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

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Abstract

This paper uses a microstructure approach to analyze the effectiveness of capital controls introduced in Brazil to counter an appreciation of the Real. Based on a rich data set from the Brazilian foreign exchange market, we estimate a reduced-form VAR to characterize the interaction of the central bank, financial and commercial customers in times of regulatory policy measures. Controlling for regular FX interventions we find that capital controls change market participants' behavior. Referring to the source of order flow, we find no evidence that the appreciation of the Real is driven by financial customers activity. Instead, commercial customers seem to be a primary driver of the Real within our model. To the extent that capital controls influence commercial customers' order flow, this is the likely channel policy makers use to respond to a perceived loss of international competitiveness.

Keywords: Foreign Exchange, Sterilized Intervention, Macroprudential Policies, Market Microstructure, VAR

JEL-Classification: F31, E58, G14, G15

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 the rescue packages for sovereign bonds in Europe. Emerging economies such as Brazil have expressed concern at G20 meetings of 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

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[1]See "What's the currency war about?" from BBC, 10.22.2010

economic performance of -0.3% GDP growth for the year. The peak of the dispute was reached in September 2010 when Brazilian Finance Minister, Guido Mantega, announced in the 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 inflow. 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 did not find much 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. Chamon and Garcia (2013) test the effectiveness of the same macroprudential policies analyzed in this paper. Their approach was to include dummies variables in a modified UIP regression and test for a significant impact on the value of the Real. This approach was unable to 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, as 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

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[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.

[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.

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 have 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 the 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 of the Real and finds that in days 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 VAR for the period between July 1999 and June 2002, and finds empirical support for his model.

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 seperately 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

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[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.

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 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 in section 2, where we describe the data 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 Ne 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] foreign currency reserves defined as the International Monetary Fund cash concept and the spot exchange rate of the Real are provided by the BCB.

Table 1 displays summary statistics for variables used in estimation. Applying an augmented Dickey Fuller test for all time series we find that the interest differential, VIX, EMBI and CRB commodity price index have a unit root. These variables are treated in first difference and 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,

$$M1 = 249.0264^{***} - 0.0059^{***}(Intervention), \quad R^2 = 0.012$$

The coefficients are close to 0, yet statisitcally significant, implying that nearly all interventions are sterilized; see Table 3 of the Appendix. Henceforth, this study will assume that all

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[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 proxy for international risk perception.

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

interventions were sterilized.

3. Estimation

A standard problem in empirical analyses of the FX market is the pervasive presence of bi-directional causality of the underlying variables. Of course, the decisions of market participants to buy or sell foreign currency may be motivated by the level or changes of the spot rate, or vice-versa. To characterize the nature of variable endogeneity in our data set, Table 4 summarizes the results of granger causality tests between the depreciation rate and order flows. From a disaggregated point of view, we find that none of the endogenous variables granger cause commercial order flow, intervention granger causes financial behavior, and intervention is granger caused by the depreciation rate, commercial and financial order flow.

In order to account for the simultaneity problem in daily data between the spot rate and order flow, we opt for a reduced-form vector autoregression (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 represents 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 treat the dynamics of market participants behavior with respect to intervention and a system of common exogenous shocks. 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 and Schwarz criterion. Table 5 contains the baseline estimation and represents the dynamics of the Brazilian FX market.

The *commercial customers' reaction function* can be viewed as an autoregressive process affected by international risk perception (VIX) and commodity prices (CPR). An increase in global volatility (VIX) leads commercials to sell BRL against US dollars. As a large share of this group are non-Brazilian multinationals, commercial customers are expected to withdraw some of their investments to cut exposures in turbulent times.[9] Furthermore, commercials' demand for dollars are negatively correlated with commodity prices. We interpret the sign of the coefficient as the consequence of an inelastic comodity demand. An appreciation of the

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[9]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.

Real is raising the bill for Brazilian exports implying that foreign commercials need to buy more BRL against USD. 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 determinant 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 concerns for speculation and independently 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 relationship between commercial customers and financial markets is not revealed within the model; that is, neither financials or commercials respond to each other within the estimation.

The major determinants in the *financials customer' reaction function* are autoregressive terms and central bank intervention. 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. BCB intervention is thus the only significant determinant of financials' order flow revealed by the disaggregated dynamics.

The rhetoric of a currency war shows that Brazilian policymakers are concerned with 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 of interest differential in the financials 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 an autoregressive process, the depreciation rate, financials' and commercials' order flow as shown in equation (3) of Table 5. 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 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 policy makers resulting from an appreciating Real. Due to daily reporting requirements for all transactions involving the Real the BCB has an information advantage in the FX market. This would facilitate the daily reaction to market activity, such as the 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, pinpointing different attitude 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. However, the size of the coefficients are small and only second-order lags are statistically significant at the 5% level.[10]

The potential for the BCB to manipulate the intraday momentum of market fluctuations is not captured within our reduced-form VAR. In addition, lagged coefficients for intervention are not a determinant of the daily depreciation rate. Wu (2012) , using a similar data set, does estimate the matrix on contemporaneous coefficients, and finds a significant and positive coefficient for the intraday response of the depreciation rate due to intervention. This supports our conjecture that the central bank is capable of accelerating the momentum in the market.

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 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

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[10]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.
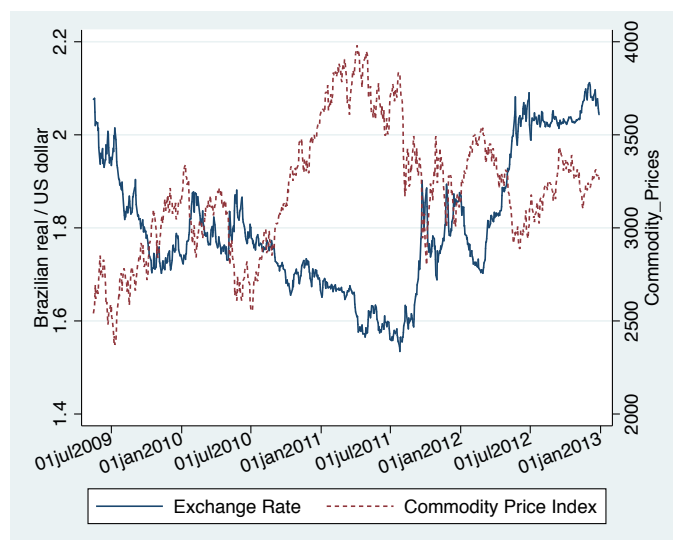
Figure 1:
BRL/USD Daily Exchange Rate and Commodity Prices.
Source: Central Bank of Brazil

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, commodity prices and central bank reserves. An increase in buying pressure from commercial customers is positively related with the change in spot rate. 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 1).

Both international and local risk perception apply downward pressure on the nominal exchange rate. VIX influences the value of the Real directly and indirectly - through its influence on commercials' 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.

During the observed period we can divide the change in Brazilian interest rate in 3 periods
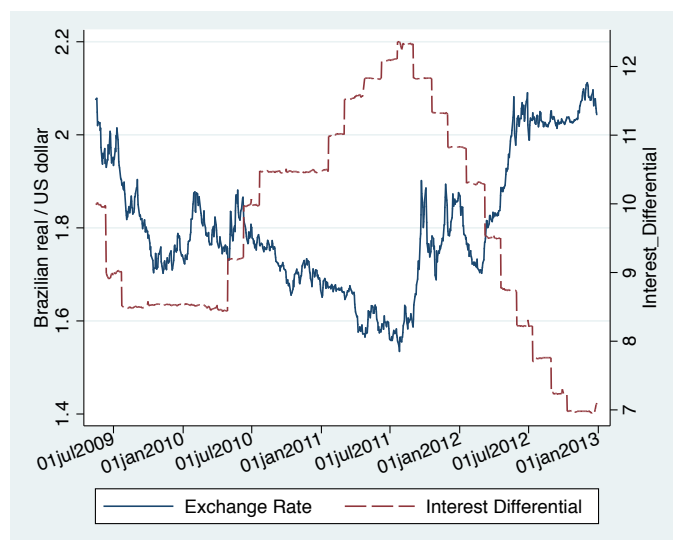
9

Figure 2:
BRL/USD Daily Exchange Rate and Interest Differential.
Source: Central Bank of Brazil

with clear trends (see Figure 2).[11] 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 following period, until August 2011, the SELIC increased 375 basis point, and inconsistently with the prediction of uncovered interest parity the Real appreciated by 9.6%. Likewise, from that point until December 2012, the SELIC and the spot exchange rate once more did not act consistently, as the SELIC was reduced in 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 the exchange rate determination.[12] Furthermore, our model 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

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[11]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.

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

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 3 days. Second, Kohlscheen (2013) finds cointegration and thus a long-run relationship between commodity prices and the Real. This 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. Controlling for both public and private information channels thus embodies 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.

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 has led some economists to argue that fundamentals are unimportant for understanding exchange rates. Our microstructure approach points towards a different direction. 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. In our Brazilian case study, these are commodities and their influence through the real economy.

3.2. Capital Controls

The previous section confirmed these findings from the perspective of an integrated approach using an up-dated sample. However, central bank intervention 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 6, Brazil introduced

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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 value of zero until the introduction date and one thereafter. In the case a policy was suspended, the value returns to zero. Table 5 presents the estimation results.

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 significant impact on the behavior of financials would be interpreted as successful in avoiding the inflow of short-term capital into the country, and a relevant change in commercial behavior would be the undesired costs. However, the introduction of a tax on capital inflows has not significantly changed market commercials or financials behavior. This means that either there was no entrance of to volatile component of capital flows in Brazil or that the Tobin tax has to be termed 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 of 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. As loans with maturity up to five years have been taxed one could think that the Brazilian government imposed this tax in order to avoid firms increasing their debt in foreign currency when 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 could find no empirical evidence within the model that supports the 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.

As loans abroad with maturity below one year started being taxed, financials reduced their daily buying pressure on average 735 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. In July of the same year, they narrowed the 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 447 and 621 million dollars for each policy shift, respectively. It is remarkble that the narrowing on the reserve requiremtents 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 remains the risk that the tax changes. In order to protect real economy players with the need to hedge their international transactions, the Brazilian government excluded hedging transaction from this tax about a half year 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 435 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 is the opposite effect from 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 189 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 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 equalizes 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 not able 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.

The statistical results of macroprudential policies found in this paper are different from those of Chamon and Garcia (2013). The inclusion of order flows allowed us to recognize the change in market participants behavior after the introduction of the policies. The taxation of currency derivatives has raised the demand for Real from financial customers. The law that introduced this tax also opened the possibility for an increase of up to 25%, which explains the unexpected behavior of financials in response. The tax on loans taken abroad influenced all market participants behavior. Interestingly this occurred only for loans with maturity below one year, implying that loans in foreign currency with higher maturity do not play a role for the Brazilian economy as it did in Asia in the late 1990s. Our estimation also shows that the reserves requirements for overnight FX positions was the single most significant policy, insofar as financials behavior significantly changed after its introduction without interfering commercial order flow. Neither the Tobin tax nor the taxation of ADR conversions significantly changed market participants behavior, which can be seen as positive since this tax can raise revenue without affecting the demand for Real. Overall, our results shed a positive light in the Brazilian macroprudential policy set and underlies the necessity of a microstructure approach to analyze the change in market behavior.

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 chan-

nels 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.

4. Discussion

The present paper has drawn a picture of capital controls when controlling for active central bank exchange rate management. Figure 3 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 can be deemed successful from the point of view that they significantly changed market participants behavior. We confirmed 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.

Regarding the policy makers' 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 point 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.
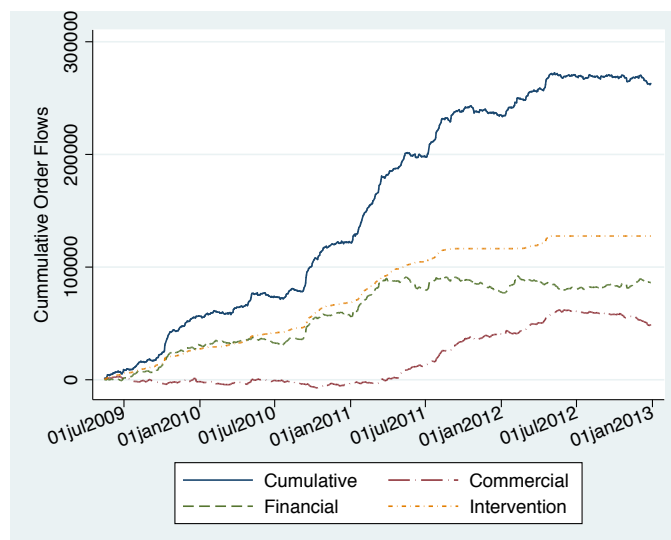
Figure 3:
Cumulative Order Flow by Participant. (US dollar, millions)
Source: Central Bank of Brazil

5. Conclusion

Due to its size, influence as a commodity exporter, and numerous exchange rate management practices, Brazil is a particularly relevant case study for understanding currency markets. Of course, by 2009, over 250 empirical papers have been written investigating the mechanisms linking order flow and exchange rates Evans (2011). 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 flows 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 (see Scalia (2008), Disyatat and Galati (2007) for two others), 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 the 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 utilized avoids the use of potentially restrictive assumptions, offers a unique disaggregated view of the Brazilian FX market, and addresses concerns of parameter stability facing similar studies by accounting for a series of changes in the policy environment - i.e., capital controls.

Using an unique data set on the microstructure of the Brazilian FX market, this paper captured the dynamics of the Brazilian Real. Collectively, our results paint a clearer picture

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about the Brazilian response to an increasingly competitive macroeconomic environment. The combination of FX interventions and macroprudential policies present a picture of a successful exchange rate management regime that is concerned with over valuation of the Real, and the related concerns of speculative behavior and the competitiveness of exports. Moreover, intervention can be deemed successful insofar as its ability to reach a subset of market participants. 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.

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 has led some economists to argue that fundamentals are unimportant for understanding exchange rates. 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.[13] In our Brazilian case study, these are commodities and their influence through the real economy.

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[13]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.

References

Aghion, Philippe, Philippe Bacchetta, and Abhijit Banerjee. 2001. "Currency crises and monetary policy in an economy with credit constraints." *European Economic Review* 45 (7):1121 – 1150.

Bird, G. and R. Rajan. 2001. "Would International Currency Taxation and Currency Stabilisation in Developing Countries?" *Journal of Development Studies* 37 (3):21–38.

Canales-Kriljenko, Jorge Ivan. 2003. *Foreign exchange intervention in developing and transition economies: results of a survey*. IMF Working Paper 03/95.

Chamon, Marcos and Marcio Garcia. 2013. "Capital controls in Brazil: effective?" Discussion Paper 606, Department of Economics PUC-Rio (Brazil).

de Roure, Calebe. 2010. "The Brazilian Confidence Crisis of 2002: A Global Game Approach." Msc. dissertation, University of Warwick.

Disyatat, Piti and Gabriele Galati. 2007. "The effectiveness of foreign exchange intervention in emerging market countries: Evidence from the Czech koruna." *Journal of International Money and Finance* 26 (3):383 – 402.

Evans, Martin D.D. 2011. *Exchange-rate dynamics*. Princeton Series in International Economics. Princeton University Press.

Evans, Martin D.D. and Richard K. Lyons. 2002. "Order Flow and Exchange Rate Dynamics." *Journal of Political Economy* 110 (1):170–180.

———. 2006. "Understanding order flow." *International Journal of Finance & Economics* 11 (1):3–23.

Fama, Eugene F. 1984. "Forward and spot exchange rates." *Journal of Monetary Economics* 14 (3):319 – 338.

Girardin, Eric and Richard K. Lyons. 2008. "Does Intervention Alter Private Behavior?" Working paper.

Kohlscheen, Emanuel. 2012. "Order Flow and the Real: Indirect Evidence of the Effectiveness of Sterilized Interventions." Working Papers Series 273, Central Bank of Brazil, Research Department.

———. 2013. "Long-Run Determinants of the Brazilian Real: a closer look at commodities." Working Papers Series 314, Central Bank of Brazil, Research Department.

Lyons, Richard K. 1997. "A simultaneous trade model of the foreign exchange hot potato." *Journal of International Economics* 42 (34):275 – 298.

Menkhoff, Lukas. 2012. "Foreign Exchange Intervention in Emerging Markets: A Survey of Empirical Studies." Discussion Paper 498, Leibniz University, Hannover.

Neely, Christopher J. 2005. "An analysis of recent studies of the effect of foreign exchange intervention." *Federal Reserve Bank of St. Louis* 87 (6):685–718.

Sager, Michael and Mark P. Taylor. 2008. "Commercially Available Order Flow Data and Exchange Rate Movements: Caveat Emptor." *Journal of Money, Credit and Banking* 40 (4):583–625.

Sager, Michael J. and Mark P. Taylor. 2006. "Under the microscope: the structure of the foreign exchange market." *International Journal of Finance & Economics* 11 (1):81–95.

Scalia, Antonio. 2008. "Is foreign exchange intervention effective? Some microanalytical evidence from the Czech Republic." *Journal of International Money and Finance* 27 (4):529 – 546.

Tobin, James. 1978. "A Proposal for International Monetary Reform." *Eastern Economic Journal* 4 (3/4):153–159.

Wu, Thomas. 2012. "Order flow in the South: Anatomy of the Brazilian FX market." *The North American Journal of Economics and Finance* 23 (3):310–324.

6. Appendix

6.1. Tables

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 US$ billions. Exchange rate is measured as the domestic price for one US dollar. 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
Δ (FX reserves)	-1.518	3.409	-0.485
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

	M1
BCB Intervention	-0.0059***
	(0.0017)
Constant	249.0264***
	(0.9208)
R-squared	0.012

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:
Granger Causality Wald Tests

Variable 1	Variable 2	Prob > Chi2
Depreciation rate	Financial flow	0.773
	Commercial flow	0.000
	Intervention flow	0.343
	All	0.000
Commercial flow	Financial flow	0.170
	Depreciation rate	0.721
	Intervention flow	0.322
	All	0.001
Financial flow	Depreciation rate	0.283
	Commercial flow	0.003
	Intervention flow	0.000
	All	0.000
Intervention flow	Financial flow	0.001
	Commercial flow	0.039
	Depreciation rate	0.003
	All	0.000

Granger causality tests using daily data from May 11, 2009 until December 28, 2012. The lag length for each Granger causality Wald test was chosen based on the Akaike and Schwartz Information Criteria. Null hypothesis is that variable 2 does not Granger cause variable 1.

Table 5:
VAR Baseline - Disaggregate Order Flows in Brazilian FX Market

| | Disaggregated Order Flows | | | |
	Commercial OF	Financial OF	Intervention	DlnSpot
Commercial OF $_{t-1}$	0.2030***	0.0062	0.0398*	0.0000***
	(0.034)	(0.061)	(0.022)	(0.000)
Commercial OF $_{t-2}$	0.0965***	-0.0184	0.0789***	-0.0000
	(0.034)	(0.062)	(0.022)	(0.000)
Financial OF $_{t-1}$	0.0019	0.1299***	0.0213*	-0.0000
	(0.018)	(0.033)	(0.012)	(0.000)
Financial OF $_{t-2}$	0.0055	-0.0030	0.0515***	0.0000
	(0.018)	(0.033)	(0.012)	(0.000)
Intervention $_{t-1}$	0.0196	0.2403***	0.2497***	0.0000
	(0.049)	(0.090)	(0.032)	(0.000)
Intervention $_{t-2}$	0.0413	0.3458***	0.1311***	0.0000
	(0.049)	(0.089)	(0.032)	(0.000)
DlnSpot $_{t-1}$	-2.21e+03	-4.03e+03	525.7787	0.0138
	(1714.614)	(3140.449)	(1126.877)	(0.029)
DlnSpot $_{t-2}$	-431.0518	-4.24e+03	-5.17e+03***	-0.0199
	(1722.028)	(3154.027)	(1131.749)	(0.029)
Δ(vix)	20.2640**	-1.0243	4.6688	-0.0005***
	(8.552)	(15.663)	(5.620)	(0.000)
Δ(embi)	-1.6955	-3.5115	1.5795	-0.0003***
	(4.531)	(8.298)	(2.978)	(0.000)
Δ(cpr)	-2.5618***	-0.9882	0.1997	-0.0001***
	(0.374)	(0.685)	(0.246)	(0.000)
Δ(Interest differential)	-56.3412	141.7855	-12.2795	-0.0026
	(142.662)	(261.297)	(93.760)	(0.002)
T1	49.4277	-8.5807	-64.9396	0.0011
	(85.271)	(156.181)	(56.042)	(0.001)
T2	44.3763	-90.8023	179.2951**	0.0008
	(120.070)	(219.918)	(78.912)	(0.002)
T3	34.6260	63.9522	-175.9936**	-0.0003
	(134.112)	(245.636)	(88.141)	(0.002)
T4	-4.2845	-149.7513	-25.5000	-0.0005
	(95.355)	(174.650)	(62.669)	(0.002)
L1	227.2580	-736.2939***	66.6891	-0.0034
	(141.820)	(259.754)	(93.207)	(0.002)
L2	-114.9156	229.7207	-179.3705*	0.0023
	(140.538)	(257.407)	(92.364)	(0.002)

continued on next page...

Table 5:

VAR Baseline - Disaggregate Order Flows in Brazilian FX Market

	Disaggregated Order Flows			
	Commercial OF	Financial OF	Intervention	DlnSpot
L3	163.2256	156.6372	51.6566	0.0016
	(147.452)	(270.070)	(96.908)	(0.002)
L4	19.0431	-356.5387	16.9681	-0.0008
	(155.141)	(284.153)	(101.962)	(0.003)
U1	-42.1982	447.3607***	130.6542**	-0.0001
	(87.177)	(159.672)	(57.295)	(0.001)
U2	36.9469	621.6201***	35.6626	0.0004
	(108.126)	(198.042)	(71.063)	(0.002)
D1	-28.7271	-434.7637**	-116.4699*	0.0011
	(102.650)	(188.012)	(67.464)	(0.002)
D2	-189.7418***	67.8153	3.6854	0.0000
	(41.958)	(76.850)	(27.576)	(0.001)
A1	-59.2820	-42.4880	63.4306	0.0001
	(81.962)	(150.120)	(53.867)	(0.001)
Constant	-15.4214	69.6946	93.2003***	-0.0013**
	(35.168)	(64.413)	(23.113)	(0.001)
R-squared	0.2634	0.1312	0.2990	0.3905

Estimation of VAR with 2 lags using daily data from May 11, 2009 until December 28, 2012.. Lag length selected according to Akaike and Schwartz criterion. Standard errors in parentheses. The symbols *, **, and *** denote that the individual coefficients are significant at a 10%, 5%, and 1% significance level, respectively.

Table 6:
Capital Controls

Variable	Start Date	Description
Tobin tax		
T1	10/20/2009	2% tax on equity and fix 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 billions
U2	7/8/2011	beyond 1 billion
-	12/18/2012	beyond 3 billions
Tax on currency derivatives		
D1	7/27/2011	Tax on nominal amount of currency derivatives
D2	3/15/2012	Tax set to zero for hedging
Tax of 1.5% on the conversion of ADRs		
A1	11/19/2009	Tax of 1.5% on the conversion of ADRs