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Working Paper

The microstructure of exchange rate management: FX intervention and capital controls in Brazil

Kiel Working Paper, No. 1865

Provided in Cooperation with:
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Suggested Citation: de Roure, Calebe; Furniagiev, Steven; Reitz, Stefan (2013) : The microstructure of exchange rate management: FX intervention and capital controls in Brazil, Kiel Working Paper, No. 1865, Kiel Institute for the World Economy (IfW), Kiel

This Version is available at:
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Working Papers

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The Microstructure of Exchange Rate Management: FX Intervention and Capital Controls in Brazil

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No. 1865| August 2013

Web: www.ifw-kiel.de

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Keywords: Foreign Exchange; Sterilized Intervention; Macroprudential Policies; Market Microstructure

JEL classification: F31, E58, G14, G15

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* We thank seminar participants at the Kiel Institute for World Economy. We are also grateful for comments from Emanuel Kohlscheen, Lucas Menkhoff and Lucio Sarno.

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The Microstructure of Exchange Rate Management: FX Intervention and Capital Controls in Brazil

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Abstract

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1. Introduction

In response to the 2007 Global Financial Crisis and the later European Confidence Crisis, the Federal Reserve, Bank of Japan, and European Central Bank have introduced loose monetary policies, including several rounds of quantitative easing in the US and Japan and rescue packages for sovereign bonds in Europe. Emerging economies such as Brazil have expressed concern at G20 meetings for an overflow of so-called hot money, and a consequent appreciation of their currencies inconsistent with economic fundamentals.[1] In fact, in 2009 the Brazilian Real appreciated 25% relative to the US Dollar, a level seemingly inconsistent with Brazil's overall economic performance of -0.3% GDP growth for the year. The peak of the dispute occurred in September 2010 when Brazilian Finance Minister, Guido Mantega, announced in a press release that a global currency war was underway.[2]

The recent currency war rhetoric is the latest example of emerging markets' desire for effective exchange rate management. In his statements, Mantega was clear that the macroprudential policy set was introduced to avoid the entrance of short-term capital inflows. In fact, Brazil has introduced several controversial macroprudential policies over the past four years. These include taxes on capital inflows, currency derivatives, loans held abroad, conversion of American Depositary receipts (ADR) into local equities and tightened reserve requirements on banks gross FX positions.

In 2012 the IMF moderately reversed its longstanding position regarding capital controls, accepting that in certain circumstances capital controls are an appropriate tool for reducing exposure to volatility and risk in emerging markets.[3] However, the appropriate context for introducing such measures remains ambiguous. Tobin (1978) suggested that all capital flows should be taxed, which found little resonance in the literature, as both speculative capital and investment in the real economy would be equally taxed. However, de Roure (2010) applies a global game model to analyze the Brazilian Confidence Crisis of 2002 and finds that a small Tobin tax could have avoided a large part of the 50% depreciation of the Real as costs for withdrawing investments would have been larger than gains.

[1] See "What's the currency war about?" from BBC, 10/22/2010

[2] See the article "Brazil in 'currency war' alert" from September, 27th 2010 in the Financial Times. The perception of a currency war is at the time of writing not over. On February, 8th 2013 Guido Mantega warns again, see "Global currency war could get nastier" from Reuters.

[3] See "The Liberalization and Management of Capitals Flow: An Institutional View", IMF 2012.

Chamon and Garcia (2013) test the effectiveness of the same macroprudential policies analyzed in this paper. Their approach was to include binary variables in a modified UIP regression and test for a significant impact on the value of the Real. This approach did not find statistically significant results as market participants are not separately identified. Nevertheless, the paper sheds a positive light on the Brazilian macroprudential policies.[4]

Between May 2009 and December 2012, the Brazilian Central Bank (BCB) accompanied these policy measures by intervening in the FX market on 62% of all trading days[5], implying that the monetary authority actively managed the exchange rate. A striking feature of the intervention data is the one-sidedness of BCB activity; they hold only buying positions in U.S. dollar (USD) throughout our sample. Such behavior is consistent with stated concerns of overvaluation in the Brazilian Real (BRL), and represents their willingness to act against an appreciation of their currency. This unique experience combined with a data set covering 100% of trades involving the Brazilian Real allows us to evaluate these policies from a unique point of view.

FX interventions have become to a large extent an emerging market practice, yet the current empirical and theoretical literature has focused on the context of advanced economies. Menkhoff (2012) argues emerging economies are structurally different, which has "lead to the unpleasant situation that most of our empirical research and literature refers to institutional circumstances that do no longer fit the typical case in the present world." First, they differ by their informational and regulatory context as seen by the many market rules and regulations. These range from reporting requirements of major banks and market participants to the use of capital controls. Second, the relative size of market participants is significantly different from advanced economies. In particular, and as the Brazilian case confirms, central banks represent a larger share of the market, implying a different environment for the effectiveness of intervention.

While literature on macroprudential policies is scarce, some empirical evidence on BCB intervention effectiveness recently emerged. Using a dataset from 2002 through 2011, Kohlscheen (2012) estimates the 'costs' for market participants to move the value

[4]More generally, Canales-Kriljenko (2003) summarizes the use of capital controls and regulatory requirements across a larger set of emerging economies.

[5]That is, 570 out of 913 trading days.

of the Real and finds that on days in which the monetary authority is present in the market this cost is much larger. This is taken as evidence for a 'damping' channel from sterilized intervention in the Brazilian FX market; the market reveals a significantly decreased sensitivity to financial players activity on days the BCB intervenes. The findings of Kohlscheen are related to that of Girardin and Lyons (2008), who show that there is a complex relationship between intervention and the markets pricing mechanisms. In another study of the Brazilian Real, Wu (2012) recognizes the endogeneity between order flow and the exchange rate, and includes intervention as a disaggregate order flow. Based on theoretically motivated restrictions, Wu estimates a structural vector autoregression (SVAR) for the period between July 1999 and June 2002; the contemporaneous coefficients suggest the BCB pursues a strategy of leaning against the wind and is an intraday liquidity provider.

This paper considers the Brazilian experience throughout the recent financial turbulences and assesses the effectiveness of its macroprudential policies controlling for FX intervention operations. We characterize the policy objectives of the Brazilian Central Bank (BCB) as revealed by the data and separately test for the ability of intervention and macroprudential policies to manage concerns over stability and competitiveness.[6] Without imposing potentially controversial assumptions, this paper utilizes a system of equations to estimate reaction functions for groups of market participants. Including explicitly the behavior of market participants in exchange rate determination captures market dynamics that are unavailable within standard and modified UIP equations.

There are several findings we highlight. First, we find unambiguous evidence that BCB intervention affects the behavior of financial customers. More specifically, and critical to their concerns of overvaluation, they elicit an increased selling pressure on the Real from financials. Second, only commercial actors induce a direct effect on the the value of the Real. As financial customers are perceived to act with speculative incentives by maintaining carry trade positions, yet have no impact on the value of the Real, we find no evidence for a channel where loose monetary policy of major central banks could be impacting the value of the Real through enhanced speculation. Third, we find

[6]While Wu is primarily concerned with a description of the anatomy and dynamics of the market, our purpose here is to address the context for exchange rate management. In addition, our use of recent macroprudential policies controls for parameter instability derived from changes in the policy environment; a concern that Neely (2005) explains faces similar structural models of intervention.

that commodity prices are a primary determinant of the Real, which is consistent with Kohlscheen (2013). Lastly, the microstructure approach allows for a richer evaluation of macroprudential policies. Importantly, we find statistical evidence that taxes on currency derivatives, loans taken abroad, and reserves requirements on FX overnight positions have changed market participants behavior in a way that reduced financial costumers position on the Real without interfering on commercials trading activity. This is taken as evidence that capital controls did not impact the real economy.

The paper proceeds with section 2 where we describe the data source and present some descriptive statistics. Section 3 shows our empirical results, section 4 provides a discussion and section 5 concludes.

2. Data

2.1. Content and Definitions

Coverage of the Brazilian foreign exchange market is unique in the reporting requirements facing participants. After each trading day banks dealing with the Real must inform the BCB of the volume and nature of all transactions regarding the sale of currencies. For this purpose, customers that originate orders for the trade in *goods and services* with non-residents are labeled *commercials*, whereas customers originating orders for trade in *assets* with non-residents are labeled *financials*. Central bank transactions in the FX market are denominated *intervention*, and also treated as disaggregated order flow.

From this comprehensive record of all FX transactions, we compiled a data set that covers 100% of all trades with the Real from May 2009 through December 2012. Disaggregated by financials, commercials and the BCB intervention, its primary feature is buyer-initiated (net demand) order flows for the Brazilian Real (BRL) and U.S. Dollar (USD). Order flows are calculated as the net of daily buying and selling transactions denominated in millions of USD. A positive order flow represents a positive excess demand for USD (buying of USD exceeds selling of BRL) while a negative order flow is an excess supply (selling of BRL exceed buying of USD). Further, the BCB publishes data on its own market intervention, interest rate, foreign exchange reserves, spot and real exchange rates vis-a-vis the USD.

To complete the analysis, we utilize data for the Brazilian interest rate (SELIC) and Fed Funds rate (from the Federal Reserve Bank of New York); an index of commodity

prices calculated by the Commodity Research Bureau (CRB); local and international risk proxies given by JP Morgan's Emerging Market Bond Index (EMBI) and the VIX volatility index, respectively.[7] The BRL/USD spot exchange is provided by the BCB.

Table 1 displays summary statistics for variables used in estimation. Applying an augmented Dickey Fuller test for each time series we find that the interest differential, VIX, EMBI and CRB commodity price index have a unit root. Interest rate is treated in first difference and all other variables in log differences. Furthermore, they are shown to be stationary in Table 2 of the Appendix.

2.2. Descriptive Statistics:

A peculiarity of the Brazilian FX market is the relative size of market players. Based on the average share of daily order flow in days with non-zero intervention, the BCB represents almost one fifth (19.5%) of the markets net demand for dollars. Commercials are also relatively large (23.4%) and financials' market share is slightly more than the half (57.1%). This suggests that commercials' behavior, and determinants thereof, will have a larger impact on the price of the Real, and that the influence of central bank presence in the market is (potentially) much stronger relative to their developed country counterparts.[8]

In order to test for the presence of unsterilized intervention in our data set, we regress changes in the money supply on intervention data. The coefficient on intervention should be bounded between 0 and 1, where the edges of the interval refer to fully sterilized and unsterilized intervention, respectively. The test for sterilized intervention proceeds as shown in Table 3. Both the one and two day lagged coefficients for intervention are statistically insignificant, which is consistent with a policy of sterilized intervention.

3. Estimation

A standard problem in empirical analyses of FX markets is the pervasive presence of bi-directional causality of the underlying variables. The decisions of market participants to buy or sell foreign currency may be motivated by the level or changes of the spot rate, and vice-versa. To characterize the nature of variable endogeneity in our data set,

[7] Kohlscheen (2013) shows that there is no statistical difference between the use of the CRB commodity index and an index weighted by the Brazilian trade balance. VIX is the implied volatility of the S&P 500 and is used as a proxy for international risk perception.

[8] The same perception is found in Kohlscheen (2012) and Menkhoff (2012).

we opt for a reduced-form VAR thereby producing a reaction function for commercials, financials, the central bank, and an equation for the exchange rate return. In this context, the additional exogenous variables represent public information. Regarding the equation for the exchange rate return, the presence of order flow introduces private information flows resulting in an augmented news approach to exchange rates.

The estimation section proceeds in two parts. We first evaluate each participant reaction function with respect to exogenous variables and to each others behavior. Second, the effectiveness of a series of capital controls is analyzed as a policy response to changes in the international macroeconomic environment.

3.1. Disaggregated Dynamics and Intervention

The appropriate number of lags in the VAR was chosen according to the Akaike criterion, which suggests a lag structure of 3. Testing for stationary of the system of equations, we find all roots of the companion matrix lie within the unit circle. A Lagrange Multiplier test for correlation of the residuals reveals serial correlation of the second and fifth lags at a 5% and 10% level, respectively. We formally test for orthogonal error terms by imposing the restrictions matrices A and B to be identity matrices.[9] Thereafter, we test if the restrictions of this SVAR overidentify the estimation. The LR test for overidentification reveals that the null hypothesis (H_0 = overidentification) can be rejected at the 1% confidence interval ($\chi^2 = 5.48e^8$). Therefore, a Cholesky decomposition as shown in Figure 1 does not depend on the order of the variables and other identification methods as the Generalized IRF from Pesaran and Shin (1998) shall generate similar results.[10]

The *commercial customers reaction function* is affected exogenously by international risk perception (VIX) and commodity prices (CPR). A 1% increase in global volatility (VIX) leads commercials to sell Real in the amount of US$ 1.12 billion after 5 days (see Figure 2)[11]. As a large share of this group are non-Brazilian multinationals, commercial

[9]Here we follow Luetkepohl (2005) terminology, where the A matrix represents the restrictions on the endogenous variables and B the restrictions on the covariance matrix of the error terms.

[10]Another way to show that the error term is orthogonal is to change the ordering of the variables and show that the Cholesky impulse responses produce the same results, but as this is not a formal testing procedure, we opt for the method described above. Nevertheless, as a check for robustness we carried out the test in both formats, confirming that the results are consistent across these methods.

[11]Figure 2 displays the dynamic multipliers associated with an impulse to the corresponding exogenous variables. The value for the 5 day cumulative effect is drawn from the corresponding table of cumulative values.

customers are expected to withdraw some of their investments to cut exposure in turbulent times.[12] Furthermore, commercials' demand for dollars is negatively correlated with commodity prices, a 1% increase in the index leads to a 5 day cumulative increase of 7.7 billion Real in longs positions held by commercials. We interpret the sign of the coefficient as the consequence of an inelastic demand for Real from commodity exporters. The first column of Figure 1 shows commercials response to a shock from each endogenous variable within a 95% confidence band. The response to an own-shock pinpoints the nature of an autoregressive process for commercials' behavior lasting roughly four days. The response to a shock on others endogenous variables are not statistically significant.

The direct impact of commercials on the exchange rate, combined with direct impact of commodity prices on commercial behavior, suggests that this channel is one of the main determinants of the Real. Kohlscheen (2013) finds that the Brazilian real effective exchange rate is cointegrated with commodity prices, implying a long run relationship. Our conclusion is that commercial customers act with regard to real economy, both locally and internationally.

It is commonly perceived in the literature that commercial customers act primarily for the purpose of FX liquidity, and thus without concern for speculation and independent of financial markets (Sager and Taylor, 2006). This perception is blurred within our model, as commercial customers respond to increases in international risk through a buying position on the dollar. However, this finding remains a descriptive observation as an explanation of the causal-relationship between commercial customers and financial markets is not revealed within the model.

None of the exogenous variables significantly determines the *financial customers' reaction function*. The combination of daily data and lack of contemporaneous coefficients in the reduced-form VAR makes it difficult to capture a potential intraday response of financial market participants. Moreover, as shown in the second column of Figure 1 financials only respond to an own-shock and intervention. On average, a US$ 1 million increase in central bank intervention leads financials to increase their net long position US$ .88 million after 5 days.

The rhetoric of a currency war shows that Brazilian policymakers are concerned with

[12]The rank of the largest exporters in 2012 from the Ministry of Development, Industry and Foreign Trade reported 5 foreign companies in the top 10.

how loose monetary policies in the US, Japan and Europe may adversely affect their currency. One possible channel is through speculative behavior, i.e. foreign investors act towards an inflow of short-term capital into Brazil by exploiting the interest differential. However, our estimation gives no support to this belief, as seen through the insignificant coefficient for the interest differential in the financial's reaction function. Nevertheless, the positive and significant coefficient for intervention reflects an environment where BCB interventions could be deemed successful from the point of view of counteracting financial driven speculation.

While the BCB does not disclose an official statement regarding its FX intervention policy, the presence of intervention on 570 out of 913 trading days in our observation window makes clear that it actively manages the exchange rate. The *central bank reaction function* is described by response to private information (order flows) and public information (depreciation rate). This implies that the BCB acts in regard to both public and private information, as revealed by the value of the Real and the trading behavior of market participants, respectively.

The third column of Figure 1 illustrates the BCB reaction function in the FX market. It is positive and significantly different from zero with respect to commercials and financials. Although our estimation is able to quantify the BCB response to financials and commercials attitude based on a daily measure of their behavior, it is likely that the monetary authority is following a rule according to a more aggregate measure.[13] However, the determination of such a rule goes beyond the scope of this paper.

The negative coefficient in the BCB reaction function for the depreciation rate - a finding consistent with 'leaning against the wind' - would usually confirm the belief that FX market stability is a primary concern. However, as the data reveals that intervention is one-sided (buying USD), this is instead consistent with price competitiveness concerns of policymakers resulting from an appreciating Real. Due to daily reporting requirements for all transactions involving the Real, the BCB possesses an information advantage in the FX market. This facilitates the daily reaction to market activity, such as the significant and positive response of FX intervention due to commercial and financial order flows.

The BCB reaction function reveals interesting details about the FX policies in Brazil,

[13] As a check for robustness we also considered a 10 day moving average for cumulative order flow and found it significant to the 1% confidence interval.

pinpointing different attitudes towards public and private information. As expected, the countercyclical response of intervention to the depreciation rate supports the perspectives of misalignment and stability as primary policy objectives. The central bank intervenes buying Dollars when the Real appreciates and reduces this buying pressure as it depreciates. This is consistent with the findings of Wu (2012), who also finds evidence for a 'leaning against the wind' policy by the BCB. Rather unexpected is the positive reaction towards the attitude of commercial and financial order flow.[14]

The distinction between private and public flows within the BCB reaction function is intuitive. As characterized by variants of the 'Portfolio-Shifts' model developed by Lyons (1997) and Evans and Lyons (2002), order flow is a valuable information aggregator precisely because it embodies information asymmetries. While the model of Evans and Lyons (2002) refers to interdealer flows, the intuition stands: a market participant would find it useful to trade on given information to the degree that it is not already reflected in current market prices. The BCB's strong reaction to private information flows - i.e. daily market-wide order flow data - along with the weak response to publicly available macro indicators reflects their incentive to capitalize on the information content of order flow.

This study has introduced the best available *equation for the determination of the Real* in a system with market participants behavior. This system allows us to better understand the dynamics and determinants of exchange rate movements, as our benchmark model can account for 39% of the variation in the differenced log exchange rate. According to our model the primary determinants of the Real are commercial order flow, local and international risk and commodity prices. An increase in buying pressure from commercial customers is positively related with the change in spot rate.

The fourth column of Figure 1 shows the price response of the Brazilian Real to an increased net-long position of $1 million for each type of market participant and to an 1% exchange rate depreciation. Only commercials have a statistically significant price impact, and this averages 0.0004% after 5 days for every 1 million. Kohlscheen (2012) estimates that on days the BCB is not active in the market, a $50 million dollar long

[14]We suggest that this is the outcome of the autoregressive interaction of the variables. Since order flows from private and official sources exhibit negative reaction coefficients with respect to the second-order lag of the exchange rate return a positive correlation among order flow variables might be observed, but cannot be interpreted as a direct influence.

position leads a 0.025% move in the Real, while a $137.5 million dollar position is required on days the BCB is active. The difference between both results comes from the fact that Kohlscheen analyses order flows aggregated over financials and commercials, but as shown in the present work only commercials order flow has an information content relevant for the Real price formation. Nevertheless, the results of Kohlscheen along with our present analysis suggest that intervention *does* influence the markets pricing mechanism. The fact that commercials are the only group with a significant impact on the depreciation rate, along with their ties to commodities, underlines the connectedness of the Brazilian Real to the real economy (See Figure 3).

Measures of international and local risk downward pressure on the nominal exchange rate, as shown in Figure 2. The 5 day cumulative effect for VIX and EMBI are -0.01% and -0.19% respectively. VIX influences the value of the Real both directly and indirectly - through its influence on commercial's behavior. Directly, the negative coefficient implies that the Real appreciates (all else equal) in response to international risk. Indirectly, real economy investors apply downward pressure on the Real as they tend to withdraw their investment from Brazil when international risk perception increases. Commodity prices also impact the value of the Real through the same two channels, however both channels act in the same direction: whenever commodity prices increase the Real appreciates. The 5 day cumulative effect for commodities is a -0.33% appreciation of the Real.

During the observed period we can divide the change in Brazilian interest rate in 3 periods with clear trends (see Figure 4).[15] From the beginning of our observation set in May 2009 until April 2010 the SELIC was reduced 150 basis points, during which time the Real appreciated 14.68%. In the following period, through August 2011, the SELIC increased 375 basis points, and inconsistently with the prediction of uncovered interest parity, the Real appreciated by 9.6%. Likewise, from August 2011 through December 2012, the SELIC and the spot exchange rate once more did not act consistently, as the SELIC declined 525 base points and the Real depreciated 28.74%.

The inconsistent behavior of the SELIC and exchange rate pinpoints the difficulty of using the interest differential for exchange rate determination.[16] Furthermore, our model

[15]It is notable that the variation in the Fed Funds rate is negligible, as it did not move above 0.25% during our observation horizon.

[16]The literature has been accumulating empirical evidence for the failure of uncovered interest parity since the seminal work of Fama (1984).

reveals that the interest differential is not a determinant of any market participants behavior nor of the nominal exchange rate. This is not taken as evidence that the exchange rate is detached from fundamentals, but simply that institutional context dictates which fundamentals are of primary importance. Recall that commodity prices and risk factors are major forces in the behavior of commercial customers.

Comparing our results with the existing literature reveals complementary findings to previous studies. Kohlscheen (2012) estimates the indirect effect of BCB intervention on currency pricing, comparing the money amount necessary to move the market in days with and without intervention. In contrast, the present work has shown that intervention has a direct impact on financial actors, which significantly alters their behavior for at least 5 days. Second, Kohlscheen (2013) finds cointegration and thus a long-run relationship between commodity prices and the Real. The present study finds that commodity prices influence the value of the Real through two channels: indirectly through their effect on commercials behavior, and directly as a determinant of the depreciation rate. This underlines the role of public and private information in the determination of the Real. Third, using OLS regressions derived from a modified UIP framework, Chamon and Garcia (2013) were not able to find a significant impact of capital controls on the value of the Real. This comes from the inability to capture the impact of these measures on the economic incentives of market participants. The exchange rate dynamics revealed in the model show that both private and public information are important for price determination in the Brazilian FX market. On one hand, private information is relevant for exchange rate determination as the behavior of commercial customers is a significant determinant of the value of the Real. On the other hand, risk perception and commodity prices, both public information, are determinants of the Real. This suggests that controlling for both public and private information channels is an extremely useful new approach. Previous studies, such as Sager and Taylor (2008) suggest that informational content flows primarily through the order flow of financial customers. In contrast, this study aligns itself with Kohlscheen (2012), who finds that order flow originating from commercial customers is driving the FX markets pricing mechanisms. More generally, this discussion is in line with Evans and Lyons (2006) who also use disaggregated data to find empirical evidence that the price impact of order flow varies across end-user segments.

3.2. Capital Controls

The previous section confirmed these findings from the perspective of an integrated approach using an updated sample. However, central bank interventions remain only one part of Brazil's active position on exchange rate management. The focus of this paper is the assessment of the effectiveness of Brazilian macroprudential policies. As summarized in Table 4, Brazil introduced 5 sets of macroprudential policies. Together with central bank intervention they share a common motivation to curb speculative behavior and avoid excessive inflow of short-term investments. In this sense, we evaluate their effectiveness based on the ability to change market participants behavior and thus the exchange rate. We introduce these policies as structural break dummy variables assuming a value of zero until the introduction date and one thereafter. In the case a policy was suspended, the value returns to zero. Tables 5 and 6 presents the point estimates for each policy based on dynamic multiplier analysis (5 periods).

Tobin Tax

Shortly after the collapse of the Bretton Woods system, Tobin (1978) proposed a tax on the conversion of currencies. The intention was to reduce the return on hot money and thus mitigate exchange rate volatility. The downside of this policy is that it also reduces the return on real economy investment from foreign investors. More recently, Bird and Rajan (2001) argue that a Tobin tax may nevertheless be efficient in the sense that it can raise substantial amounts of tax revenue, which could be used to cover losses from financial crises.

A successful policy would act to avoid the inflow of short-term capital into the country through a significant impact on the behavior of financials, while changes in the behavior of real economy actors are the undesired costs. However, the introduction of a tax on capital inflows has not significantly changed commercials' or financials' behavior. This means that either the volatile component of capital flows was limited in Brazil or that the Tobin tax can be deemed ineffective. Further, it has shown the demand for investments in Brazil was inelastic and so the increase in tax on foreigners provided a good source of revenue. According to our estimation, after the increase from 2% to 4% tax on fixed income the BCB significantly increased its intervention in the FX market. After six trading days the tax was raised to 6% and the BCB reduced its intervention by approximately the same amount. This result is considered to be an anomaly of the data, as six days is a

relatively short period in the sample and could be capturing a change in BCB behavior due to other reasons.

Tax on Loans Abroad

Aghion, Bacchetta, and Banerjee (2001) suggest that the Asian Crisis of 1997 had its origin in the share of national debt denominated in foreign currency. The Brazilian government imposed a tax on loans held abroad for maturities up to five years. This policy is consistent with an effort to incentivize firms to avoid increasing their debt in foreign currency while the Real is over-appreciated.

At the introduction of the 6% tax, only loans with maturity below one year were taxed, which mainly affected financials. The Brazilian government then expanded the tax to loans with maturity below 2, 3, and 5 years successively. We found no empirical evidence within the model to support effectiveness of those successive changes. This could explain why Brazil removed the changes in maturity and currently taxes only loans with maturity below one year.

Upon taxing loans abroad with maturity below one, financials reduced their daily buying pressure on average 818 million dollars. This reduction of short term borrowing corresponds to a reduction in carry trade transactions initiated by local institutions. The expansion of the tax for loans with longer maturity had no impact on commercials behavior; implying that this policy had no impact on the real economy. Either the interest differential is so large that companies continued taking loans abroad regardless of the tax, or the loans abroad play no central role for Brazilian companies. In summary, a tax on loans held abroad could help to divert short-term capital movements from Brazil but had no impact on the real economy.

Unremunerated Reserve Requirements on Overnight FX Positions

On June 1st, 2011, the BCB imposed an unremunerated reserve requirement of 60% on banks gross FX position beyond three billion dollars. In July of the same year, they narrowed the requirement to FX positions larger than one billion. Both instances show a significant change in the behavior of financials; on average, financials increase their daily demand to buy USD / sell BRL by 691 and 762 million dollars for each policy shift, respectively. Interestingly, the narrowing of the reserve requirements had a stronger impact than the introduction of the policy, showing that the total amount of positions above 3 billion dollars were lower than the sum of the positions between 1 and 3 billion

dollars.

Tax on Currency Derivatives

On July 27th, 2011 Brazil introduced a 1% tax on currency derivatives, and empowered the Finance Minister with the ability to raise it up to a 25% ceiling. The tax is levied whenever the derivative change hands or expires. In the latter case the risk that the tax increases remains. In order to protect real economy players with the need to hedge their international transactions, the Brazilian government excluded hedging transaction from this tax six months later.

The introduction of the tax was clearly addressed to curb speculative behavior towards the Real, an activity associated here with financial participants. The introduction of the tax (D1) led to an average reduction of 662 million dollars in daily financial order flow. The negative sign implies that the introduction of the policy increased the demand for Real from financial customers. This effect is contrary to our hypothesized policy point of view. The 25% ceiling which may be raised by the Finance Minister without prior announcement may have brought local financial actors to liquidate their position in anticipation of future increases. Thus it effectively increased, not decreased, exchange rate volatility.

The creation of an exception to hedging transactions (D2) indeed affected commercials behavior. Commercials' daily demand for dollars reduced about 271 million after the change. This represents a successful policy as it is concordant with governments intention to free the real economy from this tax.

Tax on the Conversion of ADRs

American Depositary Receipts (ADRs) are securities traded in the U.S. in dollars with an underlying foreign stock. A holder of a such receipts can request the custodian bank to transform it into the underlying stock in the withstanding currency. ADRs of Brazilian stocks have been widely used to bypass the tax in capital inflow. In order to close this channel, Brazil introduced a 1.5% tax on the conversion of ADR's, which together with bank fees equals the 2% Tobin tax. Out of fear that capital controls might have a negative influence in the Brazilian stock market, the tax on equity capital inflows was suspended but the tax on ADR conversions kept. Our model is unable to capture any change on market participants behavior after the introduction of the policy. This is either because there was no bypassing behavior or it did not significantly change after the introduction

of the tax. This result is consistent with the absence of statistical significance of the Tobin tax.

4. Discussion

This paper has drawn a picture of capital controls while controlling for active central bank exchange rate management. Figure 5 displays the time series of cumulative order flows, and reveals that in fact the BCB is the largest force exerting selling pressure on the Real; that is, nearly $300 billion over the three and a half year window. Moreover, interventions are one-sided and especially strong on days the market moves towards a depreciation. A broad set of capital controls were also introduced according to the BCB policy objectives. Both policy tools may be deemed successful from the point of view that they significantly changed market participants' behavior. We confirm the earlier finding that intervention not only significantly changed the order flow of financials, which alone supports the notion of correcting for financially-driven misalignments, but did so in the direction consistent with stated BCB concerns of over-appreciation in the Real. More important from the perspective of the paper's contribution, however, is the result that capital controls were able to deleverage financial positions on the Real with low costs for the real economy.

The Brazilian case provides another example that institutional context influences the processes driving currency prices. This can be seen in the informational content of order flow. Due to the of role of order flow in aggregating information, it is common to ask through which channels this occurs. Previous studies, such as Sager and Taylor (2008), suggest that informational content flows primarily through the order flow of financial customers. In contrast, this study aligns itself with Kohlscheen (2012), who finds that order flow originating from commercial customers is driving the FX markets pricing mechanisms. These findings are not contradictory empirical results, but instead are evidence for the unique institutional context in emerging markets.

The importance of commercial order flow to the Real is related to a pervasive debate in exchange rate economics, the role of fundamentals. The inability of theoretical exchange rate models to outperform a random walk in out-of-sample forecasting exercises has led some economists to argue that fundamentals are unimportant for understanding exchange rates (Meese and Rogoff, 1983). Our microstructure data tells a different story. The influence of commercial customers and their strong ties to the real economy suggests that

fundamentals do in fact matter; it is instead a question of which fundamentals.[17] In our Brazilian case study, these are commodities and their influence through the real economy.

Regarding the policymakers' concern that 'beggar-thy-neighbor' monetary policies in major economies may be affecting emerging market currencies, we find no evidence for a channel that links financial participants and daily fluctuations in the Real. Likewise, participants across the board do not respond to movements in the interest differential, despite fluctuations of over 1000 basis points in the Brazilian interest rate throughout our sample. As commodities are a primary determinant of the Real within our model, their effect is instead the likely link between international monetary policies and the value of the Real. However, the question of whether monetary policy affects commodity prices goes beyond the scope of this paper.

5. Conclusion

Evans (2011) estimates that by 2009, over 250 empirical papers have been written investigating the mechanisms linking order flow and exchange rates. Motivating questions of such studies include the role of order flow as an information aggregator and the consequences of institutional structure in FX markets, order flow's predictive forecasting value, and the long-run relationship between order flow and fundamentals. This paper is one of a small number of studies using order flow - via our data set on market wide end-user flows - to explicitly analyze the effectiveness of exchange rate management, wherein the efficacy of policies is judged by their ability to influence (a desired subset of) market participants.

Our analysis adds to this literature on several fronts. We expand upon the recognition that emerging market context matters in a meaningful way, and that understanding the processes driving currency prices begins on the individual microstructure level. The reduced form VAR avoids the use of potentially restrictive assumptions, offers a unique disaggregated view of the Brazilian FX market, and addresses concerns of parameter stability by accounting for a series of changes in the policy environment - i.e., capital controls.

[17] This argument is independent of the role that fundamentals play in driving the FX activity of financial participants, which is the common focus of the debate. We recall that unlike most advanced countries, commercial customers in Brazil are a relatively significant share of the market.

Using an unique data set on the microstructure of the Brazilian FX market, this paper captures the dynamics of the Brazilian Real. Collectively, our results paint a clearer picture about the Brazilian response to an increasingly competitive macroeconomic environment. The combination of FX interventions and macroprudential policies present a picture of an exchange rate management regime that is concerned with overvaluation of the Real, and the related concerns of speculative behavior and the competitiveness of exports. While commercial actors have an impact on daily movements of the exchange rate we find no similar evidence for financials. In fact, the time horizon of this study coincides with a sharp increase of commodity prices, suggesting this is rather likely to be the link for an over-appreciation of the Real and thus no support for a speculative over-appreciation of the Real in this context.

6. Acknowledgments

We thank seminar participants at the Kiel Institute for World Economy. We are also grateful for comments from Emanuel Kohlscheen, Lucas Menkhoff and Lucio Sarno.

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8. Appendix

Table 1:
Summary Statistics

Variables	**Mean**	**Std. Dev.**	**Minimum**	**Max**
Commercial OF				
(All Observations)	53.7404	407.5836	-2252	1752
(Intv > 0)	69.6666	403.0659	-2252	1752
(Intv = 0)	27.2740	414.2198	-1138	1724
Financial OF				
(All Observations)	94.5750	686.8207	-3037	6671
(Intv > 0)	159.5526	737.1891	-2405	6671
(Intv = 0)	-13.4052	578.8259	-3037	3072
Intervention				
(All Observations)	139.7054	274.2769	0	4640
(Intv > 0)	223.7737	318.9526	1	4640
Depreciation rate				
(All Observations)	-7.70e-06	.0075	-.0336	.0394
(Intv > 0)	-6.95e-05	.0071	-.0221	.0271
(Intv = 0)	-9.52e-05	.0083	-.0336	.0394
Δ (Interest differential)	-.0031689	.0833199	-.9800005	.7600002
Δ (cpr)	.7861074	43.83736	-216.68	153.76
Δ (vix)	-.0111294	1.875858	-12.94	16
Δ (embi)	.405800	2.72476	-12.8	12.8

N = 913 , N(Intv > 0) = 570

Summary statistics of daily data from May 11, 2009 until December 28, 2012. Commercial and financial customer order flows and intervention order flows are measured in USD billions. Exchange rate is measured as the domestic price for one USD. The interest differential is defined as domestic minus foreign interest rates. The domestic interest rate is the daily annualized rate of the Brazilian Selic rate. The foreign interest rate is the daily annualized rate of the Fed Funds rate. VIX is the implied volatility of the S&P 500 computed by the chicago board options exchange. EMBI is an emerging market bond index calculated by JP Morgan.

Table 2:
Unit Root Test

	Augmented Dickey-Fuller		
Variable	none	constant	trend
Commercial OF	-5.963	-5.679	-6.030
Financial OF	-6.174	-5.788	-6.384
Intervention	-4.992	-3.671	-5.341
Depreciation Rate	-7.456	-7.458	-7.603
Δ (Interest differential)	0.057	-1.104	0.056
Δ (cpr)	-1.981	0.180	-1.968
Δ (vix)	-3.056	-1.035	-3.110
Δ (embi)	-0.051	3.514	-2.272
Test 1% critical value	-3.430	-2.580	-3.960

Test statistics of Augmented Dickey-Fuller test for unit roots. Null hypothesis is variable has a unit root.

Table 3:
Test for Sterilized Intervention

	ΔM1
L.ΔM1	0.1890***
	(0.0324)
L2.ΔM1	0.1806***
	(0.0325)
L3.ΔM1	0.2239***
	(0.0324)
BCB Intervention	0.0003
	(0.0002)
L.BCB Intervention	-0.0003
	(0.0002)
_cons	0.0991
	(0.1161)
R-squared	0.196

standard errors in parenthesis
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Intervention and M1 are denominated in Brazilian Real and expressed in millions. Standard errors in parentheses. The symbols *, **, and *** denote that the individual coefficients are significant at a 10%, 5%, and 1% significance level, respectively.

Table 4:
Capital Controls

Variable	Start Date	Description
Tobin tax		
T1	10/20/2009	2% tax on equity and fixed income capital inflows
T2	10/5/2010	4% on fixed income
T3	10/18/2010	6% on fixed income
T4	12/1/2011	0% on equity
Loans taken abroad		
L1	3/29/2011	6% for loans with maturity below 1 year
L2	4/7/2011	below 2 years
L3	3/1/2012	below 3 years
L4	3/9/2012	below 5 years
-	6/13/2012	below 2 years
-	12/4/2012	below 1 year
Unremunerated reserve requirement		
U1	1/6/2011	Unremunerated reserve requirement of 60% on bank's gross FX position beyond 3 billion
U2	7/8/2011	beyond 1 billion
-	12/18/2012	beyond 3 billion
Currency derivatives		
D1	7/27/2011	Tax on nominal amount of currency derivatives
D2	3/15/2012	Tax set to zero for hedging
Conversion of ADRs		
A1	11/19/2009	Tax of 1.5% on the conversion of ADRs

Table 5:
Impact of Capital Controls on Financials, 95% confidence interval

Variable	Point Estimate	Lower	Upper
T1	-84.3	-484.7	316.1
T2	39.4	-523.3	602.2
T3	-66.2	-696.7	563.3
T4	-218.9	-665.1	228.3
L1*	-818.3	-1485.2	-152.4
L2	111.7	-549.2	773.7
L3	2231.2	-456.5	918.1
L4	-391.1	-1117.4	334.2
U1*	669.5	300.9	1098
U2*	762.6	259.8	1265.3
D1*	-650.9	-1127.8	-174.1
D2	62.3	-127.8	252.4
A1	12.7	-372.4	397.7

Results based on cumulative value of dynamic multiplier analysis after 5 Periods, (*) denotes variable significantly different from zero. Lower and Upper are the bounds of the confidence interval.

Table 6:
Impact of Capital Controls on Commercials, 95% confidence interval

Variable	Point Estimate	Lower	Upper
T1	61.3	-170.2	292.8
T2	57.2	-268.2	382.7
T3	46.4	-317.7	410.6
T4	-8.3	-266.8	250.2
L1	368.3	-17.1	753.8
L2	-209.9	-592.3	172.4
L3	262.7	-134.5	659.8
L4	-1.1	-420.6	418.4
U1	-45.6	-275.9	184.7
U2	52.3	-238.3	342.8
D1	51.7	-327.2	223.9
D2*	-268.2	-378.1	-158.4
A1	-74.5	-297.1	148.0

Results based on cumulative value of dynamic multiplier analysis after 5 Periods, (*) denotes variable significantly different from zero. Lower and Upper are the bounds of the confidence interval.

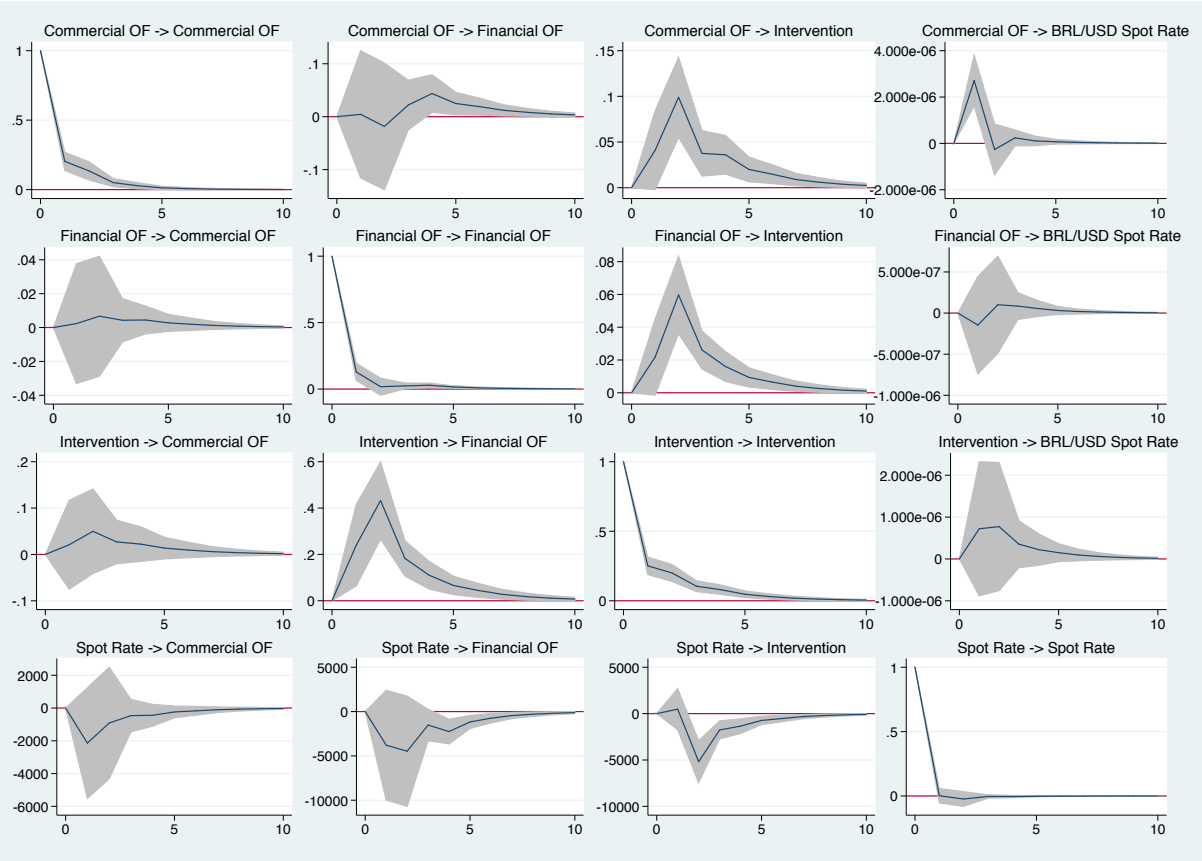

Figure 1:
Impulse Response Functions, Cholesky Decomposition
Labeled: Impulse → Response
Response to a $1 million impulse; 95% confidence interval

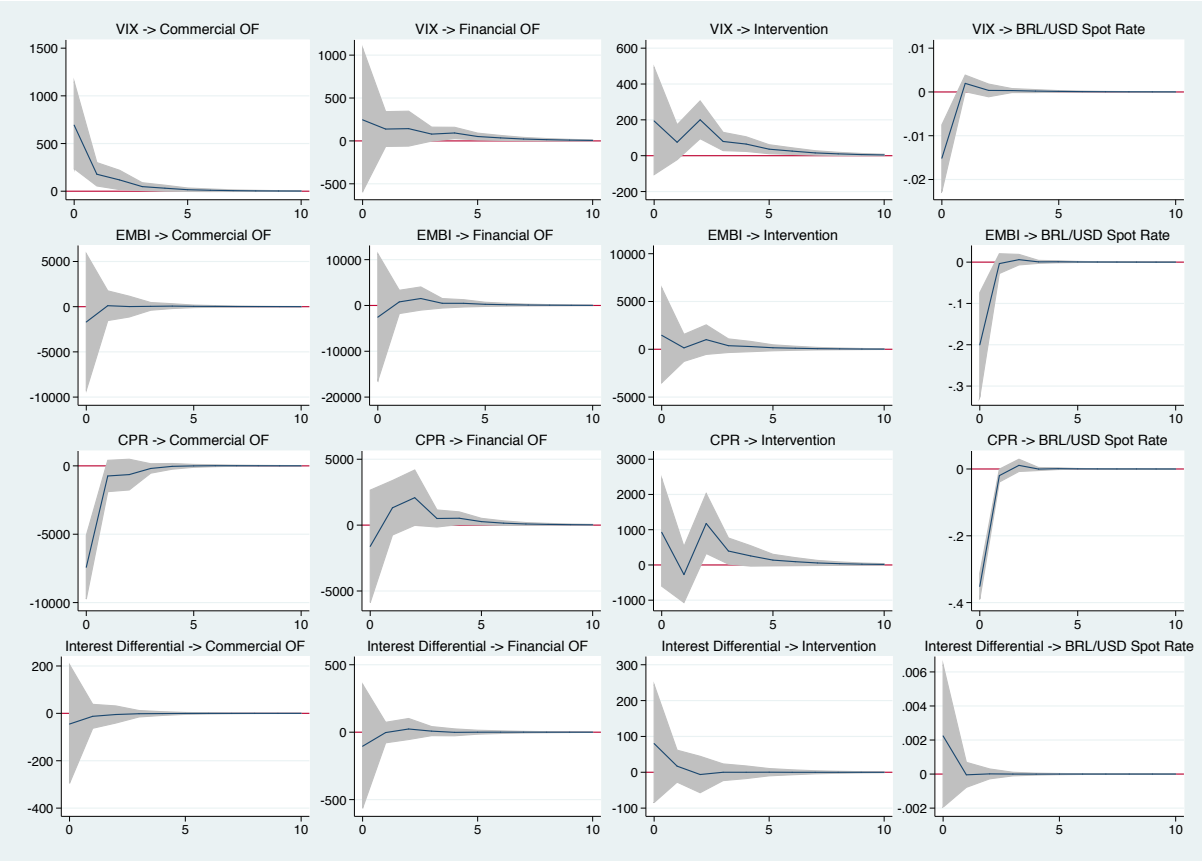

Figure 2:
Dynamic Multipliers
Labeled: Impulse → Response
Response to 1% impulse; 95% confidence interval; all impulse variables treated in differenced-log specification.

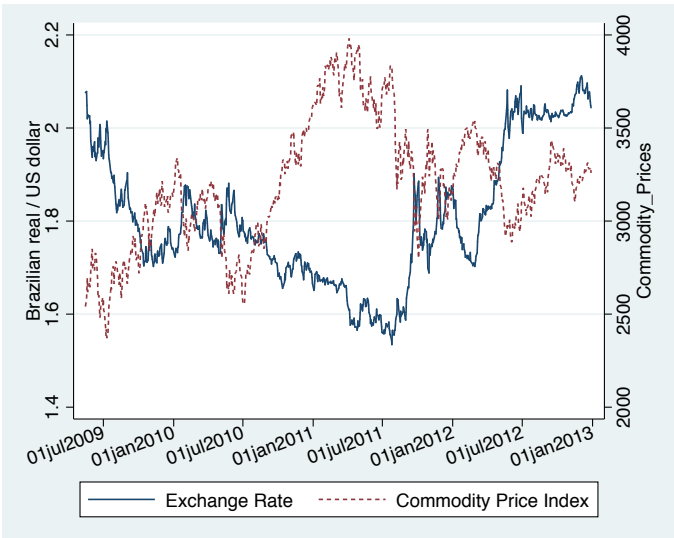

Figure 3:
BRL/USD Daily Exchange Rate and Commodity Prices.
Source: Central Bank of Brazil

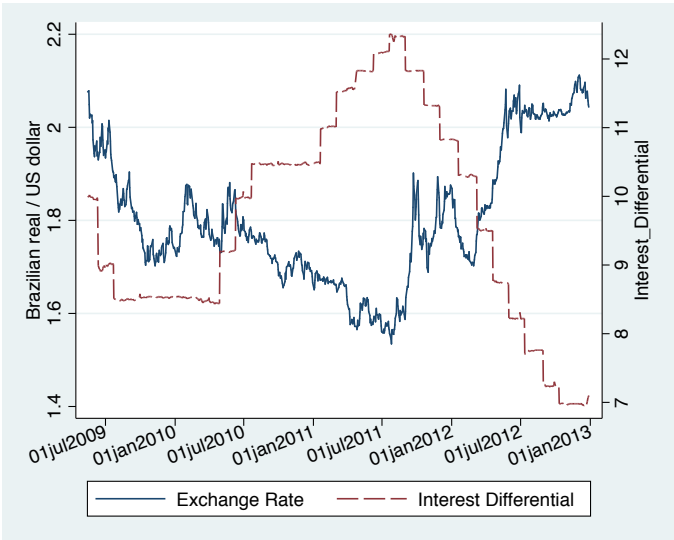

Figure 4:
BRL/USD Daily Exchange Rate and Interest Differential.
Source: Central Bank of Brazil

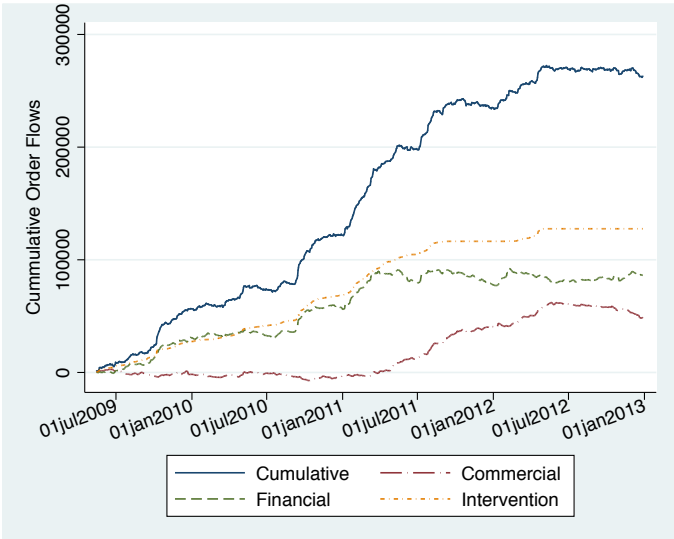

Figure 5:
Cumulative Order Flow by Participant. (US dollar, millions)
Source: Central Bank of Brazil