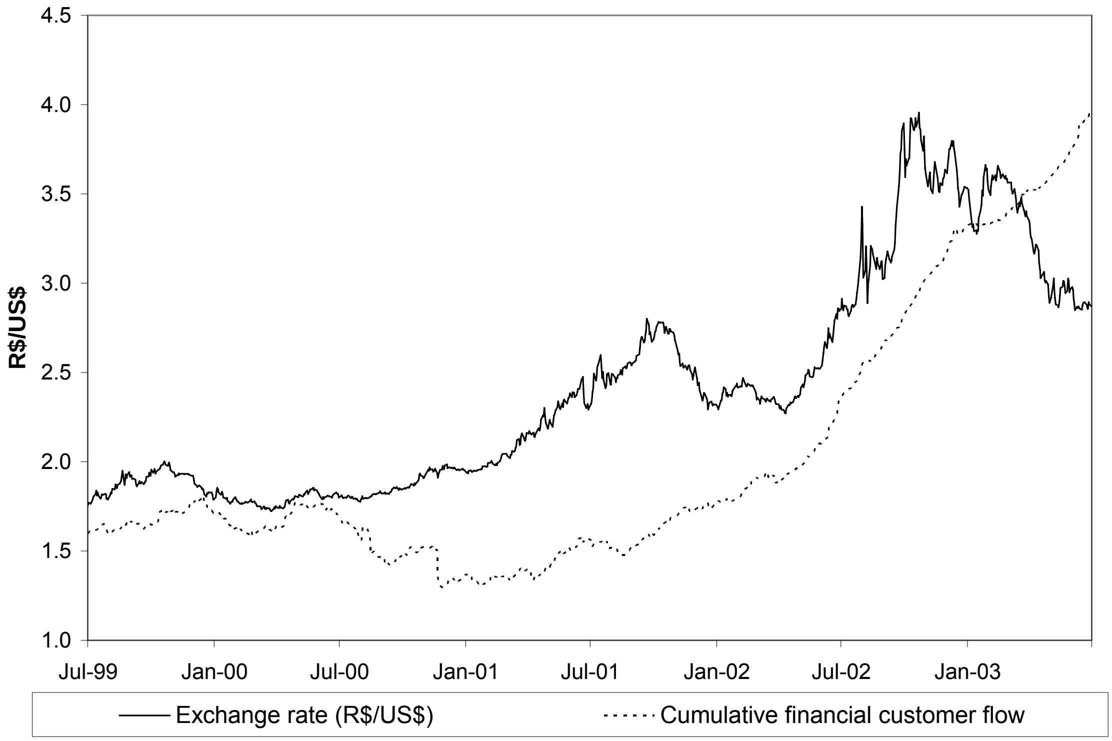
Daily data from July 1, 1999 until June 30, 2003. Cumulative customer flow from the retail market includes commercial and financial flows. Cumulative customer order flow in a date *t* is the sum of all customer flows between date 0 (July 1, 1999) and date *t*. Positive (negative) customer flow indicates 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: Cumulative commercial customer flow and exchange rate



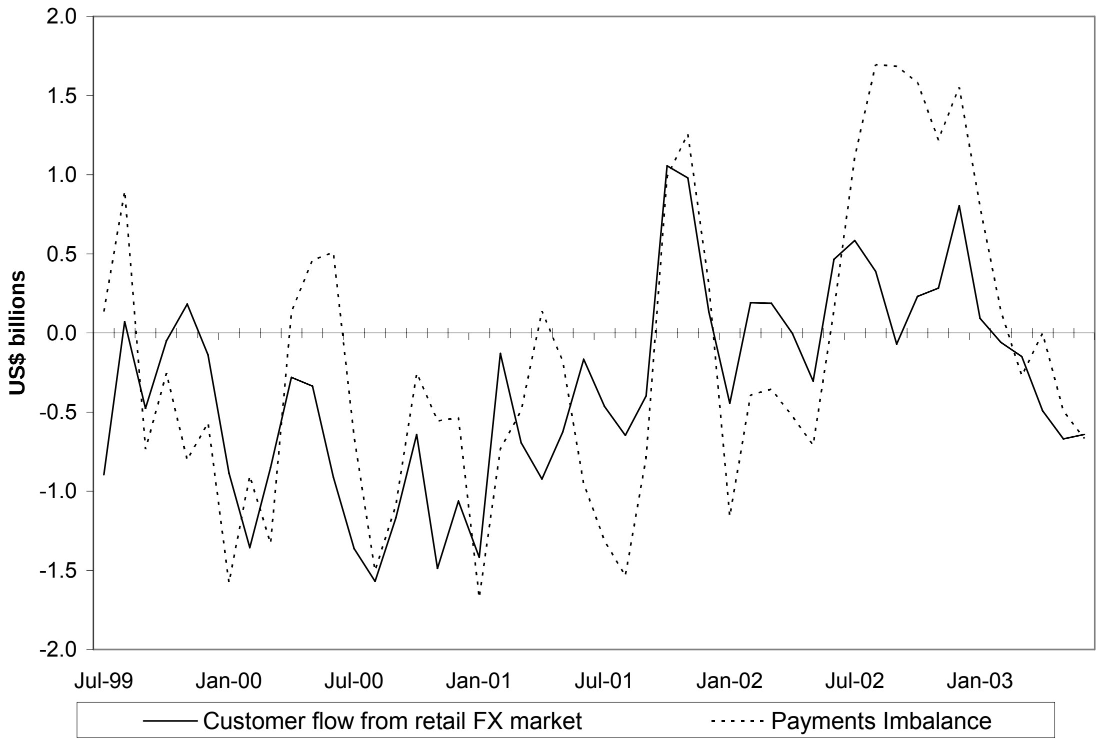
Daily data from July 1, 1999 until June 30, 2003. Commercial customer flow includes all contracts from the Brazilian FX retail market associated with a transaction in the goods market. Cumulative commercial customer flow in a date *t* is the sum of all commercial customer flows between date 0 (July 1, 1999) and date *t*. Positive (negative) commercial 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 3: Cumulative financial customer flow and exchange rate



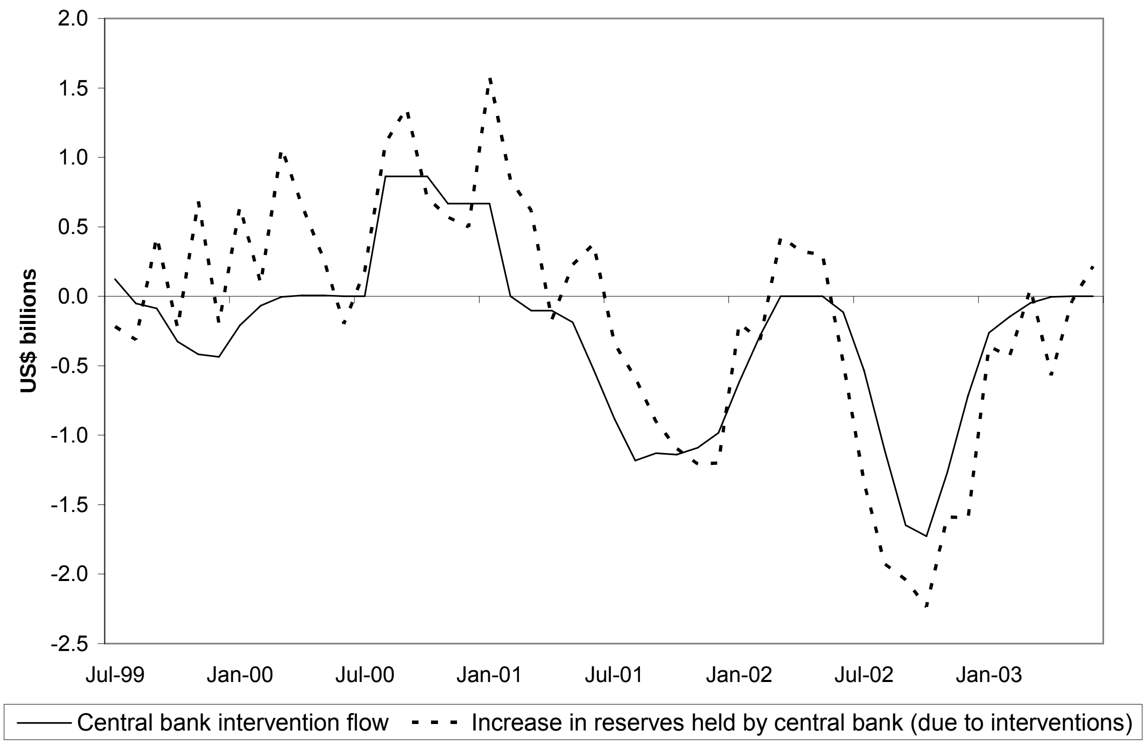
Daily data from July 1, 1999 until June 30, 2003. Financial customer flow includes all contracts from the Brazilian FX retail market associated with a transaction in the assets market. Cumulative financial customer flow in a date *t* is the sum of all financial customer flows between date 0 (July 1, 1999) and date *t*. Positive (negative) financial 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 4: Customer flow from retail FX market and balance of payments imbalance



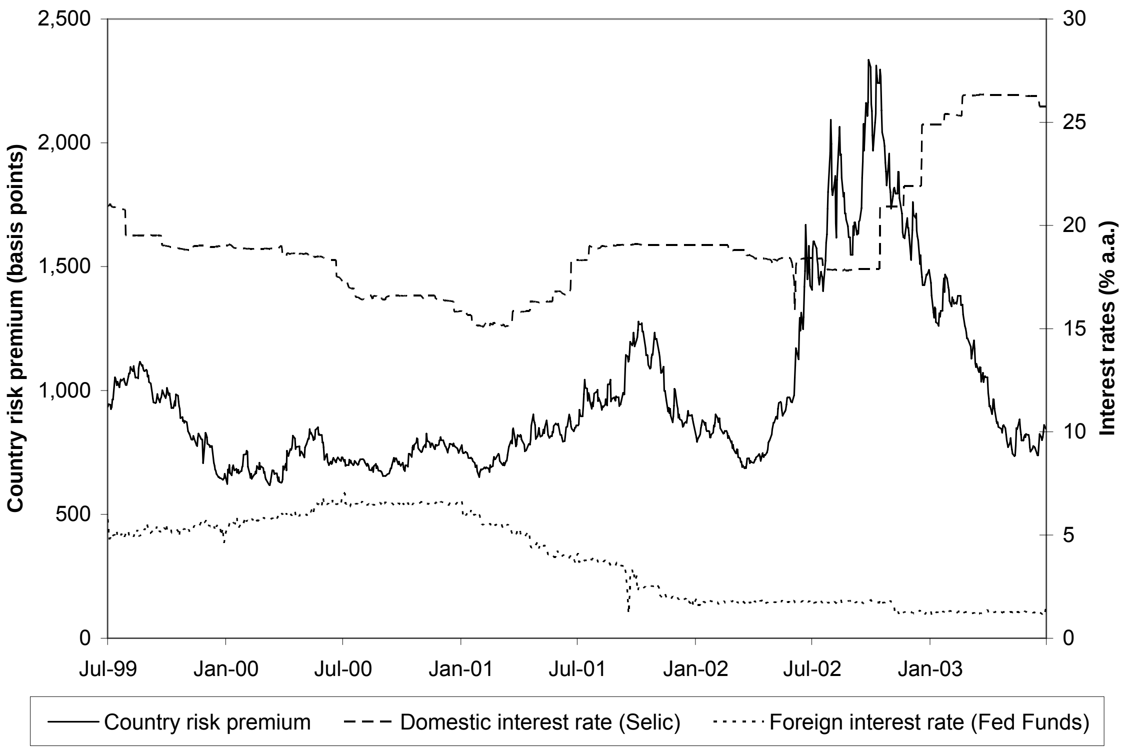
3 months moving average of monthly data from July 1999 until June 2003. Customer flow from the retail market includes commercial and financial flows. Balance of payments imbalance includes the current account, the capital account and the financial account subtracted from the change in FX cash balances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

Figure 5: Central bank intervention flow and decrease in reserves held by central bank due to interventions



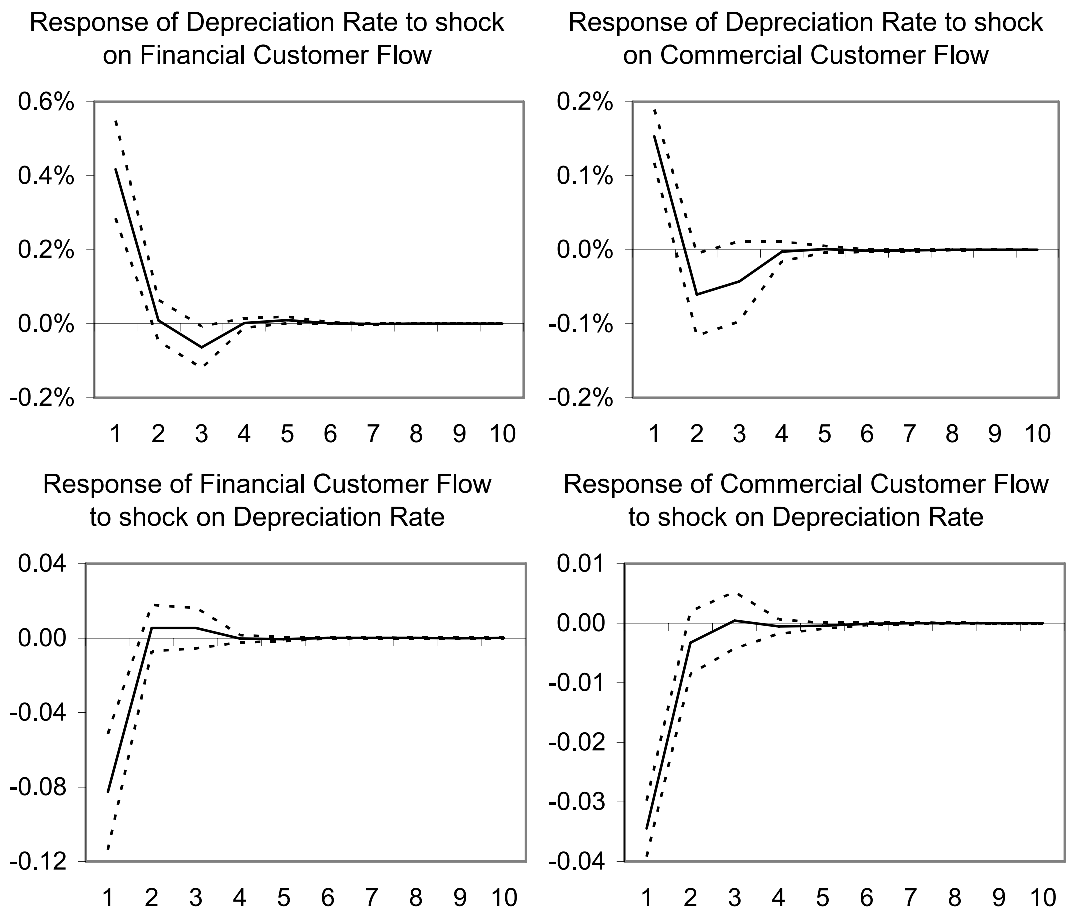
3 months moving average of monthly data from July 1999 until June 2003. Central bank intervention flows are central bank's net purchases of FX from dealers. Increase in reserves held by central bank due to interventions is obtained by subtracting through the balance of payments by subtracting from the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

Figure 6: Country risk premium and domestic and foreign interest rates



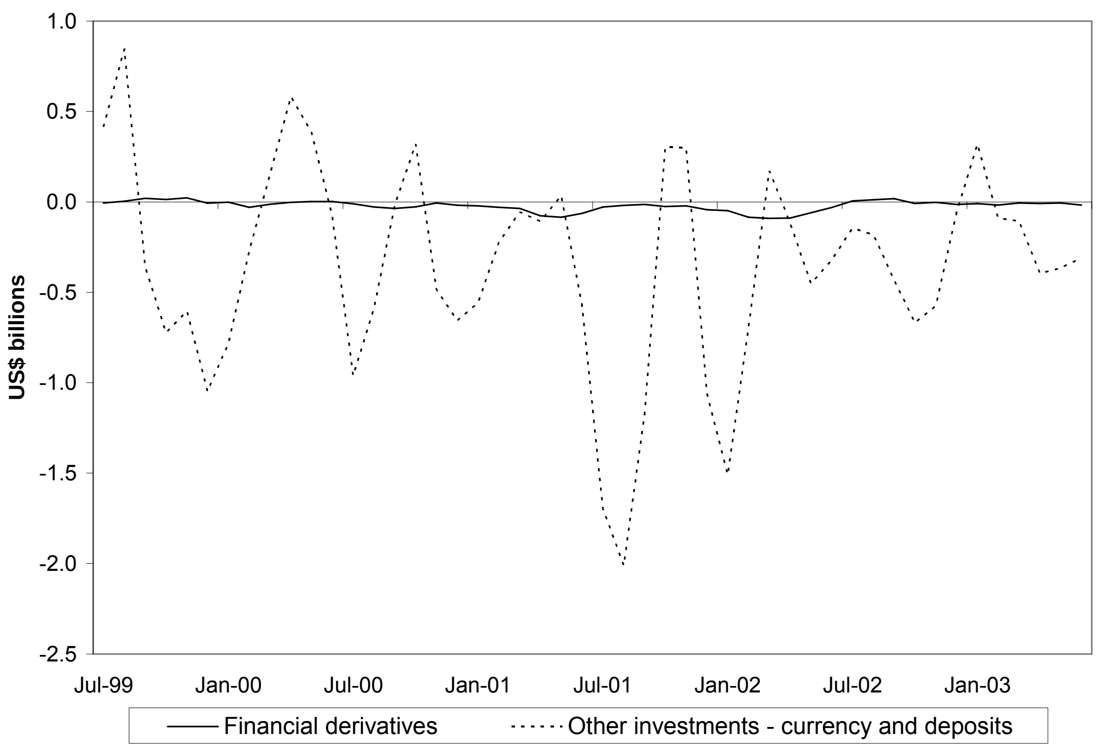
Daily data from July 1, 1999 until June 30, 2003. Country risk premium is the spread of the C-Bond (the most liquid Brazilian Brady bond in the sample period) over the Treasury, measured in annualized basis points. The domestic interest rate is the Brazilian Selic rate in % a.a. The foreign interest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

Figure 7: Impulse response functions based on structural VAR decomposition



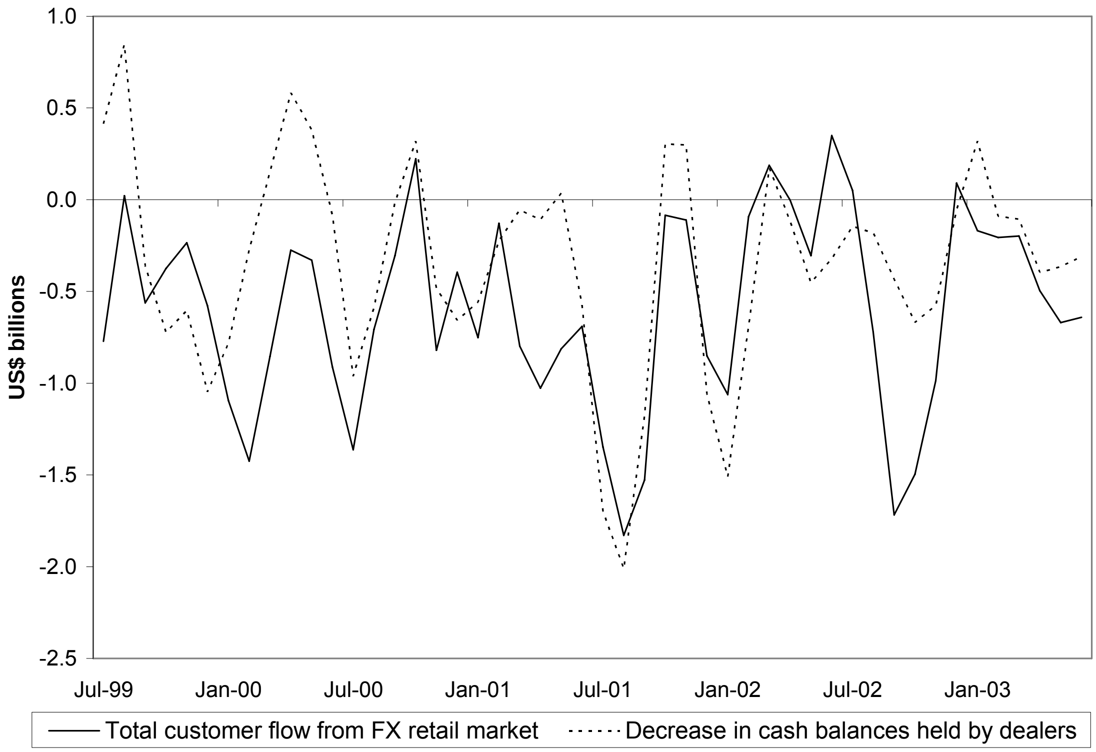
Solid lines represent impulse response functions to one standard deviation shock. Dotted lines represent impulse response function +/- 2 standard errors. Commercial and financial customer flows measured in US$ billion and depreciation rate measured in %.

Figure 8: Cash flows generated by the FX derivatives market



3 months moving average of monthly data from July 1999 until June 2003. "Financial derivatives" include the financial flows relative to the liquidation of assets and liabilities due to transactions in the derivative markets registered in the balance of payments. It refers to the flows generated in all financial derivatives markets, and not only to the FX derivates market. "Other investments - currency and deposits" is the balance of payments measure of the change in dealers inventories.

Figure 9: 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.